North Carolina
Fishery Management Plan

Kingfish

North Carolina Department of Environment and Natural Resources
Division of Marine Fisheries
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1. ACKNOWLEDGEMENTS

The 2007 North Carolina Kingfish Fishery Management Plan (FMP) was developed under the direction of the North Carolina Marine Fisheries Commission (NCMFC) with the advice of the Kingfish Advisory Committee. The North Carolina Department of Environment and Natural Resource's Division of Marine Fisheries (NCDMF) prepared the plan.

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2.1 LIST OF ACRONYMS

AC – Advisory Committee

ALWTRP – Atlantic Large Whale Take Reduction Plan

ASMFC – Atlantic States Marine Fisheries Commission

BDTRT – Bottlenose Dolphin Take Reduction Team

BRD – Bycatch Reduction Device

CHPP – Coastal Habitat Protection Plan

COE – United States Army Corps of Engineers

CPI – Consumer Price Index

CPUE – Catch Per Unit Effort

CRC – North Carolina Coastal Resources Commission

CRFL – Coastal Recreational Fishing License

DO – Dissolved Oxygen

DWQ- North Carolina Division of Water Quality

EA – Environmental Assessment

EFH – Essential Fish Habitat

EMC – North Carolina Environmental Management Commission

EPA – United States Environmental Protection Administration

ESA – Endandered Species Act

FDA – United States Food and Drug Administration

FMP – Fishery Management Plan

FRA – Fishery Reform Act

FRG – Fishery Resource Grant

G.S. – General Statute

GSI – Gonadosomatic Index

HCP – Habitat Conservation Plan

HPTRP – Harbor Porpoise Take Reduction Plan

HQW- High Quality Waters

ICW – Intercoastal Waterway

ITP – Incidental Take Permit

MMPA – Marine Mammal Protection Act

MRFSS- Marine Recreational Fisheries Statistical Survey

MSC – Moratorium Steering Committee

NCDENR – North Carolina Department of Environment and Natural Resources

NCDMF – North Carolina Division of Marine Fisheries

NCMFC – North Carolina Marine Fisheries Commission

NCTTP – North Carolina Trip Ticket Program

NEFMC – Northeast Fishery Management Council

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

NSW – Nutrient Sensitive Waters

OPR – Office of Protected Resources

ORV – Off Road Vehicle

ORW – Outstanding Resource Waters

PBR – Potential Biological Removal

PDT – Plan Development Team

PNA – Primary Nursery Area

PPT – Parts Per Thousand

PSE – Proportional Standard Error

PSGRNA – Pamlico Sound Gill Net Restricted Area

PSS – Pamlico Sound Survey

RCGL – Recreational Commercial Gear License

SAB – South Atlantic Bight

SAFMC – South Atlantic Fishery Management Council

SAV – Submerged Aquatic Vegetation

SCFL – Standard Commercial Fishing License

SEAMAP – Southeast Area Monitoring and Assessment Program

SHA – Strategic Habitat Area

STAC – Sea Turtle Advisory Committee

TED – Turtle Excluder Devices

TEWG – Turtle Expert Working Group

TL – Total Length

TRT – Take Reduction Team

TSS – Total Suspended Solids

USFWS – United States Fish and Wildlife Service

WRC – North Carolina Wildlife Resources Commission

YOY – Young of the Year

3. EXECUTIVE SUMMARY

Three species of kingfishes occur in North Carolina: southern kingfish (*Menticirrhus americanus*), Gulf kingfish (*M. littoralis*), and northern kingfish (*M. saxatilis).* These species support significant recreational and commercial fisheries. Southern kingfish is the most abundant kingfish in the South Atlantic Bight and was chosen as the indicator species for this assemblage. All three species are short-lived, demersal fish that inhabit nearshore ocean and estuarine habitats. The sharp decline in the commercial landings for the South Atlantic from 1986 to 1998 and for North Carolina from 1993 to 1998 has raised concerns. This decline may have been due to a decrease in the population of kingfishes, decreasing effort in the fisheries, and/or regulations on the shrimp trawl, gill net, and ocean trawl fisheries.

Two different stock assessments were modeled to determine sustainable harvest levels, but peer reviewers and the Kingfish Fishery Management Plan Development Team (PDT) rejected the stock assessments due to deficiencies in the data. A major deficiency cited by all the reviewers was the lack of migration (mixing) data to determine the movement of kingfishes along the North Carolina coast as well as the Atlantic coast. Since a stock assessment did not pass peer review, the stock status of kingfish as classified by the North Carolina Division of Marine Fisheries will remain "unknown" until a coastwide stock assessment is completed. Although the stock status will remain unknown, management measures were considered to ensure a sustainable harvest of kingfishes. Trend analyses were conducted for southern kingfish in lieu of a stock assessment and were used as a guideline for the management of the three species.

Trend analyses indicated that the majority of the indices for the kingfish stocks are encouraging: increasing trends in dependent and independent catch per unit effort, no clear indication of growth overfishing, a healthy age structure and an increase in the number of citation fish being captured by recreational anglers. Management actions taken in the mid 1990s including the flynet closure south of Cape Hatteras, the mandatory use of fish and turtle excluder devices in trawls and the implementation of the "50-50" rule for trawl fisheries (1998) have all had a positive impact on the stocks of kingfishes by reducing the number harvested and protecting smaller fish.

Research recommendations were endorsed by North Carolina Marine Fisheries Commission (NCMFC), PDT and the Advisory Committee (AC) that will address deficiencies, which currently exist in the data and the recommendations will increase our understanding of the biology and population dynamics of kingfishes. The NCMFC, PDT and the AC agreed on proclamation authority for the director with management triggers that will provide managers the flexibility to initiate management actions to maintain a sustainable harvest. A 30 day comment period prior to a proclamation release by the NC DMF Director was originally recommended by the AC, then later rescinded. Neither the NCMFC nor PDT supported the 30 day comment period. In response to comments by reviewers and migratory nature of kingfishes, the PDT further recommended that the Atlantic States Marine Fisheries Commission or South Atlantic Fisheries Management Council manage the stock. This recommendation was not supported by the NCMFC nor AC. A technical amendment to rule 15A NCAC 3J .0202. (5) was supported by all groups. The wording in the rule was inadvertently switched from "lawful" to "unlawful", which was discovered in the development of this fishery management plan.

4. INTRODUCTION

4.1 LEGAL AUTHORITY FOR MANAGEMENT

All authority for management of North Carolina's fishery for kingfishes is vested in the state of North Carolina. Management of the fishery includes all activities associated with the use, maintenance, and improvement of populations of kingfishes and their habitats in the coastal area, including: research, development, regulation, enhancement, and enforcement. North Carolina's jurisdiction over kingfishes is limited to ocean waters located within three miles of the states coastline.

The North Carolina General Assembly has provided a very powerful and flexible legal basis for coastal fisheries management. Many state laws provide the necessary authority for fishery management in North Carolina. General authority for stewardship of the marine and estuarine resources by the North Carolina Department of Environment and Natural Resources (NCDENR) is provided in G.S. 113-131. The Division of Marine Fisheries (NCDMF) is the agency of NCDENR that carries out this responsibility. G.S. 113-136 provides enforcement authority for NCDMF enforcement officers. General Statute 113-163 authorizes research and statistical programs. The North Carolina Marine Fisheries Commission (NCMFC) 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 NCMFC 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). The NCMFC also has authority to establish individual permits for various commercial fishing gears and activities under G.S. 113-169.1. General Statutes 113-221 and 143B-289.52 allow the NCMFC to delegate authority to implement its regulations for fisheries "which may be affected by variable conditions" to the Director of NCDMF by issuing public notices called "proclamations". The North Carolina General Assembly retained for itself the authority to establish commercial fishing licenses and fees and to limit entry into specific coastal fisheries.

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

a. Contain necessary information pertaining to the fishery or fisheries, including management goals and objectives, status of the relevant fish stocks, stock assessments for multi-gear species, fishery habitat and water quality considerations consistent with CHPPs (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 will provide the greatest overall benefit to the state, particularly with respect to food production, recreational opportunities, protection of marine ecosystems, and will produce a sustainable harvest.

d. Specify a time period, not to exceed 10 years from the date of adoption of the plan, for ending overfishing, if it is occurring and achieving a sustainable harvest. This time period shall not apply to a plan for a fishery where the biology of the fish or environmental conditions make ending overfishing and achieving a sustainable harvest within 10 years impractical.

Sustainable harvest is defined in the FRA as “The amount of fish that can be taken from a fishery on a continuing basis without reducing the stock biomass of the fishery or causing the fishery to become “overfished”. Overfished is defined as “The condition of a fishery that occurs when the spawning stock biomass of the fishery is below the level that is adequate to replace the spawning class of the fishery”. Overfishing is defined as “fishing that causes a level of mortality that prevents a fishery from producing a sustainable harvest”.

4.2 RECOMMENDED MANAGEMENT PROGRAM

4.2.1 Goals and Objectives

The goal of the 2007 Kingfish Fishery Management Plan is to determine the status of the stock and ensure the long-term sustainability for the kingfishes stock in North Carolina.

Objectives:

1. Develop an objective management program that provides conservation of the resource and sustainable harvest in the fishery.

2. Ensure that the spawning stock is of sufficient capacity to prevent recruitment overfishing.

3. Address socio-economic concerns of all user groups.

4. Restore, improve, and protect critical habitats that affect growth, survival, and reproduction of the North Carolina stock of kingfishes.

5. Evaluate, enhance, and initiate studies to increase our understanding of kingfishes' biology and population dynamics in North Carolina.

6. Promote public awareness regarding the status and management of the North Carolina kingfishes stock.

4.2.2 Sustainable Harvest

Sustainable harvest in the North Carolina fishery for kingfishes is defined as the amount of harvest that can be taken without reducing the kingfishes spawning stock below a level necessary to ensure adequate reproduction. The reference point for sustainable harvest (overfishing/overfished) cannot be determined due to deficiencies in the data required for a stock assessment. Sustainable harvest will be based on trends in the southern kingfish population since this kingfish has the most biological data available and has accounted for the largest portion of the harvest of kingfishes.

4.2.3 Management Strategy

The proposed management strategy for kingfishes in North Carolina is to 1) maintain a sustainable harvest of kingfishes over the long-term and 2) promote public education. The first strategy will be accomplished by developing management triggers based on the biology of kingfishes, landings of kingfishes, independent surveys, and requesting a stock assessment of kingfishes be conducted by Atlantic States Marine Fisheries Commission (ASMFC). The second strategy will be accomplished by the NCDMF working to enhance public information and education.

4.3 DEFINITION OF MANAGEMENT UNIT AND UNIT STOCK

The management unit for the North Carolina FMP includes the three species of kingfishes (southern, Gulf, and northern), their habitat, and the fisheries that harvest these species in all coastal waters of North Carolina. To the extent practicable, an individual stock of fish should be managed as a unit throughout its range, and interrelated stocks of fish should be managed as a unit or in close coordination (National Standard 3 of the Magnuson-Stevens Act). The correct identification of the unit stock is important for proper management. If subunits of the population that spawn separately, have distinct growth and mortality characteristics, are fished by a different set of fishermen, and are grouped into a single unit, the combined stock may appear to be in reasonable shape even though some component is being over fished. On the other hand if the defined unit fails to include all the stock, the estimates of fishing mortality and population size will be distorted. In the absence of supporting data and for management needs, the precautionary approach is to define the unit stock in the broadest terms (Berkes et al. 2001). The unit stock of kingfishes is herein defined as their geographical range along the Atlantic coast (New York to Florida).

4.4 GENERAL PROBLEM(S) STATEMENT

4.4.1 Environmental Issues

Healthy and productive habitats are crucial to the sustainable harvest of kingfishes and the coastal ecosystem of North Carolina. The kingfishes rely on variety habitats defined in the CHPP including: water column, submerged aquatic vegetation, wetlands, shell bottom, soft bottom, and hard bottom (Street et al. 2005) as well as a balanced ecosystem. These habitats provide kingfishes and other fauna with refuge and/or an energy source. Habitat and water quality protection, conservation, and restoration are essential to the long-term sustainability of kingfishes and the ecosystem of the coastal waters of North Carolina.

4.4.2 Management Measures for Kingfishes

Determining sustainable harvest levels requires a stock assessment be conducted; however, the stock assessment for kingfishes did not pass peer review. A major concern of the assessment was it only addressed a portion of the southern kingfish stock. A lack of comprehensive length and age data also hindered the stock assessment. A stock assessment should be conducted with the broadest definition of a stock to ensure all sources of mortality are incorporated into the model (Berkes et al. 2001). Three management measures were recommended to maintain a sustainable harvest. The first measure, management triggers, was recommended by the Kingfish Advisory Committee (AC), Plan Development Team (PDT), and Marine Fisheries Commission (NCMFC) to manage kingfishes on a sustainable level. The triggers are based on biological, landings, and independent survey data. Consideration for a management action will occur if one of the triggers below is met:

Biological Monitoring
  Mean fish length by fishery compared to last five years
  Proportion of age one kingfishes greater than 50% of fish 11.0 to 11.8" TL
Catch Per Unit Effort (CPUE)
  Commercial < 2/3 of the mean harvest from 1999 to 2004
  Recreational < 2/3 of the mean harvest from 1999 to 2004
Surveys Juvenile and Adult
  Pamlico Sound fall 2/3 below mean CPUE
  Southeast Area Monitoring and Assessment Program (SEAMAP) fall 2/3 below mean CPUE

The triggers listed above should provided the NCDMF with information to determine if the population is experiencing a precipitous decline that needs rapid implementation of a management action. The actions would be enacted using proclamation authority granted to the director.

The second management measure, recommend the ASMFC or SAFMC manage kingfishes, was only recommended by the PDT. This option was selected by the NCDMF to address concerns in the stock assessment. Kingfishes likely migrate along the Atlantic Coast; and therefore, should be managed by a group with interjurisdictional authority until migration and mixing rates are determined. Neither the AC nor the NCMFC supported this measure.

The third management measure supported by the AC, PDT, and NCMFC recommended the technical amendment to the rule 15A NCAC 3J .0202. (5). The rule was inadvertently changed from "lawful" to "unlawful to possess 300 lb of kingfish (*Menticirrhus* sp.) taken south of Bogue Inlet regardless of the amount of shrimp, crabs, or fish taken" in the 2004 rule book supplement. The rule was reworded to capture the intent of the original rule (see Appendix 6).

A forth management measure was proposed by the AC for a 30 day comment period prior to release of a proclamation by the NCDMF director. The intent of the measure was to allow the public and AC members have a chance to comment on the proposed regulations. After hearing comments from regional AC, public, and PDT, the kingfish AC rescinded their recommendation. This recommendation was not supported by the AC, NCMFC, or PDT.

4.5 EXISTING PLANS STATUTES, AND RULES

4.5.1 Plans

There are no existing state or federal fishery management plans along the US Atlantic coast for kingfishes.

4.5.2 Statutes

There are few General Statutes (G.S.) that govern specific aspects of finfish management in North Carolina. Instead, the North Carolina General Assembly has given the NCMFC broad authority to promulgate rules that may be used for species specific management. General statutes that may apply to the kingfish fisheries include:

- It is unlawful to fish in the ocean from vessels or with a net within 750 feet of a properly licensed and marked fishing pier. G.S. 113-185

- It is unlawful to engage in trash or scrap fishing (the taking of young of edible fish before they are of sufficient size to be of value as individual food fish) for commercial disposition as bait, for sale to any dehydrating or nonfood processing plant, or for sale or commercial disposition in any manner. The NCMFC's rules may authorize the disposition of the young of edible fish taken in connection with the legitimate commercial fishing operations, provided it is a limited quantity and does not encourage "scrap fishing". G.S. 113-185
- It is unlawful for any person without the authority of the owner of the equipment to take fish from nets, traps, pots, and other devices to catch fish, which have been lawfully placed in the open waters of the state. G.S. 113-268 (a)
- It is unlawful for any vessel in the navigable waters of the state to willfully, wantonly, and unnecessarily do injury to any seine, net or pot. G.S. 113-268 (b)
- It is unlawful for any person to willfully destroy or injure any buoys, markers, stakes, nets, pots, or other devices or property lawfully set out in the open waters of the state in connection with any fishing or fishery. G.S. 113-268 (c)

The NCMFC may also approve rules that give the Fisheries Director the ability to issue proclamations establishing temporary provisions for finfish management due to the existence of variable conditions. These authorities are discussed in Section 4.1. Similarly, the statutory licensing and reporting requirements for fishing activities apply equally to all types of finfish harvest and there is no statute that would affect kingfish directly.

4.5.3 Marine Fisheries Commission Rules

The following rules adopted by the NCMFC affect management of kingfishes in North Carolina. The version of the rules shown below is taken from North Carolina Fisheries Rules for Coastal Waters effective January 1, 2005. These rules are codified in Title 15A Chapter 3 of the North Carolina Administrative Code (15A NCAC 03).

SUBCHAPTER 03J – NETS, POTS, DREDGES, AND OTHER FISHING DEVICES

SECTION .0100 – NET RULES, GENERAL

.0101 FIXED OR STATIONARY NETS
It is unlawful to use or set fixed or stationary nets:
(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, bay, 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.

History Note: Authority G.S. 113-134; 113-182; 143B-289.52;
Eff. January 1, 1991.

.0103 GILL NETS, SEINES, IDENTIFICATION, RESTRICTIONS
(a) It is unlawful to use a gill net with a mesh length less than 2½ inches.
(b) The Fisheries Director may, by proclamation, limit or prohibit the use of gill nets or seines in coastal waters, or any portion thereof, or impose any or all of the following restrictions on the use of gill nets or seines:
    (1) Specify area.

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

(c) It is unlawful to use fixed or stationary gill nets in the Atlantic Ocean, drift gill nets in the Atlantic Ocean for recreational purposes, or any gill nets in internal waters unless nets are marked by attaching to them at each end two separate yellow buoys which shall be of solid foam or other solid buoyant material no less than five inches in diameter and no less than five inches in length. Gill nets, which are not connected together at the top line, shall be considered as individual nets, requiring two buoys at each end of each individual net. Gill nets connected together at the top line shall be considered as a continuous net requiring two buoys at each end of the continuous net. Any other marking buoys on gill nets used for recreational purposes shall be yellow except one additional buoy, any shade of hot pink in color, constructed as specified in 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 last name and initials and if a vessel is used, one of the following:
(1) Owner's N.C. motor boat registration number, or
(2) Owner's US 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 to 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 03J .0101(2) and Paragraph (e) of this Rule.

(g) It is unlawful to use unattended gill nets with a mesh length less than five inches in a commercial fishing operation in the following areas:
(1) Pamlico River, west of a line beginning at a point on Mauls Point at 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° 35.1594' 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 the 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 highrise bridge;
(6) Trent River and its tributaries;
(7) Within 200 yards of any shoreline in Neuse River and its tributaries east of a line from the Highway 17 highrise bridge and west of a line beginning at a point on Wilkinson Point at 34° 57.9116' 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 03R .0103, all permanent secondary nursery areas described in 15A NCAC 03R .0104, and no trawl areas described in 15A NCAC 03R .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; 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'; 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° 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 the point of beginning;
(4) Within 200 yards of any shoreline, except from October 1 through October 31,

south and east of Highway 12 in Carteret County and south of a line from a point on Core Banks at 34° 58.7853' N - 76° 09.8922' W; to Camp Point at 35° 59.7942' N - 76° 14.6514' W to the South Carolina state line.

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

SECTION .0200 – NET RULES, SPECIFIC AREAS

15A NCAC 3J .0202 ATLANTIC OCEAN

In the Atlantic Ocean:

(1) It is unlawful to use nets from June 15 through August 15 in the waters of Masonboro Inlet or in the ocean within 300 yards of the beach between Masonboro Inlet and a line running southeasterly through the water tank 34° 13.1500'N - 77° 47.300' W on the northern end of Wrightsville Beach, a distance of 4400 yards parallel with the beach.

(2) It is unlawful to use trawls within one-half mile of the beach between the Virginia line and Oregon Inlet.

(3) It is unlawful to use a trawl with a mesh length less than four inches in the main body, three inches in the extension, and one and three-fourths inches in the cod end or tail bag inshore of a line beginning on the western side of Beaufort Inlet Channel at a point 34° 41.3000' N - 76° 40.1333' W; running westerly parallel to and one-half miles from the shore off Salter Path to a point 34° 40.5333' N - 76° 53.7500' W.

(4) It is unlawful to use trawl nets, including flynets, southwest of the 9960-Y chain 40250 LORAN C line (running offshore in a southeasterly direction) from Cape Hatteras to the North Carolina/South Carolina line except:
   (a) Shrimp trawls as defined in 15A NCAC 03L .0103;
   (b) Crab trawls as defined in 15A NCAC 03L .0202; or
   (c) Flounder trawls as defined in 15A NCAC 03M .0503.

(5) Finfish taken with shrimp or crab trawls:
   (a) It is unlawful to possess finfish (including pursuant to 15A NCAC 03M .0102) incidental to shrimp or crab trawl operations from December 1 through March 31 unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish except as provided in Sub-Item (5)(b) of this Rule;
   (b) It is unlawful to possess more than 300 pounds (lb) of kingfishes (*Menticirrhus*, sp.) taken south of Bogue Inlet regardless of the amount of shrimp, crabs or finfish taken.

(6) It is unlawful to use unattended gill nets or block or stop nets in the Atlantic Ocean within 300 yards of the beach from Beaufort Inlet to the South Carolina line from sunset Friday to sunrise Monday from Memorial Day through Labor Day.

(7) It is unlawful to use gill nets in the Atlantic Ocean with a mesh length greater than seven inches from April 15 through December 15.

(8) It is unlawful to use shrimp trawls in all waters west of a line beginning at the southeastern tip of Baldhead Island at a point 33° 50.4833' N - 77° 57.4667' W; running southerly in the Atlantic Ocean to a point 33° 46.2667' N - 77° 56.4000' W; from 9:00

P.M. through 5:00 A.M.

(9) It is unlawful to use gill nets from September 1 through November 15 in the Atlantic Ocean off the eastern end of Bogue Banks from a point at the western end of Fort Macon State Park, offshore 350 yards to a point at 34° 41.4269'N - 76° 44.7856'W, then running west to a point 350 yards offshore of the Raleigh Street stop net area at 34° 41.6824'N -76° 44.5351'W, then to shore at the Raleigh Street site at 34° 41.8666'N - 76° 44.5333' W., unless such nets are used in accordance with the following conditions:
  - (a) Only gill nets with a maximum length not exceeding 160 yards may be used;
  - (b) No stationary gill nets shall be used in a zone 200 yards wide beginning at a point 150 yards from the beach at mean low water and extending offshore in a southerly direction;
  - (c) No gill nets may be set within 750 feet of an ocean fishing pier; and
  - (d) No gill nets may be set within 450 yards east of a deployed stop net, as measured from where both nets connect with the shore.

SECTION .0400 – FISHING GEAR

.0402 FISHING GEAR RESTRICTIONS

(a) It is unlawful to use commercial fishing gear in the following areas during dates and times specified for the identified areas:
- (1) Atlantic Ocean - Dare County:
  - (A) Nags Head:
    - (i) Seines and gill nets may not be used from the North Town Limit of Nags Head at Eight Street southward to Gulf Street:
      - (I) From Wednesday through Saturday of the week of the Nags Head Surf Fishing Tournament held during October of each year the week prior to Columbus Day.
      - (II) From November 1 through December 15.
    - (ii) Commercial fishing gear may not be used within 750 feet of licensed fishing piers when open to the public.
  - (B) Oregon Inlet. Seines and gill nets may not be used from the Friday before Easter through December 31:
    - (i) Within one-quarter mile of the beach from the National Park Service Ramp #4 (35° 48' 15" N - 75° 32' 42" W) on Bodie Island to the northern terminus of the Bonner Bridge (35° 46' 30" N - 75° 32' 22" W) on Hwy. 12 over Oregon Inlet.
    - (ii) Within the area known locally as "The Pond", a body of water generally located to the northeast of the northern terminus of the Bonner Bridge.
  - (C) Cape Hatteras (Cape Point). Seines and gill nets may not be used within one-half mile of Cape Point from the Friday before Easter through December 31. The closed area is defined by a circle with a one-half mile radius having the center at Cape Point (35° 12' 54" N - 75° 31' 43" W). The closed area begins one-half mile north of Cape Point at a point on the beach (35° 13' 26" N - 75° 31' 39" W) and extends in a clockwise direction, one-half mile from Cape Point, to a point on the beach (35° 13' 23" N - 75° 31' 59" W) northwest of Cape Point.
- (2) Atlantic Ocean - Onslow and Pender Counties. Commercial fishing gear may not be used during the time specified for the following areas:
  - A) Topsail Beach. From January 1 through December 31, that area around Jolly Roger Fishing Pier bordered on the offshore side by a line 750 feet

from the end of the pier and on the northeast and southwest by a line beginning at a point on the beach one-quarter mile from the pier extending seaward to intersect the offshore boundary.

(B) Surf City:

(i) From January 1 to June 30, those areas around the Surf City and Barnacle Bill's Fishing Piers bordered on the offshore side by a line 750 feet from the ends of the piers, on the southwest by a line beginning at a point on the beach one-quarter mile from the piers and on the northeast by a line beginning at a point on the beach 750 feet from the piers extending seaward to intersect the offshore boundaries.

(ii) From July 1 to December 31, those areas around the piers bordered on the offshore side by a line 750 feet from the ends of the piers, on the southwest by a line beginning at a point on the beach 750 feet from the piers and on the northeast by a line beginning at a point on the beach one-quarter mile from the piers extending seaward to intersect the offshore boundaries.

(3) Atlantic Ocean - New Hanover County. Carolina Beach Inlet through Kure Beach. Commercial fishing gear may not be used during the times specified for the following areas:

(A) From the Friday before Easter to November 30, within the zones adjacent to the Carolina Beach, Center and Kure Beach Fishing Piers bordered on the offshore side by a line 750 feet from the ends of the piers and on the north and south by a line beginning at a point on the beach one-quarter mile from the pier extending seaward to intersect the offshore boundary, except the southern boundary for Kure Beach Pier is a line beginning on the beach one mile south of the pier to the offshore boundary for the pier.

(B) From May 1 to November 30, within 900 feet of the beach, from Carolina Beach Inlet to the southern end of Kure Beach with the following exceptions:

(i) From one-quarter mile north of Carolina Beach Fishing pier to Carolina Beach Inlet from October 1 to November 30:

(I) Strike nets may be used within 900 feet of the beach;

(II) Attended nets may be used between 900 feet and one-quarter mile of the beach.

(ii) Strike nets and attended gill nets may be used within 900 feet of the beach from October 1 to November 30 in other areas except those described in Part (a)(3)(A) and Subpart (a)(3)(B)(i) of this Rule.

(iii) It is unlawful to use commercial fishing gear within 900 feet of the beach from Carolina Beach Inlet to New Inlet from October 15 through October 17.

(b) It is unlawful to use gill nets or seines in the following areas during dates and times specified for the identified areas:

(1) Neuse River and South River, Carteret County. No more than 1,200 feet of gill net(s) having a stretched mesh of five inches or larger may be used:

(A) Within one-half mile of the shore from Winthrop Point at Adams Creek to Channel Marker "2" at the mouth of Turnagain Bay.

(B) Within South River.

(2) Cape Lookout, Carteret County:

(A) Gill nets or seines may not be used in the Atlantic Ocean within 300 feet of the Rock Jetty (at Cape Lookout between Power Squadron Spit and Cape Point).

(B) Seines may not be used within one-half mile of the shore from Power Squadron Spit south to Cape Point and northward to Cape Lookout Lighthouse including the area inside the "hook" south of a line from the COLREGS Demarcation Line across Bardens Inlet to the eastern end of Shackleford Banks and then to the northern tip of Power Squadron Spit from 12:01 a.m. Saturdays until 12:01 a.m. Mondays from May 1 through November 30.

(3) State Parks/Recreation Areas:

(A) Gill nets or seines may not be used in the Atlantic Ocean within one-quarter mile of the shore at Fort Macon State Park, Carteret County.

(B) Gill nets or seines may not be used in the Atlantic Ocean within one-quarter mile of the shore at Hammocks Beach State Park, Onslow County, from May 1 through October 1, except strike nets and attended gill nets may be used beginning August 15.

(C) Gill nets or seines may not be used within the boat basin and marked entrance channel at Carolina Beach State Park, New Hanover County.

(4) Mooring Facilities/Marinas. Gill nets or seines may not be used from May 1 through November 30 within:

(A) One-quarter mile of the shore from the east boundary fence to the west boundary fence at US Coast Guard Base Fort Macon at Beaufort Inlet, Carteret County;

(B) Canals within Pine Knoll Shores, Carteret County;

(C) Spooners Creek entrance channel and marina on Bogue Sound, Carteret County; and

(D) Harbor Village Marina on Topsail Sound, Pender County.

(5) Masonboro Inlet. Gill nets and seines may not be used:

(A) Within 300 feet of either rock jetty; and

(B) Within the area beginning 300 feet from the offshore end of the jetties to the Intracoastal Waterway including all the waters of the inlet proper and all the waters of Shinn Creek.

(6) Atlantic Ocean Fishing Piers. At a minimum, gill nets and seines may not be used within 300 feet of ocean fishing piers when open to the public. If a larger closed area has been delineated by the placement of buoys or beach markers as authorized by G.S. 113-185(a), it is unlawful to fish from vessels or with nets within the larger marked zone.

(7) Topsail Beach, Pender County. It is unlawful to use gill nets and seines from 4:00 p.m. Friday until 6:00 a.m. the following Monday in the three finger canals on the south end of Topsail Beach.

(8) Mad Inlet to Tubbs Inlet – Atlantic Ocean, Brunswick County. It is unlawful to use gill nets and seines from September 1 through November 15, except that a maximum of four commercial gill nets per vessel not to exceed 200 yards in length individually or 800 yards in combination may be used.

History Note: Authority G.S. 113-133; 113-134; 113-182; 113-221; 143B-289.52;
Eff. March 1, 1996.

SUBCHAPTER 03M – FINFISH

SECTION .0100 – FINFISH, GENERAL

.0102 UNMARKETABLE FOOD OR SCRAP FISH

(a) It is unlawful to land or dispose of finfish as trash or scrap fish if in violation of minimum size or possession limits established by rule or proclamation.

(b) It is unlawful to land or dispose of finfish as trash or scrap fish taken in connection with legitimate commercial fishing operations which are unmarketable as individual food fish by reason of size, except that a quantity not exceeding 5,000 pounds per vessel per day may be:

   (1) Landed and sold to a licensed finfish dealer, a licensed fish dehydrating plant or licensed finfish processing plant, and

   (2) Purchased or accepted by a licensed finfish dealer, a licensed finfish dealer, a licensed fish dehydrating plant or licensed finfish processor.

(c) Menhaden, herring, and gizzard shad are exempt from this Rule.

History Note: Authority G.S. 113-134; 113-185; 143B-289.52;
Eff. January 1, 1991.

.0103 MINIMUM SIZE LIMITS

It shall be unlawful to possess, sell, or purchase fish under four inches in length except:

   (1) for use as bait in the crab pot fishery in North Carolina with the following provision: such crab pot bait shall not be transported west of US Interstate 95 and when transported, shall be accompanied by documentation showing the name and address of the shipper, the name and address of the consignee, and the total weight of the shipment.

   (2) for use as bait in the finfish fishery with the following provisions:

      (a) It shall be unlawful to possess more than 200 pounds of live fish or 100 pounds of dead fish.

      (b) Such finfish bait may not be transported outside the state of North Carolina.

Bait dealers who possess valid finfish dealers license from the Division of Marine Fisheries are exempt from Subitems (2)(a) and (b) of this Rule. Tolerance of not more than five percent shall be allowed. Menhaden, herring, gizzard shad, pinfish and live fish in aquaria other than those for which a minimum size exists are exempt from this Rule.

History Note: Authority G.S. 113-134; 113-185; 143B-289.52; Eff. July 1, 1993.

4.5.4 Other States Kingfish Rules and Regulations

Georgia has a 10” size limit for kingfishes, which was enacted in 1998. South Carolina is proposing a 10” size limit for kingfishes.

4.5.5 Federal Regulations

Pursuant to Title 33 US Code Section 3, the US Army Corps of Engineers has adopted regulations which restrict access to and activities within certain areas of coastal and inland fishing waters. Federal Rules codified at 33 CFR 334.410 through 334.450 designate prohibited and restricted military areas, including locations within North Carolina coastal fishing waters, and specify activities allowed in these areas.

Gill nets are prohibited in federal waters from the North Carolina/South Carolina border to New Smyrna Beach, Florida in response to an entanglement and mortality of a northern right whale (*Eubalaena glacialis*). A closure was enacted first on 15 February, 2006 through 31

March, 2006 and listed in the Federal Registry (US Office of the Federal Register 2006a). A permanent closure in these waters is expected (US Office of the Federal Register 2006b). Currently, the waters are closed from 15 November, 2006 through 15 April, 2007 using the Federal Registry Notice (US Office of the Federal Register 2006c). Maps of the closure area are available in the Federal Registry (2006b) or http://sero.nmfs.noaa.gov/pr/EmergencyRuleGillnetClosure.htm

5. STATUS OF STOCK

5.1 LIFE HISTORY

5.1.1 Background

Three species of kingfishes occur in North Carolina: southern (*Menticirrhus americanus*), Gulf (*M. littoralis*), and northern kingfishes (*M. saxatilis*). Kingfish refers to a single species while kingfishes refers to multiple species. Kingfishes are demersal members of the drum family (Sciaenidae). Southern kingfish is the most abundant kingfish in the South Atlantic Bight (SAB) and Gulf of Mexico (Irwin 1971; Dahlberg 1972; Crowe 1984; Smith and Wenner 1985; Harding and Chittenden 1987) with a range extending from Cape May, NJ southward to Buenos Aires, Argentina (Fischer 1978). Northern kingfish is the most abundant kingfish in the Mid-Atlantic Bight (Hildebrand and Schroeder 1928; Schaefer 1965; Ralph 1982) with a range extending from the Gulf of Maine into the Gulf of Mexico (Fischer 1978). Gulf kingfish is the most abundant kingfish in the surf zone south of Cape Hatteras, NC, and has a range extending from Virginia (Welsh and Breder 1923; Irwin 1971) to Rio Grande, Brazil (Fischer 1978). Past reports had listed a fourth species, *M. focaliger*, but the species was determined to be southern kingfish (Irwin 1971). The kingfishes have several regional names including sea mullet, king whiting, king croaker, sea mink, roundhead, hard head, whiting, hake, Carolina whiting, and Virginia mullet (Welsh and Breder 1924).

Kingfishes are an elongate fusiform fish with a single chin barbel and an S-shaped caudal fin. The three Atlantic species are morphologically and meristically similar causing difficulty in species identification. A rough key is outlined in the Adult Section below and a more detailed key is given in Carpenter (2002).

Since all three species are harvested in North Carolina, the FMP will include discussions on the three species (if data are available). However, the focus of the management plan will be on southern kingfish due to its greater abundance relative to the other two kingfish species and a larger amount of published research. Gulf and northern kingfishes will be included as an initial effort to describe information on life history, biology, and fishery importance in North Carolina's waters.

Length will be reported as total length (TL) in millimeters (mm) unless otherwise noted. Millimeters can be converted to inches by dividing mm by 25.4.

5.1.1.1 Development

Only general descriptions will be used in the next sections since past studies may have confused the three species (Fahay 1983; Ditty et al. 2006).

5.1.1.2 Eggs

The eggs are pelagic and buoyant with many oil globules (1-18) and a diameter of 0.7 - 0.9 mm. Incubation lasts 46-50 hours at 20 to 21° C (Welsh and Breder 1923).

5.1.1.3 Larvae

The larvae are 2.0 - 2.5 mm TL at hatching. Early larvae have 3 vertical bands of chromatophores on the tail posterior to the vent, and melanophores in the anterior-dorsal finfold. At 3.7 mm the head is large and deep and melanophores form along the ventral surface of the abdomen in rows. Pigmentation on upper lip and patch on the roof of mouth is visible externally. At 5 mm, almost all soft dorsal and anal fin rays are developed (Lippson and Moran 1973). At 8-10 mm, all fins are present and the upper jaw projects beyond the lower jaw [Figure 5.1 (Lippson and Moran 1973; Able and Fahay 1998)]. Body and fins are covered partially or wholly with melanophores (Able and Fahay 1998). Pigmentation patterns occur at different sizes in juveniles collected from the Gulf of Mexico and juveniles from the Atlantic Coast (Ditty et al. 2006). The caudal fin is asymmetrically elongate (Welsh and Breder 1923).

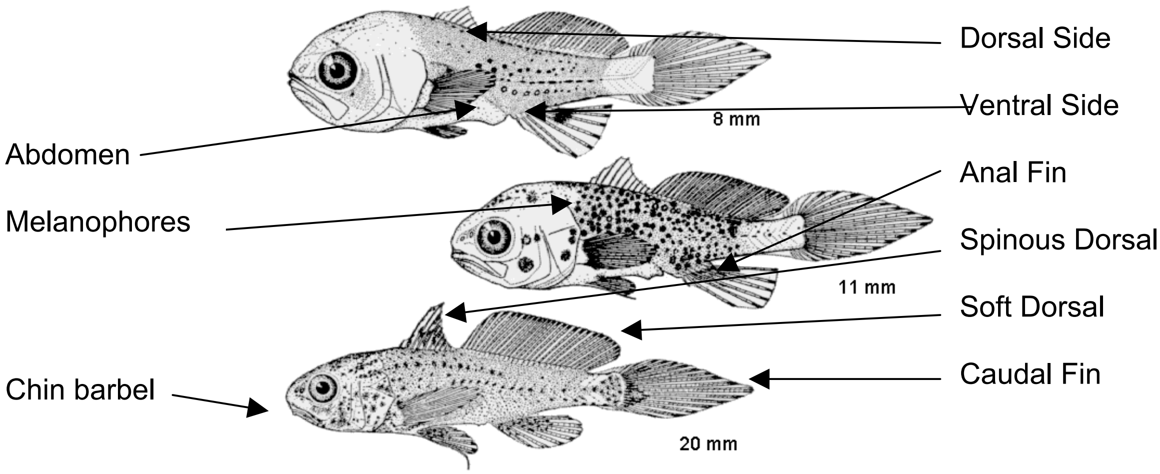

Figure 5.1. Larval and juvenile southern kingfish with a key to morphological characters. Modified from Johnson, G.D. 1978.

5.1.1.4 Juvenile

At 18-20 mm, a small knob begins to form the single chin barbel (Figure 5.1). The tail becomes more pointed asymmetrically (Lippson and Moran 1973). The spinous dorsal fin is distinct from the soft dorsal fin. The soft dorsal fin is about twice the length of the anal fin and body pigmentation is dusky to dark (Able and Fahay 1998). Juveniles begin to display adult characteristics by 100 mm.

5.1.1.5 Adults

Adult kingfishes are an elongate fusiform fish with a single chin barbel and a S-shaped caudal fin. The spinous dorsal fin contains 10-11 rays and the soft dorsal fin contains 19-27 rays. The anal fin has 1 spine with 6-9 soft rays (Carpenter 2002).

Southern kingfish color are variable and ranges from silvery to a blotchy gray with 7-8 faint oblique bars. The inner side of the gill cover is often black (Carpenter 2002).

Gulf kingfish are silvery in color with black etching on the upper lobe of the caudal fin and has reduced scales on the pelvic (breast) plate. The inner side of the gill cover is dusky (Carpenter 2002).

Northern kingfish have a large dorsal spine that extends approximately half way down the second (soft) dorsal fin, 5-6 oblique bars on both sides, and a longitudinal stripe beginning behind the pectoral fin that continues into the caudal fin. The second and third bars on the side form a V-shape under the spinous dorsal fin. The inner side of the gill cover is dusky (Carpenter 2002).

5.1.2 Physio-Chemical Preferences and Tolerances

5.1.2.1 Temperature

Kingfishes are temperate fishes generally found in waters warmer than 10° C. Southern kingfish have been collected in waters with temperatures ranging from 8.0° C (Bearden 1963) to 37.3° C (Irwin 1971). Larval and postlarval southern kingfish were found in warmer temperature waters (12.0 - 37.3° C) than adults (Crowe 1984). Since kingfish spawn during the early spring to early fall, it would be unlikely to find larval and postlarval kingfish in cold water (<10° C). As temperatures cool southern kingfish move to deeper, warmer water or migrate south (Bearden 1963). Southern kingfish were not collected in water with temperatures less than 8.0° C (Bearden 1963).

Northern kingfish occur in water temperatures of 7.8 to 35.8° C (Irwin 1971). Northern kingfish first appear in the surf zone between 7.8 and 10° C and begin to migrate from the shore when the water temperature drops below 15.6° C (Schaefer 1963). The greatest concentration of northern kingfish occurs in temperatures between 24 and 26° C (Ralph 1982).

Gulf kingfish were collected in water temperature ranging from 10.8 to 31.0° C (Irwin 1971). Few studies have reported temperature tolerances of Gulf kingfish.

5.1.2.2 Salinity

Kingfishes are euryhaline and inhabit waters that range from nearly fresh (2.0 part per thousand (ppt)) to hypersaline (36.6 ppt) depending on the species (Bearden 1963; Irwin 1971; Crowe 1984). Southern kingfish have been observed in ocean and estuarine waters with salinities as low as 2.0 ppt. Mean length increases with salinity indicating inshore waters act as a nursery area for juveniles and sub-adult southern kingfish (Crowe 1984). Most southern kingfish are found in salinities greater than 20 ppt (Bearden 1963; Irwin 1971).

In North Carolina, Gulf and northern kingfishes are more common in the surf zone than southern kingfish (Ross and Lancaster 2002). Northern kingfish have been collected in waters with salinities as low as 8 ppt but are most common in waters with salinities greater than 16 ppt (Irwin 1971). Smaller northern kingfish are associated with lower salinity waters while adults are in higher salinity waters indicating the importance of estuaries as nursery habitats (Ralph 1982). Gulf kingfish are almost exclusively oceanic but have been found in waters with salinities as low as 17.9 ppt (Irwin 1971).

5.1.3 Food/ Feeding

The kingfishes are opportunistic benthic feeders that use a single chin barbel to detect epibentic prey or benthic prey (Viosca 1959; Irwin 1971; Chao and Musick 1977). Southern kingfish consume polychaetes, crabs, mysids, pelecypod siphon tips, and mole crabs (Hildebrand and Cable 1934; Viosca 1959; Irwin 1971; McMichael and Ross 1987). Northern kingfish switch from feeding on copepods, mysids, crabs, and amphipods as juveniles to mole crabs, amphipods, mysids, hermit crabs, polychaetes, and small fishes as adults (Irwin 1971; Chao and Musick 1977; McMichael and Ross 1987). Dietary analyses of Gulf kingfish found crustaceans, polychaetes, molluscs, fishes, and pelecypod siphon tips (Viosca 1959; Irwin 1971; McMichael and Ross 1987).

Ontogenetic change in diet observed for the kingfishes has been attributed to the atrophication of the swimbladder (Bearden 1963; Irwin 1971; Delancey 1984; McMichael and Ross 1987). The swimbladder of southern and northern kingfishes begins to atrophy at approximately 3.9 inches [100 mm TL (Irwin 1971; Ross et al. 1987)]. As the swimbladder atrophies, the diet shifts from epibenthic or planktonic prey to more benthic items such as pelecypod siphon tips, polychaetes, and mole crabs (Bearden 1963; Irwin 1971; Delancey 1984; McMichael and Ross 1987).

Tidal stage and day/night feeding may have an influence on the diets of kingfishes. Delancey (1984) observed tidal variation in the diet of Gulf kingfish. Ross et al. (1987) found a significant difference between day and night diets but did not observe a difference in the tidal stage. More detailed studies need to be conducted to understand the feeding habits of kingfishes.

5.1.4 Biology

5.1.4.1 Age and Growth

Juvenile growth rates were estimated using length frequency and direct estimation by tagging. Kingfishes have rapid growth as juveniles. Growth has been documented as much as 2 mm/day (Miller et al. 2002). After the first winter, the growth rate decreases (Schaefer 1965, Smith and Wenner 1985).

Adult growth rates have been estimated using length frequency, scale aging, and otolith aging. An age and growth study conducted by NCDMF estimated length at age using otolith-based age estimates. Growth curves were developed for males and females of each kingfish species because kingfishes exhibit a sexual dimorphic growth rate with females attaining a larger maximum size than males (Table 5.1).

The NCDMF length at age for southern kingfish is larger than those reported by Smith and Wenner (1985). The difference in size at age may be attributed to selectivity by gear since a majority of the NCDMF kingfishes collections were from gillnets. Size selectivity of gillnets will generally capture the fastest growing young fish and slow growing older fish. The asymptotic size for male southern kingfish is 12.0 inches (305 mm), slightly larger than previously reported size of 11.5 inches [292 mm (Smith and Wenner 1985)]. Female asymptotic size estimated by NCDMF [14.3 inches (362 mm)] was much lower than the 18.8 inches (477 mm) previously reported (Smith and Wenner 1985). The hook and line fishery was investigated to determine if significantly larger fish were present. There was no evidence of substantially larger fish being captured in the hook and line fishery. Therefore, the 14.3 inches (362 mm) asymptotic size was accepted as an estimation of the average maximum size for female southern kingfish.

The length at age for northern kingfish is similar to other published studies up to age 2 (Schaefer 1965; Ralph 1982). After age 2, the NCDMF study predicts a much smaller size at age and asymptotic size for both males and females. The selectivity of gillnets may have influenced the results of the length at age estimation, but the previous reports had few fish greater than 14.3 and 14.5 inches (364 and 369 mm), the predicted asymptotic sizes for male and female northern kingfish, respectively.

Results of the aging study on Gulf kingfish conducted by NCDMF indicate that Gulf kingfish growth rates are similar to northern and southern kingfishes growth rates. Females reach a larger size at age and have a larger asymptotic size than males. The asymptotic sizes for Gulf kingfish are 15.4 inches (392 mm) for males and 16.0 inches (406 mm) for females.

Table 5.1 Predicted length at age for the Atlantic Coast kingfishes captured in NC waters. Kingfishes were aged using otoliths by NCDMF (2001-2004).

	Southern		Gulf		Northern	
Age	Male	Female	Male	Female	Male	Female
1	8.2	8.9	9.2	10.2	10.4	11.0
2	9.9	11.2	10.7	12.5	12.2	13.0
3	10.9	12.6	11.9	13.9	13.2	13.9
4	11.4	13.3	12.7	14.7	13.7	14.3
5	11.7	13.7	13.4	15.2	14.0	14.4
6	11.8	13.9	13.9		14.2	

5.1.4.2 Length-Weight Relationship

A separate length-weight relationship was developed for each species and sex. The three species exhibit differing growth patterns. Among the three kingfish species, the southern kingfish has the greatest growth coefficient (3.18 and 3.21), which indicates the southern kingfish weighs more per unit length than do northern and Gulf kingfishes (Table 5.2). In each of the length-weight equations estimated by the NCDMF, the values for the y-intercept are higher than previous studies due to differing scalar values. The weights for the kingfishes in the study were in kilograms and length in millimeters. The other studies used grams to develop the length-weight relationship. Since the equation was linearized, the choice of the weight measure only shifted the y-intercept and not the slope of the line (i.e. the growth coefficient).

Table 5.2 Length-Weight relationship for the three Atlantic Coast kingfish species. The variables are log transformed to linearize the data.

Southern Kingfish

log W = -5.32 + 3.15 log TL (Smith and Wenner 1985)
log W = -5.79 + 3.33 log TL (Harding and Chittenden 1987)
log W = -4.49 + 2.93 log SL (Crowe 1984)
log W = -19.56 + 3.21 log TL (female NCDMF)
log W = -19.41 + 3.18 log TL (male NCDMF)

Northern Kingfish

log W = -5.17 + 3.07 log TL (Schaefer 1965)
log W = -5.20 + 3.11 log TL (Ralph 1982)
log W = -19.72 + 3.23 log TL (female NCDMF)
log W = -19.90 + 3.25 log TL (male NCDMF)

Gulf Kingfish

log W = -18.85 + 3.08 log TL (female NCDMF)
log W = -18.83 + 3.08 log TL (male NCDMF)

5.1.4.3 Maximum Size and Age

The International Gamefish Association records world record sizes for kingfishes caught recreationally. The current world record sizes are 18.0, 19.0, and 18.3 inches (457 mm, 483 mm, and 464 mm) for southern, Gulf, and northern kingfishes, respectively (D. Blodgett, personal communication, July 16, 2003). Harding and Chittenden (1987) reported a maximum size of 16.5 inches (419 mm) for southern kingfish in the Gulf of Mexico. The fish was aged using length frequency analysis and estimated to be 4 years old. The maximum size for southern kingfish recorded in the aging study by NCDMF was 16.1 inches (410 mm) aged at 5 years old. The maximum observed length for a southern kingfish in all NCDMF sampling was a 18.5 inch (471 mm) fish captured in a gillnet (no aging sample was collected).

The maximum observed age in NC (using otoliths) is a 12.6 inch (320 mm) male aged at 8 years old collected during an age validation experiment (Collier, personal observation). The oldest age class for males included in the NCDMF study was slightly lower at 6 years old and ranged from 11.3 to 13.1 inches [287-334 mm (n=4)]. The oldest female in the study was a 6 year old at 13.1 inches (333 mm).

The maximum age for Gulf kingfish males and females was 7 [13.1 inches (332 mm)] and 5 years old [15.0- 16.3 inches (380-413 mm, n=3)], respectively. The largest Gulf kingfish was 17.9 inches (454 mm) aged at 3 years old.

Northern kingfish were aged to 6 years old for males [12.8 inches (324 mm)] and 5 years old for females [14.3 inches (362 mm)]. The largest northern kingfish aged by NCDMF was a 17.1 inch (435 mm) female at 3 years old.

Although not plotted here, there is considerable overlap in the length at age for kingfishes as indicated by the data above on the maximum size and age of kingfishes. The largest fish for each species was aged at 3 years old and the oldest fish tended to be near the predicted average maximum size for each species.

5.1.5 Reproduction

5.1.5.1 Spawning Location

Spawning locations are unknown off North Carolina. Anecdotal evidence suggests spawning occurs on the bottom (Ralph 1982) in the nearshore ocean and possibly inshore. Ripe kingfishes and kingfish eggs have been collected in nearshore ocean and estuarine waters from early spring to September (Hildebrand and Cable 1934; Bearden 1963; Hoese 1965; Smith and Wenner 1985; Bourne and Govoni 1988).

5.1.5.2 Spawning Seasonality

Based on the appearance of juveniles in surf zone seine surveys, the spawning season of kingfishes occurs from April through October (Welsh and Breder 1924; Hildebrand and Schroeder 1928; Bearden 1963; Schaefer 1965; Smith and Wenner 1985). Southern and northern kingfishes spawn earlier than Gulf kingfish based on peak juvenile abundance in the surf zone (Irwin 1971; Modde 1981; McMichael and Ross 1987).

Spawning seasonality for southern kingfish was determined by NCDMF to be from April to September using macroscopic determination of female gonadal development as well as gonadosomatic index (GSI) (Figure 5.2). The GSI values are the percent of gonad weight/ (total weight-gonad weight). GSI is a technique to standardize gonad weight for fish of all sizes to enable quantitative investigations of spawning seasonality.

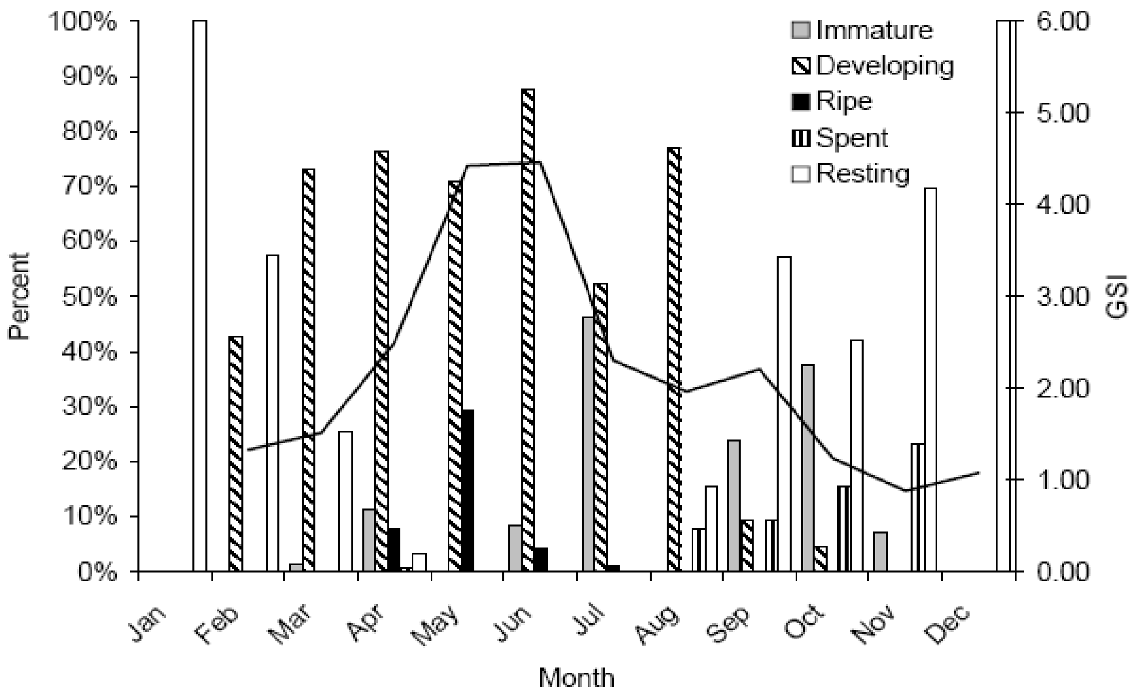

Figure 5.2 The percent of southern kingfish females in the 5 stages of reproductive development (n=686) and gonadosomatic index (GSI) by month. The stages were based on macroscopic descriptions from Smith and Wenner (1985). GSI values graphed are an average for females by month.

The spawning season for Gulf kingfish begins in May and extends through September based on length frequency data from seine studies (Bearden 1963; Modde 1980; McMichael and Ross 1987). NCDMF collected ripe fish from April to October and developing fish from March to October (Figure 5.3). The GSI values are highest in late spring and early summer and decrease monthly until November when fish were either resting or immature.

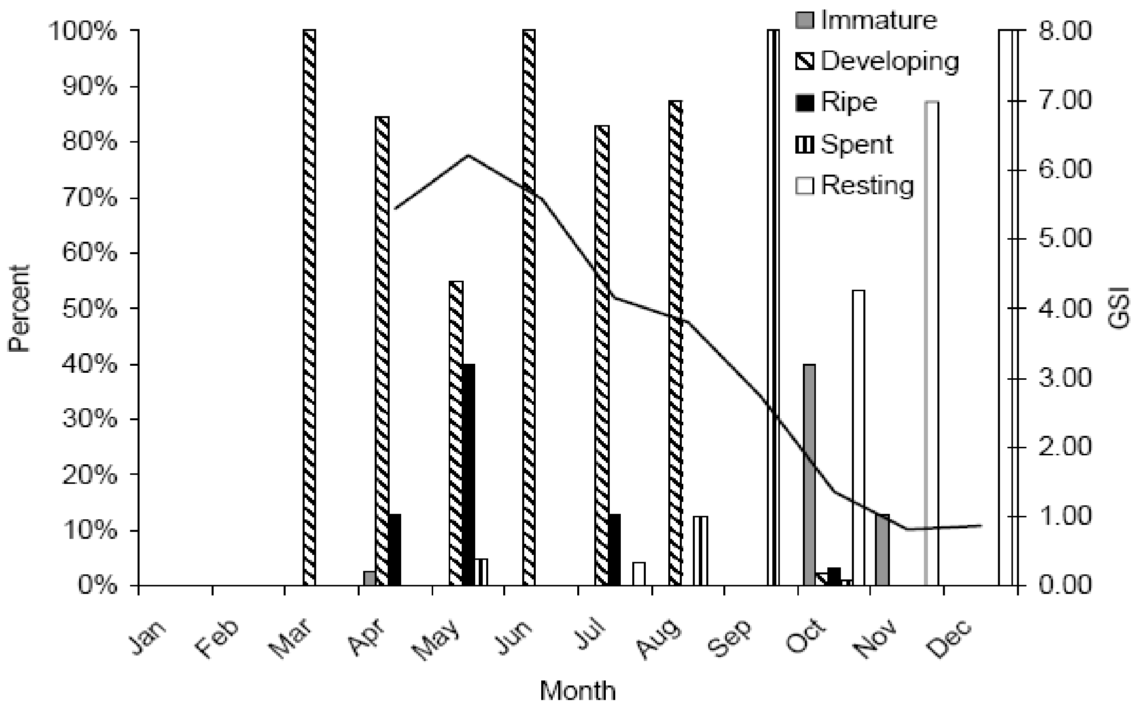

Figure 5.3. The percent of Gulf kingfish females in the 5 stages of reproductive development (n=257) and gonadosomatic index (GSI) by month. The stages were based on macroscopic descriptions from Smith and Wenner (1985) for southern kingfish. GSI values graphed are an average for females by month.

The spawning season for northern kingfish extends from late June through August (Welsh and Breder 1923; Schaefer 1965; Miller et al. 2002). NCDMF has collected northern kingfish in the ripe condition in May and September and developing fish from April to October (Figure 5.4). The GSI values indicated peak spawning occurs in the early summer and then drops dramatically in late summer (after June).

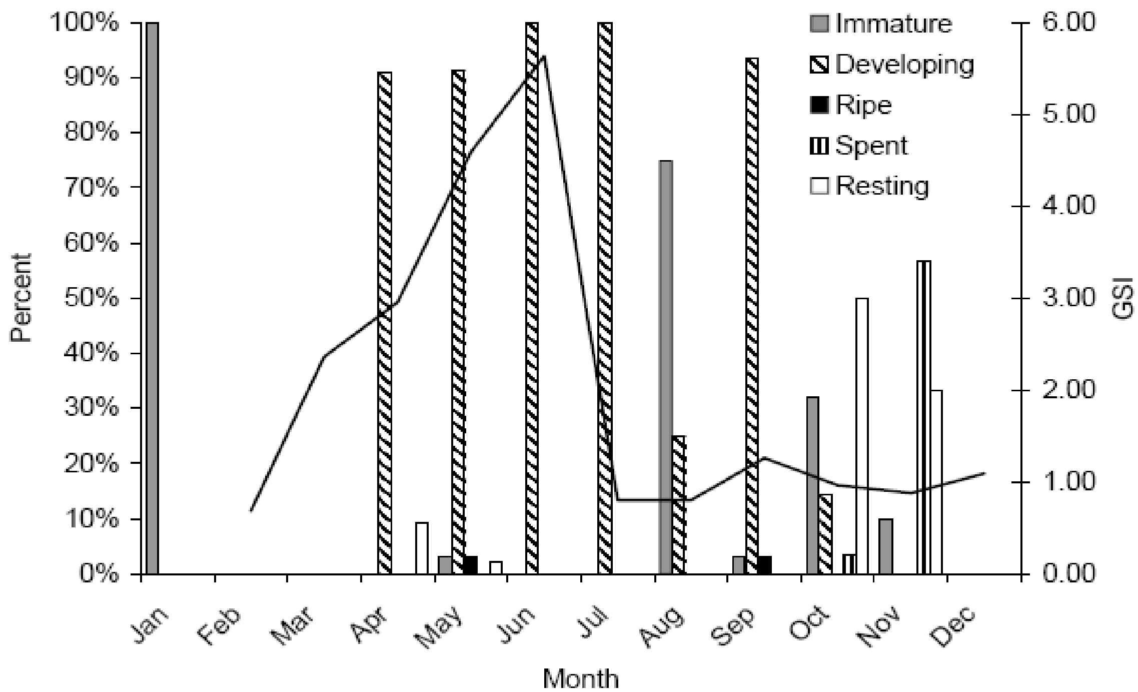

Figure 5.4. The percent of northern kingfish females in the 5 stages of reproductive development (n=256) and gonadosomatic index (GSI) by month. The stages were based on macroscopic descriptions from Smith and Wenner (1985) for southern kingfish. GSI values graphed are an average for females by month.

5.1.5.3 Maturity Schedule

Female kingfishes begin to mature at 6.7 inches (170 mm) with most kingfishes (>75%) mature by 10 inches TL (250 mm). Length at maturity varies for each kingfish species as well as sex. Southern kingfish mature sexually at a total length of approximately 5.3 inches (135 mm) for males and 7.6 inches (192 mm) for females (Smith and Wenner 1985). Southern kingfish females mature at 8.2 inches (209 mm) in North Carolina (n=686) (NCDMF unpublished data) (Figure 5.5). The length at maturity was defined as the point at which 50% of the fish are mature using logistic regression.

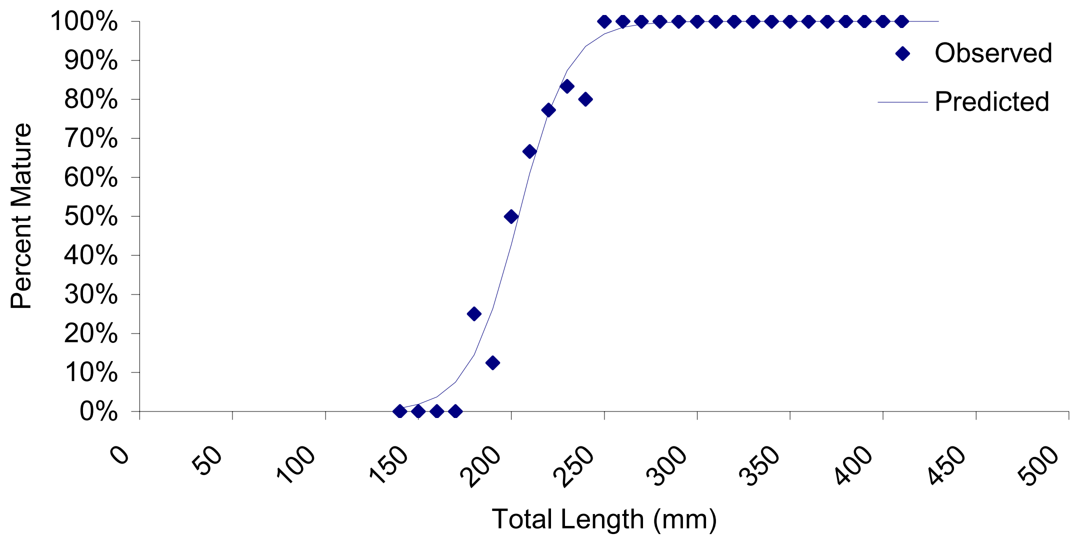

Figure 5.5 The percent of southern kingfish females mature by size as estimated by NCDMF. Total length was grouped into 10 mm size bins to increase sample sizes in each size class. The squares represent observed percent mature and the line is the predicted maturity schedule using a logistic equation.

The smallest female southern kingfish observed maturing in NC was 7.2 inches (183 mm). Males mature at a smaller size than the females. The smallest mature male southern kingfish was a 3.9 inch (99 mm) fish (SC DNR unpublished data) and smallest mature female was 7.1 inches [180 mm (Smith and Wenner 1985)].

Gulf kingfish females begin to mature at 7.4 inches (187 mm), and 50% of the fish are mature at 8.7 inches [221 mm (Figure 5.6)]. The females are fully mature by 10.6 inches [270 mm, n=257 (NCDMF unpublished data)].

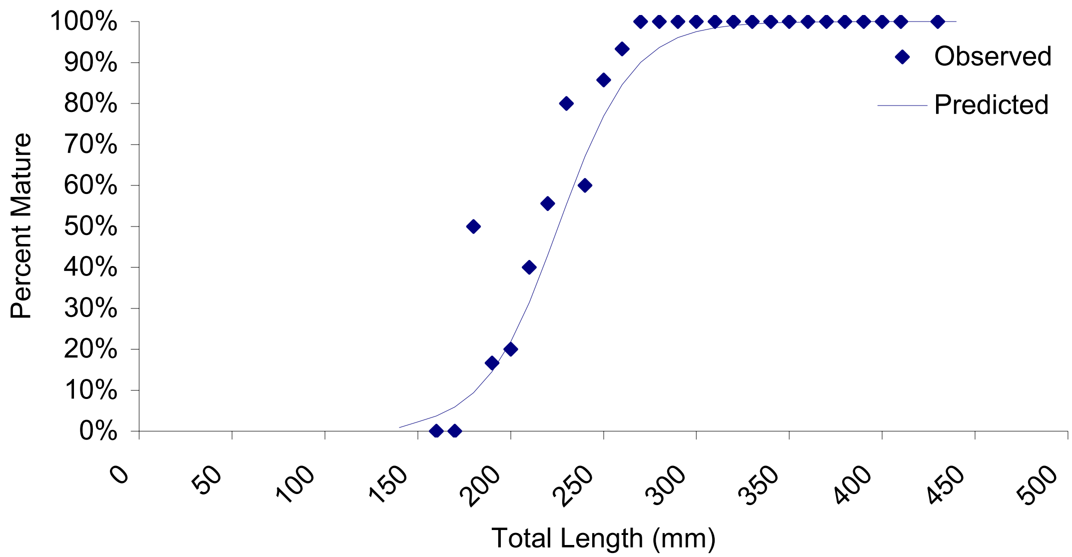

Figure 5.6 The percent of Gulf kingfish females mature by size as estimated by NCDMF. Total length was grouped into 10 mm size bins. The squares represent observed percent mature and the line is the predicted maturity schedule.

Northern kingfish females began to mature at 7.0 inches (178 mm) with 50% of the fish mature at 7.9 inches (201 mm) in NC [n=256 (Figure 5.7) (NCDMF unpublished data)]. Northern kingfish are all mature at 11.8 inches (300 mm). Past studies did not report length at maturity for northern kingfishes.

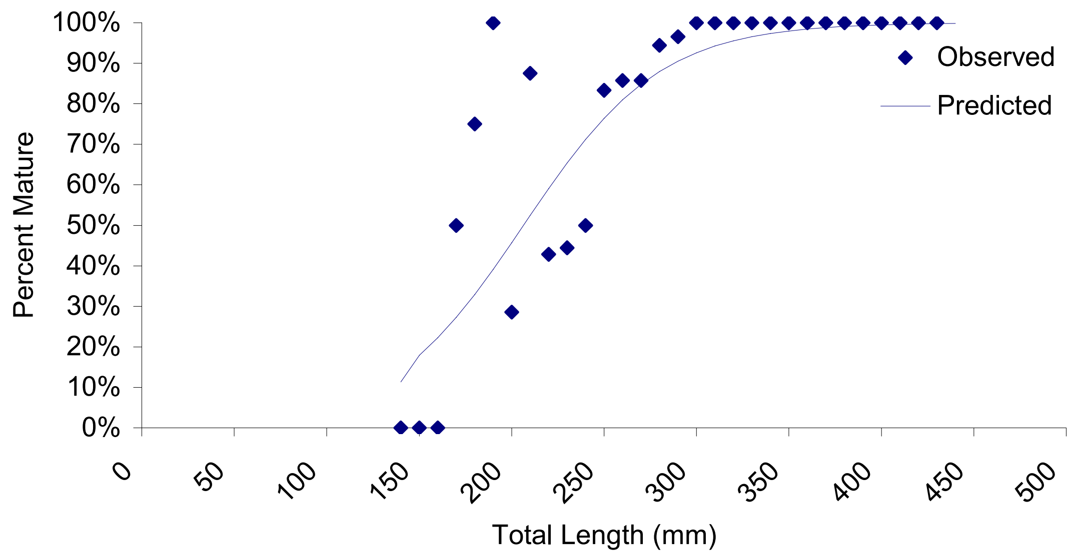

Figure 5.7 The percent of northern kingfish females mature by size as estimated by NCDMF. Total length was grouped into 10 mm size bins. The squares represent observed percent mature and the line is the predicted maturity schedule.

5.1.5.4 Age at Maturity

Kingfishes begin to mature during their second summer (Hildebrand and Cable 1934; Schaefer 1965; Smith and Wenner 1985). The age at maturity is defined differently than length at maturity since kingfishes are 50% mature between age 0 and 1 (Figure 5.8). Individuals of all three species begin to mature at age 0 and most individuals are mature by age 1 with southern kingfish females having the smallest proportion mature at 85%. All kingfishes are mature by age 3. The NCDMF assigned the birth date of kingfishes as May 1 based on the presence of annulus on the otolith and peak GSI for southern and Gulf kingfishes (Figures 5.2 and 5.3).

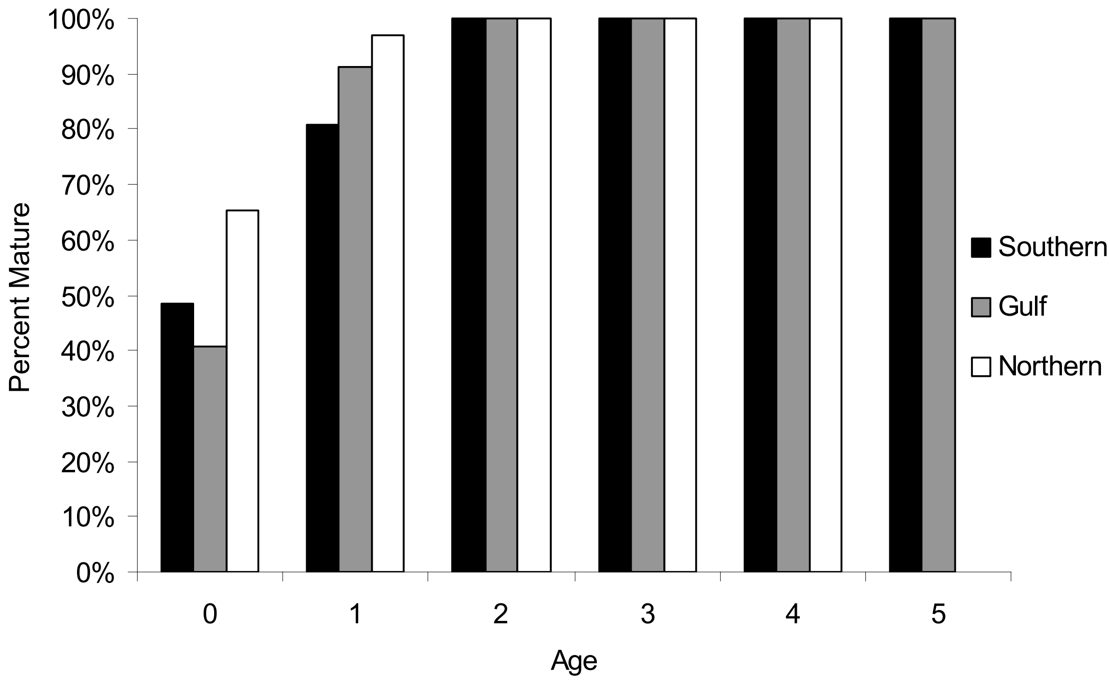

Figure 5.8. The percent mature at age for female southern, Gulf, and northern kingfishes. Ages are rounded down to the nearest whole year.

5.1.5.5 Sex Ratio

The sexually dimorphic growth rates of kingfishes causes changes in sex ratio depending on the length of the fish (Figure 5.9). The ratio of southern kingfish females to males begins to increase after 9.8 inches (250 mm). All southern kingfish are females by 13.4 inches (340 mm). Gulf kingfish are 100% female by 15.4 inches (390 mm). The proportion of northern kingfish females was greater than 50% for all lengths except 6.3 to 7.0 inches (160-179 mm) and had an increasing trend in percent of females as length increased for sizes greater than 6.3 inches (160 mm).

Most of the southern kingfish (79%) landed in the shrimp trawl fishery were female (Smith and Wenner 1985); however, more recent work by NCDMF noted only 60% to be female (Table 5.3). In Smith and Wenner (1985), only the fish retained by the fishermen [>7.5 inches (190 mm)] were included in the ratio, while in the NCDMF study all fish caught were included. Since southern kingfish have an increasing percentage of females with increasing size, the ratios in the NCDMF study would be expected to have a smaller percentage of females than Smith and Wenner study (1985). The sex ratio of southern kingfish for all gears combined is skewed toward females (73%).

Gulf kingfish are the only kingfish to have similar proportions of males and females. Seines and hook and line tended to harvest more females than males, but the overall percentage was 54% female.

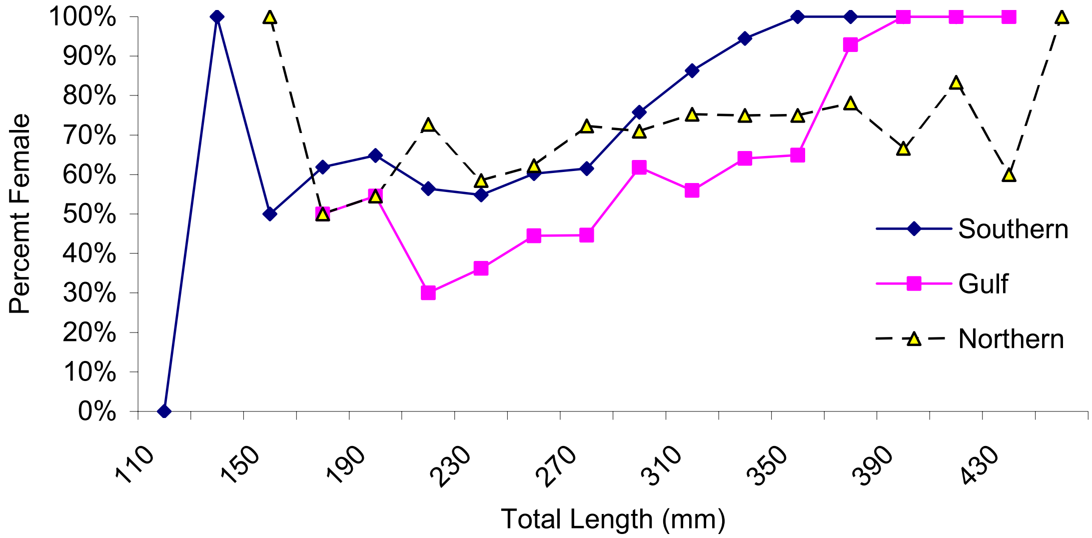

Figure 5.9 Percent female of southern, Gulf, and northern kingfishes grouped in 20 mm length classes. The size classes were grouped into 20 mm bins to reduce the variability in the data.

Contrary to an earlier study that found the sex ratio for northern kingfish did not differ from a 1:1 ratio statistically (Ralph 1982), the NCDMF study found 71% of the northern kingfish to be female. The bias in the NCDMF study could be due to the size selective nature of commercial gears, which tend to harvest larger individuals. The ratios were similar among gill nets, seines, and trawls.

Table 5.3 Proportion female by gear for the southern, Gulf, and northern kingfishes. Sample sizes are listed for each gear category in parentheses. For gears with less than 10 fish, the proportion was not listed but was included in the grand total for species composition.

Species	Pound Net	Gill net	Beach Seine	Long Haul Seine	Hook and Line	Trawl	Grand Total
Southern	0.94 (16)	0.81 (837)	1.00 (13)	0.71 (21)	0.76 (50)	0.60 (644)	0.73 (1581)
Gulf		0.50 (151)	0.70 (63)		0.64 (112)	0.50 (303)	0.54 (629)
Northern		0.74 (255)	0.73 (56)			0.67 (253)	0.71 (565)

5.1.6 Movements and Migrations

In the surf zone, juvenile kingfishes are regarded as spring-summer residents (Tagatz and Dudley 1961; Bearden 1963; Dahlberg 1972; Modde 1980; Modde and Ross 1981; McMichael and Ross 1987). Abundance of juvenile southern and northern kingfishes (<150 mm) in the surf zone peaks during May throughout the SAB and Gulf of Mexico slightly before the peak abundance of juvenile Gulf kingfish (Irwin 1971; Modde 1980; Modde and Ross 1981; McMichael and Ross 1987). The difference in peak abundances of the kingfishes has been explained by interspecies resource partitioning or by varying temperature tolerances (Ross et al. 1987). Adult kingfishes (> 150 mm) are most common at depths less than 26 meters (Ralph 1982; Crowe 1984; Harding and Chittenden 1987) but have been reported in the ocean as deep as 99 meters (Bearden 1963).

5.1.6.1 Larval Transport

Little is known about the spawning of kingfishes, and therefore, the mechanisms that transport larvae are poorly understood. The eggs of kingfishes are buoyant. Buoyant eggs and larvae of other species are transported into estuaries by wind driven currents, Ekman transport, and advection pushing the buoyant eggs and larvae toward shore (Lawler et al. 1998). The spawning of kingfishes likely takes place in the near shore ocean (Hoese 1965) with some kingfishes spawning inshore (Bourne and Govoni 1988). These inshore spawned kingfishes need to be retained within the nursery habitat for protection and food resources. Mechanisms to transport southern and northern kingfishes into estuaries and retention of kingfishes in the surf zone need to be studied to better understand the recruitment dynamics of kingfishes.

5.1.6.2 Juvenile Movement

Young of the year (YOY) tend to be found in shallower water than adults but it varies among species. Northern kingfish juveniles utilized the surf zone in New Jersey and began to egress as the fish grew (Miller et al. 2002). A North Carolina study found Gulf kingfish to exhibit site fidelity in which Gulf kingfish remained in an area throughout a summer (Ross and Lancaster 2002). As waters cool, YOY migrate from the surf zone to deeper water (Bearden 1963; Schaefer 1965; Miller et al. 2002).

5.1.6.3 Adult Migration

Offshore trawl surveys observed that adult abundance is lowest in summer and peaks in the winter (Hoese 1965; Anderson 1968; Smith and Wenner 1985). A gradual increase in the abundance of kingfishes occurs with decreasing latitude during the winter along the Atlantic coast (Anderson 1968; Smith and Wenner 1985). The increase in abundance during the winter has been hypothesized to represent a southerly migration of kingfishes (Smith and Wenner 1985). A tagging study was conducted in Southeastern North Carolina to determine migration patterns of adult kingfishes off North Carolina, but the study had very few tag returns limiting the conclusions of the study (Beresoff and Schoolfield 2002).

5.2 STOCK STATUS

The status of the North Carolina kingfish stock is unknown. The status was classified as unknown because of unknown discard rates, the defined management unit did not address the unit stock of kingfish, and unknown fishing mortality rates (a peer reviewed stock assessment was not accepted).

5.3 TREND ANALYSIS

Two different stock assessment models were attempted to determine sustainable harvest levels, but peer reviewers and the Kingfish Fishery Management PDT rejected the stock assessments due to deficiencies in the data. A major deficiency cited by all the reviewers was the lack of migration (mixing) data to determine the movement of kingfish along North Carolina (NC) as well as the Atlantic coast. Clearly, if management addresses only one part of a large resource that is being affected by heavy exploitation in other areas, its chances for success will be constrained by those outside forces (Berkes et al. 2001). Other deficiencies included: low or no correlation between the indices used in the biomass dynamic model, gaps in the aging data from 1997 to 2001 along with a low sample size of aged fish, lack of discard data, and low fishery dependent sample sizes in the directed kingfish sink net fishery.

Trend analysis was conducted for southern kingfish in lieu of a stock assessment. Trend analysis was conducted on dependent and independent data to detect relative changes in kingfish abundance. Ideally, these data sources would be representative of the kingfish population in number, size, and age. Dependent data are data collected from the different fisheries (both recreational and commercial) by the NCDMF. Dependent data included the South Atlantic commercial and recreational, NC commercial and recreational, and FL commercial landings. Independent data are collected through biological studies by NCDMF or other agencies. Independent data included the SEAMAP and Pamlico Sound Survey (PSS). Analyses used to determine trends in the kingfish stock included: regression analysis, length frequency plots, survivorship curves, and age distribution. This paper includes a brief description and summary of the life history and landings for kingfish. A more detailed review is included in the Life History, Commercial Fishery, and Recreational Fishery sections.

The trend analysis section should be used as a guideline for the management of kingfish. The stock status of kingfish will remain unknown until a coastwide stock assessment is completed. Although the stock status will remain unknown, management measures can still be considered to ensure a sustainable harvest of kingfish.

5.3.1 Life History and Distribution

Three species of kingfishes occur in NC: southern kingfish (*Menticirrhus americanus*), Gulf kingfish (*M. littoralis*), and northern kingfish (*M. saxatilis).* Southern kingfish is the most abundant kingfish in the SAB and Gulf of Mexico (Irwin 1971; Dahlberg 1972; Crowe 1984; Smith and Wenner 1985; Harding and Chittenden 1987) with a range that extends from Cape May, NJ to Buenos Aires, Argentina (Fischer 1978). Northern kingfish is most abundant in the Mid-Atlantic Bight (Hildebrand and Schroeder 1928; Schaefer 1965; Ralph 1982) with a range that extends from the Gulf of Maine into the Gulf of Mexico (Fischer 1978). Gulf kingfish is most abundant in the surf zone south of Cape Hatteras, NC, and has a range that extends from Virginia (Welsh and Breder 1923; Irwin 1971) to Rio Grande, Brazil (Fischer 1978).

Juvenile kingfishes are regarded as spring-summer residents of the surf zone (Tagatz and Dudley 1961; Bearden 1963; Dahlberg 1972; Modde 1980; Modde and Ross 1981; McMichael and Ross 1987). Abundance of juvenile southern and northern kingfishes [<5.9 inches (150 mm)] in the surf zone peaks during May throughout the SAB and Gulf of Mexico slightly before the peak abundance of juvenile Gulf kingfish (Irwin 1971; Modde 1980; Modde and Ross 1981; McMichael and Ross 1987). Southern kingfish also use estuarine waters as habitat. They are frequently captured in the NCDMF PSS and by shrimp boats and gillnets in estuarine waters of NC. However, little research has been done to describe the utilization of estuarine habitats by southern kingfish and migration of southern kingfish out of the estuaries. Adult kingfishes (> 5.9 inches) are most common at depths less than 85 feet (Ralph 1982; Crowe 1984; Harding and Chittenden 1987) but have been reported in the ocean as deep as 325 ft (Bearden 1963).

Length at maturity varies by sex and species. Males mature at a smaller size than the females. Southern kingfish on average mature at a TL of 5.3 inches (135 mm) for males and 7.6 inches (192 mm) for females in the SAB (Smith and Wenner 1985). However in NC, southern kingfish females mature at a slightly larger size, 8.2 inches (209 mm) [n=686 (NCDMF unpublished data)]. Most individuals of each species are mature by age 1 with southern kingfish females having the least percent mature at age 1 (85%). All kingfishes are mature by age 3.

Spawning seasonality for southern kingfish was from April to September based on the presence of developing and ripe females as well as a gonadosomatic index. Although spawning locations are unknown off NC, anecdotal evidence suggests spawning occurs on the bottom (Ralph 1982) in the nearshore ocean and possibly in high salinity estuarine waters. Ripe kingfishes have been collected in nearshore ocean waters from early spring to September (Bearden 1963; Smith and Wenner 1985). Ripe fish and eggs have also been collected in estuarine waters (Hildebrand and Cable 1934; Hoese 1965; Bourne and Govoni 1988).

Adult growth rates have been estimated using length frequency, scale aging, and otolith aging. Otoliths were found to be the most precise aging structure, and therefore, the NCDMF aging study used otolith-based age estimates to predict length at age (Collier, NCDMF, unpublished data). Kingfishes were found to exhibit sexually dimorphic growth rates with females attaining a larger maximum size than males for each species (Table 5.4).

Table 5.4 Predicted total length at age for the Atlantic coast kingfishes captured in NC waters. Kingfishes were aged using otoliths by NCDMF (2001 - 2004).

	Species					
	Southern (n=1,801)		Gulf (n=629)		Northern (n=565)	
Age	Male	Female	Male	Female	Male	Female
1	8.2	8.9	9.2	10.2	10.4	11.0
2	9.9	11.2	10.7	12.5	12.2	13.0
3	10.9	12.6	11.9	13.9	13.2	13.9
4	11.4	13.3	12.7	14.7	13.7	14.3
5	11.7	13.7	13.4	15.2	14.0	14.4
6	11.8	13.9	13.9		14.2	

Current evidence suggests that kingfish migrate south and offshore during the fall and north during the spring. Abundance gradually increases with decreasing latitude during the winter along the South Atlantic coast (Anderson 1968; Smith and Wenner 1985). During the summer, abundance was lower and more evenly distributed along the South Atlantic coast. A kingfish tagging project conducted off Southeastern NC had limited success in describing kingfish migratory patterns due to few tag returns (Beresoff and Schoolfield 2002). However, evidence of southerly migration was present with one fish released off Holden Beach, NC recaptured off Tybee Island, SC, which is just north of the GA border.

5.3.2 Landings Data

5.3.2.1 Commercial

The Atlantic coast states (Maine to Florida) have accounted for 71% of the commercial kingfish landings since 1950 with the remainder coming from Gulf states (Personal communication from the National Marine Fisheries Service (NMFS), Fisheries Statistics Division). The South Atlantic states (North Carolina, South Carolina, Georgia, and Florida) have contributed 96% of the total Atlantic coast landings (1950-2004). Landings in the South Atlantic have shown a significant downward trend since 1950 (Figure 5.10). The east coast of Florida accounted for the highest percentage (48%) of the South Atlantic kingfish landings followed by North Carolina 37%, Georgia 9%, and South Carolina 6%.

More recent landings for the South Atlantic (1989-2004) have shown a slightly steeper decrease. However, the decline in North Carolina's landings over the same time period was not as dramatic (Figure 5.11). Regulations that were enacted in Florida (gill net ban) and North Carolina (flynet restrictions, 50-50 rule) most likely accounted for some of the decrease although the decline in landings began before any of these regulations were passed. The percent contribution of South Atlantic landings has shifted with North Carolina accounting for the greatest proportion (50%) of landings since 1989. The other South Atlantic states had a decrease in percent contribution of landings with Florida dropping from 48% to 43%, Georgia from 9% to 3%, and South Carolina from 6% to 4%.

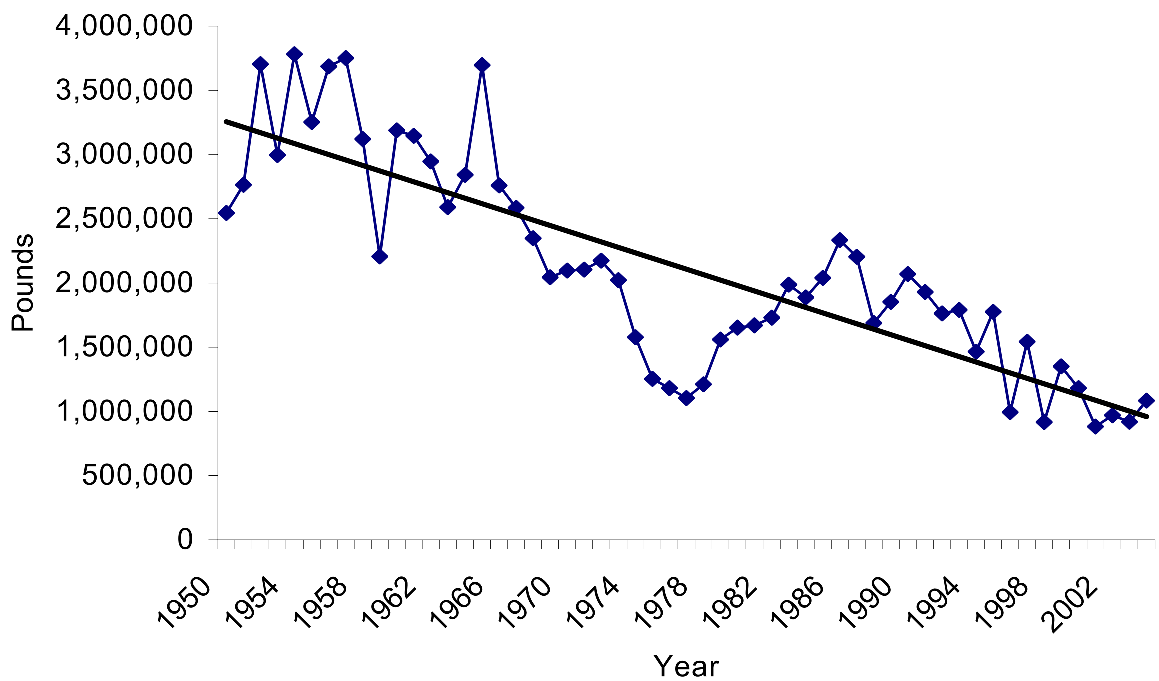

Figure 5.10 Commercial landings of kingfishes and overall trend for the South Atlantic (North Carolina to Florida), 1950 – 2004.

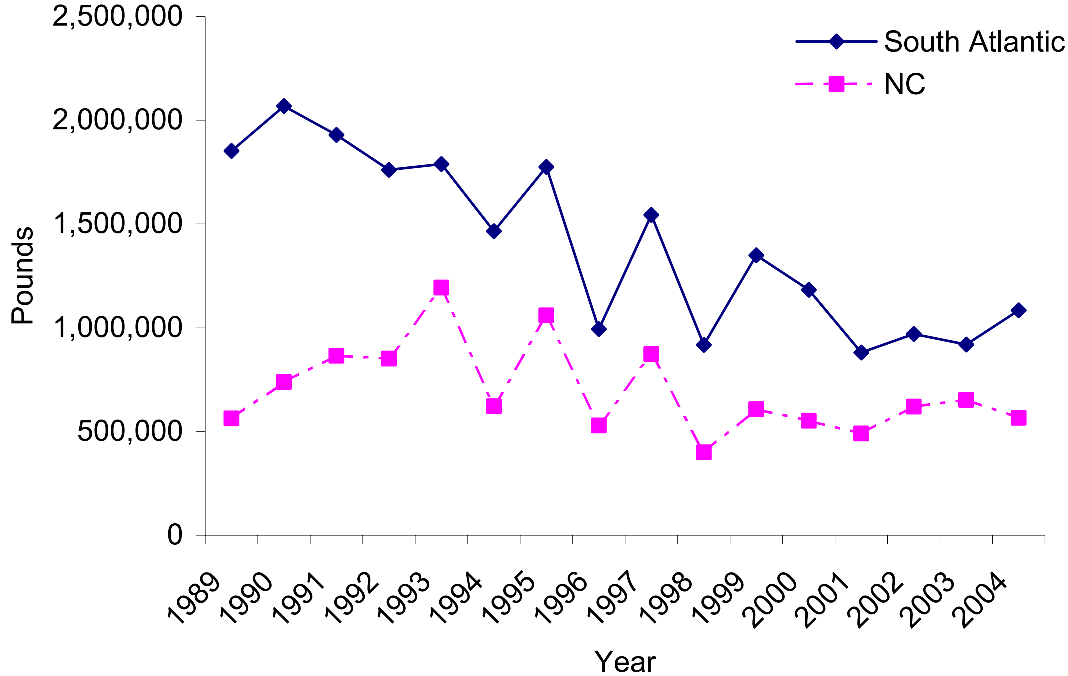

Figure 5.11 South Atlantic and NC commercial harvest of kingfishes, 1989 - 2004.

North Carolina's commercial landings peaked in 1954 at 1.8 million lb [Figure 5.12 (Personal communication from the NMFS, Fisheries Statistics Division)] and had a low in 1976 harvesting 123,700 lb. Landings gradually increased in the 1980's and 1990's. Landings decreased from 1993 to 1998 in conjunction with the phase out of the flynet fishery south of Cape Hatteras and harvest restrictions placed on the shrimp trawl fishery. Landings of kingfishes averaged 581,380 lb from 1999 to 2004.

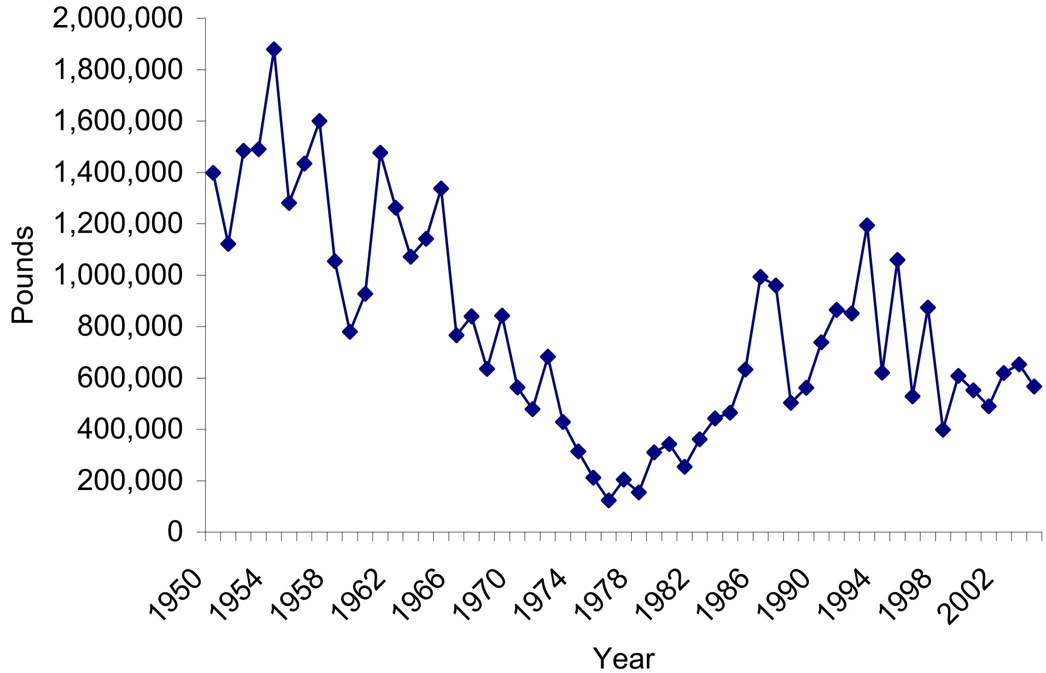

Figure 5.12 Commercial landings of kingfishes for North Carolina, 1950 - 2004.

The majority of landings of kingfishes have come from the ocean (84%) and, to a lesser extent, Pamlico (9%) and Core (4%) sounds. Harvest and effort in the fisheries for kingfishes are seasonal with peak landings and effort occurring in the spring and fall. Since 1994, the gill net fishery has dominated the landings (62%) while shrimp trawls ranked second (23%) and fish trawls third (8%).

5.3.2.2 Recreational

Recreational data have been collected since 1981 by the Marine Recreational Fisheries Statistics Survey (MRFSS). The recreational catch for all three species is substantial averaging 1.2 million lb from 1981 to 2004 in the South Atlantic for all modes and strata [Figure 5.13 (Personal communication from the NMFS, Fisheries Statistics Division)]. The landings in 2001 and 2004 were the two highest on record catching over 2 million lb. The dominant species (1981-2004) was southern kingfish averaging 783,291 lb or 68% of the total kingfish catch. Gulf kingfish were second in lb caught averaging 237,787 lb (21%) and northern kingfish averaged 132,312 lb (11%).

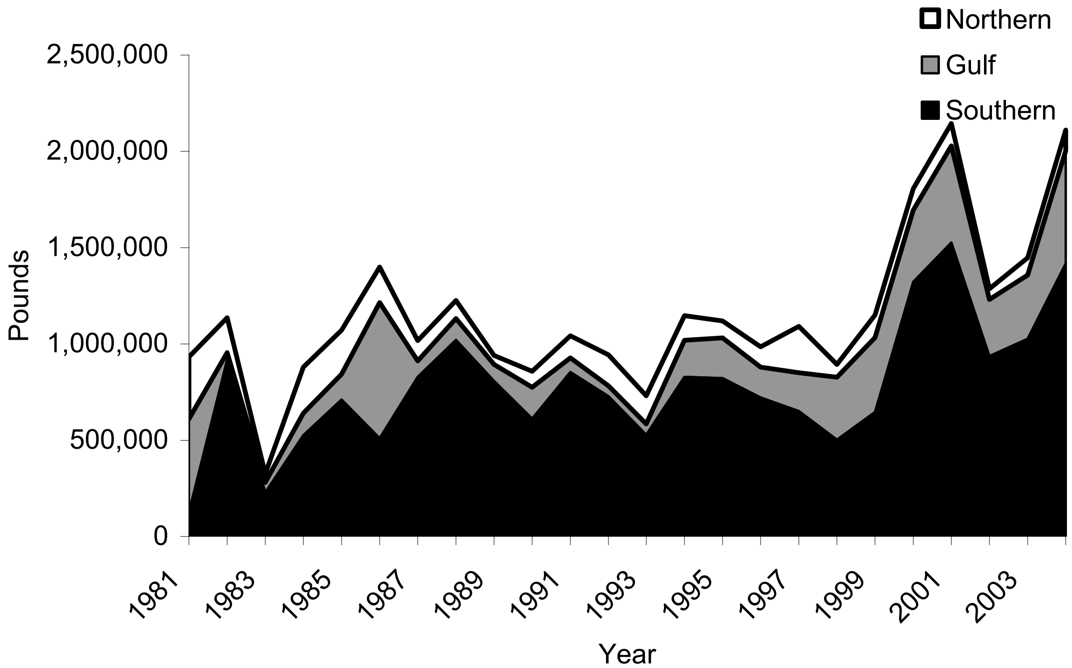

Figure 5.13 The recreational landings of southern, Gulf, and northern kingfishes for the South Atlantic, 1981 - 2004.

Recreational landings of all three species in NC have fluctuated from 1981 to 2004 averaging 277,004 lb [Figure 5.14 (Personal communication from the NMFS, Fisheries Statistics Division)]. The NC harvest averaged 24% of the total landings for the South Atlantic and ranked second behind FL. The highest landings occurred in 2001. Southern kingfish was the most common kingfish averaging 150,718 lb or 54% of the total NC kingfish catch. Northern kingfish ranked second averaging 108,922 lb (39%) and Gulf kingfish averaged 17,363 lb (6%). The recreational data for kingfish caught in NC have a fairly high proportional standard error (PSE) that should be considered. Tables of the total landings and corresponding PSEs by species are listed in Recreational Fishery section of the FMP.

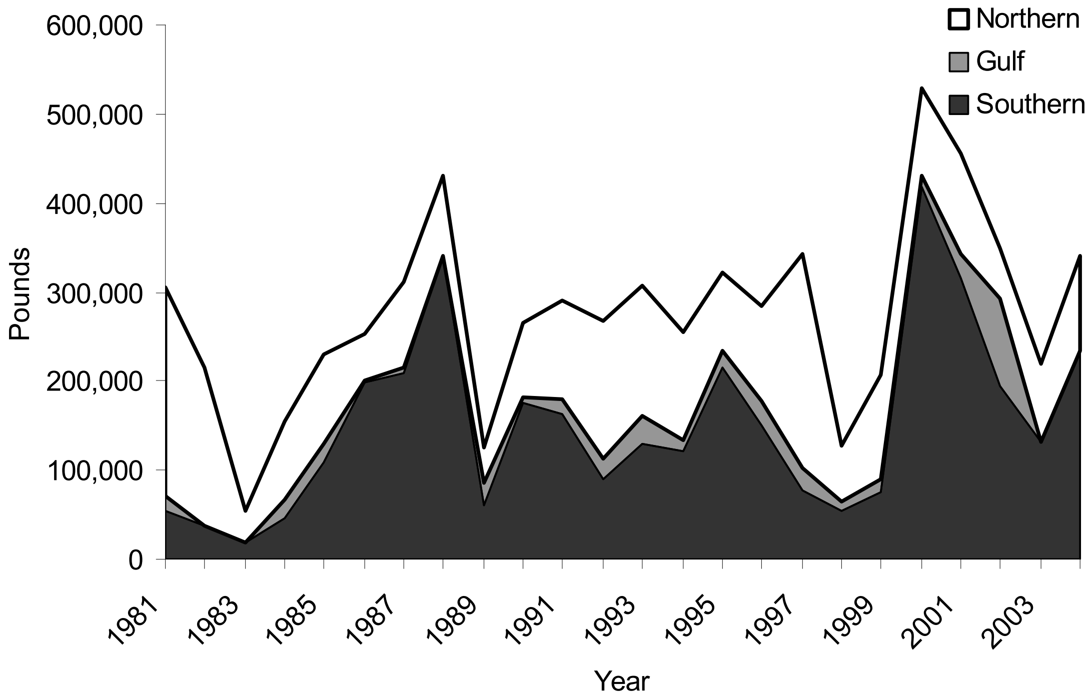

Figure 5.14 Recreational landings of southern, Gulf, and northern kingfishes for NC, 1981 - 2004.

5.3.3 Trend Analysis

The trend analysis uses data broken down to the finest level of detail. Commercial fisheries data from the North Carolina Trip Ticket Program (NCTTP) does not differentiate among species but the recreational fishery has species level data available. The Kingfish PDT recommended using southern kingfish as the indicator species for this complex. This decision was based on three criteria: 1) Southern kingfish are the most abundant kingfish in the SAB (Irwin 1970; Dahlberg 1972; Smith and Wenner 1985), 2) NCDMF's biological data are primarily southern kingfish data, and 3) Species-specific management measures would be difficult to develop because all three are caught and landed as a functional unit. Therefore, based on fish house sampling, commercial landings were converted to southern kingfish landings using proportion by weight and by gear. The proportions in the major commercial fisheries were 0.837 for ocean sink net, 0.99 for estuarine fisheries, and 0.877 for ocean fisheries excluding sink nets for all years combined. An average proportion by fishery was calculated due to limited fishery dependent sampling in some years. Proportions were based on NCDMF's dependent sampling where species-specific identifications were made.

The years described in the trend analysis included 1989 to 2004. This time span represented NCDMF's best time series of data. The SEAMAP and PSS surveys had been conducted since 1989. The MRFSS survey had consistent sampling methodology since1989. The NCTTP started in 1994, limiting the analyses of dependent data to 1994 through 2004.

5.3.3.1 Data Sources

Dependent

CPUE can be used as a proxy for stock abundance although this type of analysis is often hindered by several problems. Populations may experience hyper-aggregation as stock size decreases causing CPUE to increase as stock size decreases. Fishermen may change the unit of effort by increasing gear size or by becoming more efficient due to advances in technology (Hilborn and Walters 1992; Walters and Martell 2004). Despite these precautions and a lack of better dependent data, CPUEs were developed for data from the NCTTP (1994 - 2004) and MRFSS (1989 - 2004). The sink net and recreational fisheries were analyzed for trends. The unit of effort for all dependent indices was a trip since this was the finest level of detail available from 1994 to 2004 in the commercial fisheries.

The sink net fishery targets kingfishes and was included due to this gears dominance in landings. However, this fishery is particularly problematic for CPUE analysis due to selectivity and effort. Selectivity in gillnets can change with mesh size and effort can change by increasing or decreasing the soak time and amount of gear used. The sink net CPUE was calculated for all trips for a subset of fishermen that were known to target kingfishes in the ocean using sink nets as the primary gear, and also reported landing kingfishes on the trip ticket.

The recreational fishery has likely been the most consistent relative to catchability since rules have not been implemented on the recreational fishery. Harvest from MRFSS was calculated for trips in the ocean (< 3 miles), sound, and river from piers, docks, bridge/causeway, private boats, and rental boats. CPUEs were calculated for both the South Atlantic and NC to determine if the trend observed in NC was similar along the coast.

Commercial shrimp trawl, ocean trawl, and long haul seine CPUEs were not included in the trend analysis due to a lack of confidence in the data and significant regulations placed on the three fisheries. The long haul seine fishery was included in the length frequency analysis since it was the only inshore fishery with adequate samples to develop length frequency plots. However, cull rings were required in the bunt of the seine and may have impacted the size selectivity.

Trends for FL commercial fisheries were provided for additional insight into the kingfish population since the population is likely to mix throughout the South Atlantic. FL has been a major contributor to the commercial kingfish landings ranking second to NC in total of kingfish commercially landed from 1989 to 2004. FL catch per trip was analyzed for the top four fisheries (trawls, gillnets, cast nets, and beach seines) from 1989 to 2004 (Personal communication from Steve Brown, Florida Fish and Wildlife Conservation Commission).

Independent

SEAMAP (1989-2004) and NC PSS (1989-2004) were the two best independent data sets available to detect trends in the population abundance of southern kingfish. Independent CPUEs were calculated as the number of fish captured per tow with an assumption that catchablity has remained consistent. These two independent data sources were separated into adult and YOY CPUEs. Since many of the fish caught in the independent studies were not aged directly, an upper size limit was established for YOY based on length at age and month of sampling.

SEAMAP was initiated in 1986 to provide a long-term independent data on the seasonal abundance and biomass of finfish in the nearshore ocean along the southeastern US Atlantic coastline (SEAMAP 2004). The survey design was replicated after the NMFS Groundfish Fish Survey and is conducted in the spring, summer, and fall of each year. The fishing effort unit was a 20-minute tow of a paired 75 foot mongoose-type Falcon trawl net without a turtle excluder device (TED). Since the SEAMAP survey is conducted from Cape Hatteras to Cape Canaveral, the survey allowed for a direct comparison of the NC subset of the SEAMAP data with the overall trend for the South Atlantic. This comparison was done for a combined yearly CPUE (number of individuals) for all southern kingfish. Southern kingfish captured along the NC coast were further separated into YOY and adults based on lengths with 5.9 inches (150 mm) the maximum length for YOY during the summer and 8.1 inches (205 mm) the maximum length for YOY during the fall. CPUEs (combined summer and fall surveys) were calculated and regressed to detect a trend in the CPUE.

The PSS was initiated in 1989 to develop a long-term database of species diversity, richness, and length composition in the Pamlico Sound and its tributaries. The survey is conducted in the summer and fall of each year. Pamlico Sound was sampled in both shallow (1.8-3.7 m or 6-12 ft) and deep (greater than 3.5 m or 12 ft) strata by towing a double-rigged 30 foot demersal mongoose trawl without a TED for 20-minutes. The length cutoff to separate YOY southern kingfish from adults was 5.9 inches (150 mm) for the summer and 7.5 inches (190 mm) for the fall, based on the length at age key.

5.3.4 Trend Analysis Methods

5.3.4.1 General Linearized Model (GLM)

Regression analysis (Proc GLM) was used to determine if a linear trend in the CPUE was evident in the surveys (SAS 1985). A 0.10 level of significance was chosen because of the low sample size (11 or 16 years) and the high natural variation in population sizes (Walters and Martell 2004).

Two dependent (sink net and MRFSS) and two independent (SEAMAP and PSS) surveys were combined and then analyzed to determined their respective trends. A Z - transformation (normal deviate) was used to standardize the CPUEs. The standardization was conducted with CPUEs during identical time periods to eliminate confounding effects associated with comparing means with different time periods. The standardization was calculated as:

Z = (x-mean(survey))/std(survey)

Where x = yearly data point, mean (survey) is the mean calculated for each survey, std (survey) is the standard deviation for each survey. Using this technique standardizes the data sets to zero with a standard deviation of 1 (Zar 1984). The dependent data included: sink net and MRFSS CPUE. The MRFSS data were limited to 1994 to 2004 since the NCTTP data were limited to that time period. The Z calculation is reliant on a mean, which is influenced by a change in time analyzed or in the population size. The SEAMAP and PSS surveys were combined to calculate separate CPUEs for YOY and adult surveys. The dependent and independent data were modeled using a Proc GLM to determine if a linear trend was present (SAS 1985). The Z transformation has an assumption of normality. Normality was tested using the Kolmogorov-Smirnov test (SAS Proc Capability). Normality was violated for the SEAMAP adult index (p=0.01). Additionally the Kolmogorov-Smirnov test is often inaccurate at low samples [type II error (Zar 1984)]. The CPUEs for all indices were transformed using log

(CPUE+1). After the data was transformed, all indices met the criteria for normality.

5.3.4.2 Length Frequency

Length frequencies can be used to detect growth overfishing. Growth overfishing is defined as harvesting the population before individuals have had a chance to grow and are relatively small (Haddon 2001, Jennings et al. 2002). If a population has a truncation in the size structure or a decrease in the modal size, the population may be experiencing growth overfishing. Length frequency distributions were created by year for the sink net, fish trawl, and long haul seine fisheries as well as SEAMAP and the PSS surveys. Additionally, the percent of fish greater than 13 inches was investigated to determine if growth overfishing was present in the fisheries. This length was selected because less than one third of the measured fish were greater than 13 inches and the length was close to the average maximum size for females (14 inches). The selectivity of fish was assumed to remain constant over time.

5.3.4.3 Population Age Structure

Age structure was described using survivorship curves and catch at age in the sink net and recreational fisheries. The survivorship curves were created for southern kingfish based on a constant natural mortality rate of 0.55 (based on the mortality equation of Hoenig 1983) and fishing mortality rates ranging from 0 to 1 to determine the number of kingfish that would survive to each age class. The survivorship curves assume that recruitment and catchability have remained constant. The curves were compared with raw aging data from SEAMAP for the South Atlantic from 1996 and 2002 (only two years available for comparison) to estimate fishing mortality and to determine if the age structure has changed. The SEAMAP survey has collected aging structures on a random sampling design as opposed to NCDMF's collection of aging structures, which uses a size-based collection method. The random sampling design collects individuals representative of the overall population in the sample.

The percent at age was calculated as the number at each age divided by the total number aged. Since kingfish were not fully recruited to the SEAMAP study until age 1, only fish age 1 and greater were plotted. The total number aged included all aged fish. A line plot was created to investigate the distribution of ages observed in the SEAMAP aging data set with a theoretical population that has experienced either no fishing or a fishing mortality rate of 1.0.

A catch at age was developed for the landings of the sink net and recreational fisheries. A yearly length at age key was used to expand the length frequency distributions observed in biological samples to the two fisheries. When aging samples were not available for a given size, pooled length at age keys were constructed. Histograms were based on numbers at age for each fishery to illustrate the age distribution of the fisheries. The years 2002 to 2004 were selected since these were the years that had the best aging data to describe NC fisheries and the length samples appeared representative of the two fisheries.

5.3.5 Trend Analysis Results

5.3.5.1 North Carolina Landings and CPUEs

Commercial landings were highly variable from 1989 to 2004 with peaks in 1993 and 1995 followed by a low in 1998 (Figure 5.15). The commercial landings were variable but a declining trend from 1992 to 1998 was apparent. Since the flynet closure south of Hatteras was finalized in 1998, there has been a slight increasing trend in landings (see Commercial Section).

Recreational landings have been fairly stable from 1989 to 2004 with the exception of 2000 and 2001 that were relatively high. The low in the recreational fishery occurred in 1998 (54,478 lb), which was the same year that the commercial fishery had its lowest landings.

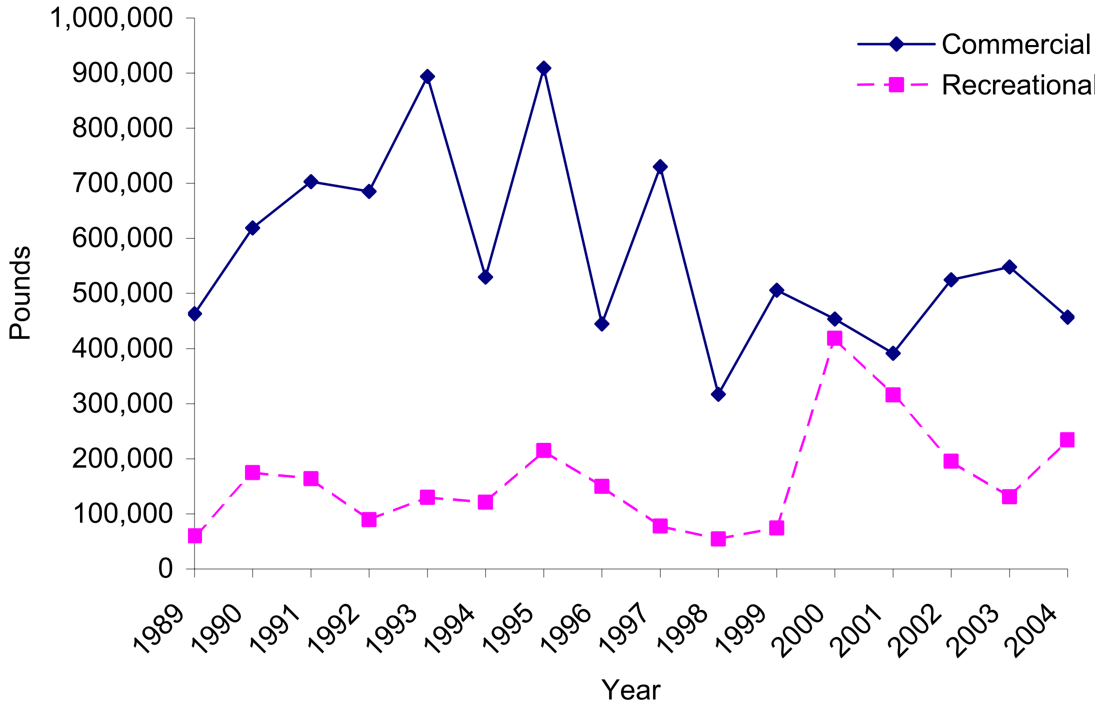

Figure 5.15 NC commercial and recreational landings of southern kingfish, 1989 - 2004.

The CPUEs for the sink net and MRFSS data indicated a slightly increasing trend with the sink net fishery showing the largest increase (Figure 5.16). The MRFSS trend was heavily influenced by the high CPUE in 2000. These data were transformed using the Z transformation and combined in a model to determine the resulting trend using Proc GLM (Figure 5.17). The significance of the model ($p=0.079$, $r^2=0.146$) was below the acceptable significance of 0.10. The slope of the line was positive indicating that the CPUE is increasing; however, the low r^2 value indicates little of the variation in CPUE is explained by year alone.

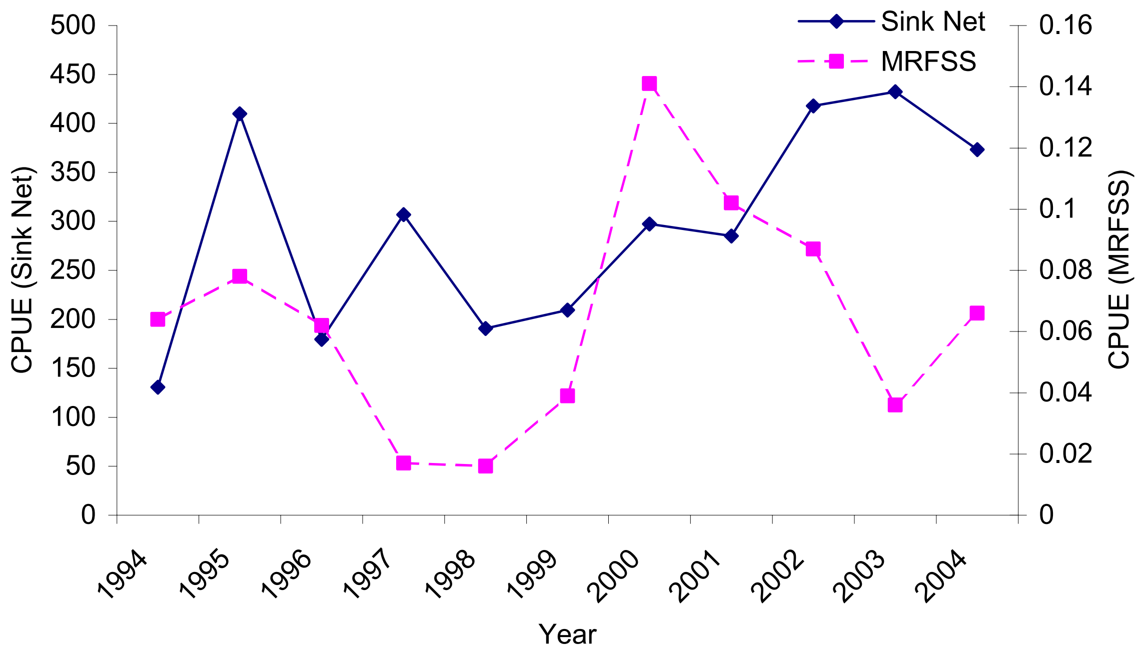

Figure 5.16 CPUEs for the NC sink net (lb per trip) and NC MRFSS (number per trip), 1994 - 2004. Sink net CPUE is on the left axis and MRFSS is on the right axis.

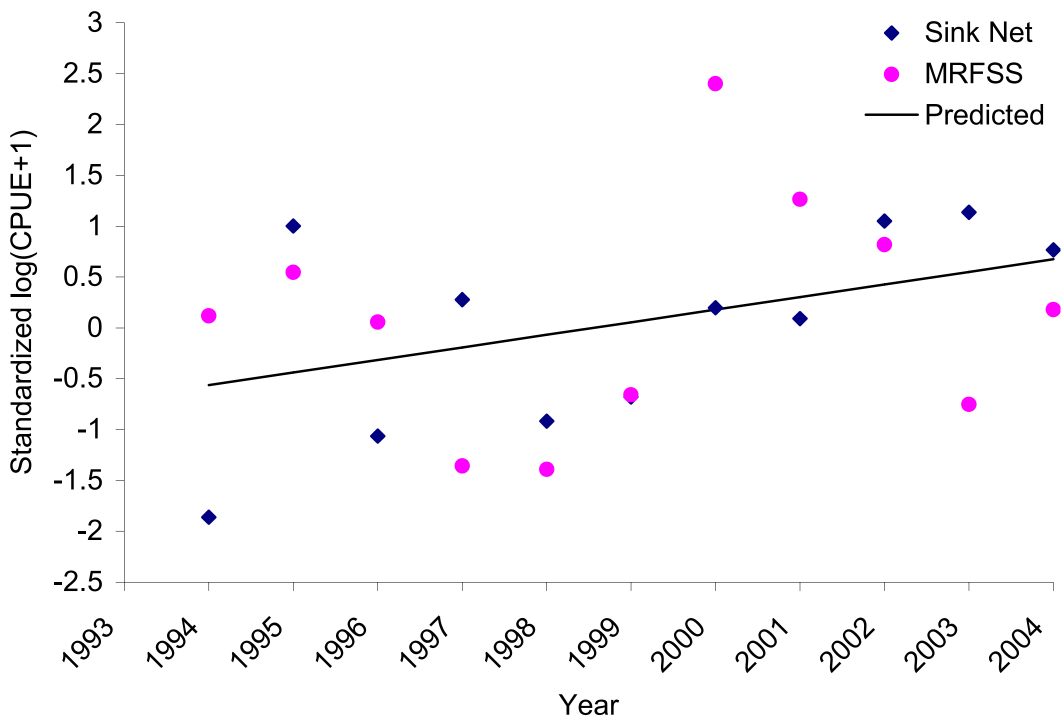

Figure 5.17 Predicted model developed using a GLM for the log transformed CPUE of NC sink net and NC MRFSS data sets (p=0.079).

5.3.5.2 Florida Commercial Fisheries CPUEs

The trawl, gillnet, beach seine, and cast net fisheries accounted for 86.9% of Florida's Atlantic coast commercial landings of kingfishes from 1989 to 2004. The CPUEs were highly variable and no significant trends were present (Figure 5.18). The CPUE in 2004 (350 lb per trip) was more than three times the average CPUE from 1989 to 2003. This rapidly developing gillnet fishery was a concern for stocks of kingfishes.

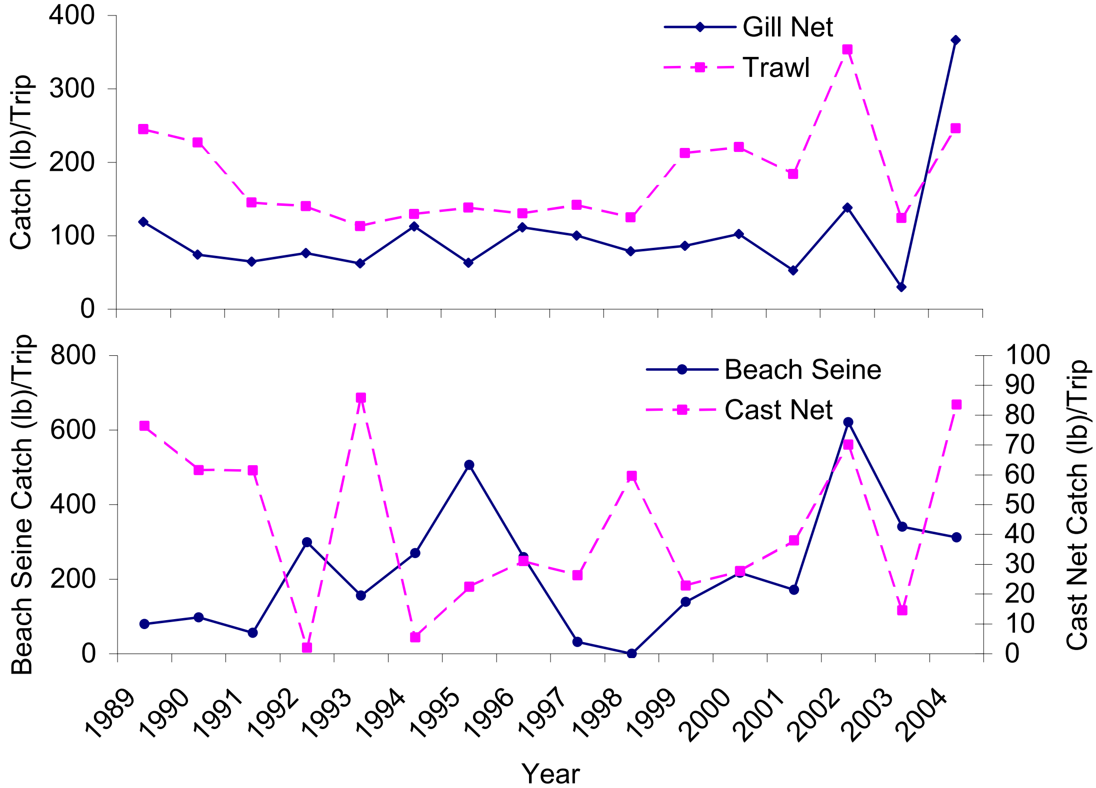

Figure 5.18. Florida catch of kingfishes (lb) per trip for trawl, gill net, cast net, and beach seine, 1989 - 2004.

5.3.5.3 MRFSS CPUE

The recreational CPUE for southern kingfish has been stable in the South Atlantic from 1990 to 1999 [Figure 5.19 (Personal communication from the NMFS, Fisheries Statistics Division)]. After 1999, the MRFSS CPUE for the South Atlantic had an increasing trend. The NC MRFSS CPUE for southern kingfish was variable from 1998 to 2004. A low occurred in 1998 followed by a high two years later in 2000. The increasing trend evident in the South Atlantic CPUE after 1999 was not present in the NC subset of the MRFSS data.

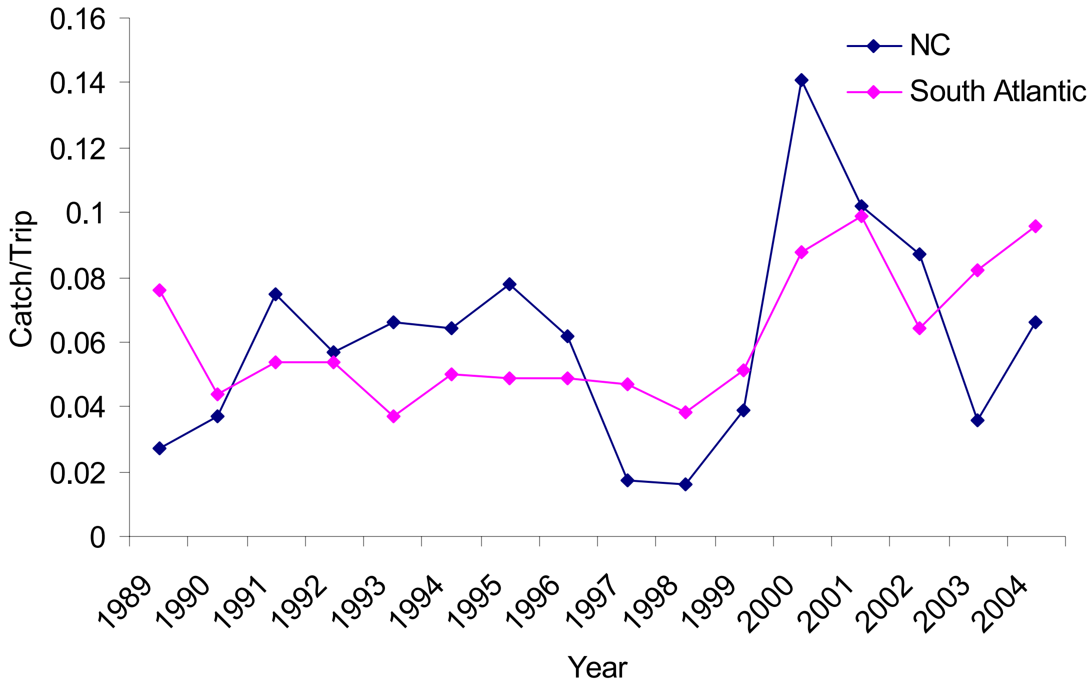

Figure 5.19 MRFSS southern kingfish data for the South Atlantic and NC, 1989 - 2004. These included all trips for strata likely to catch southern kingfish.

5.3.5.4 Independent CPUEs

SEAMAP South Atlantic CPUEs

The SEAMAP survey for the South Atlantic collected 76,945 southern kingfish from 1989 to 2004. Overall, there is no discernable trend and the data were variable (Figure 5.20). The variability from year to year inhibits the use of a regression line to describe either the South Atlantic ($p=0.97$) or NC ($p=0.53$) data. However, there appears to be an increasing trend since 1998 in the South Atlantic. This analysis combined both YOY and adults and was not designed to look at differences between the abundance of YOY and adult indices.

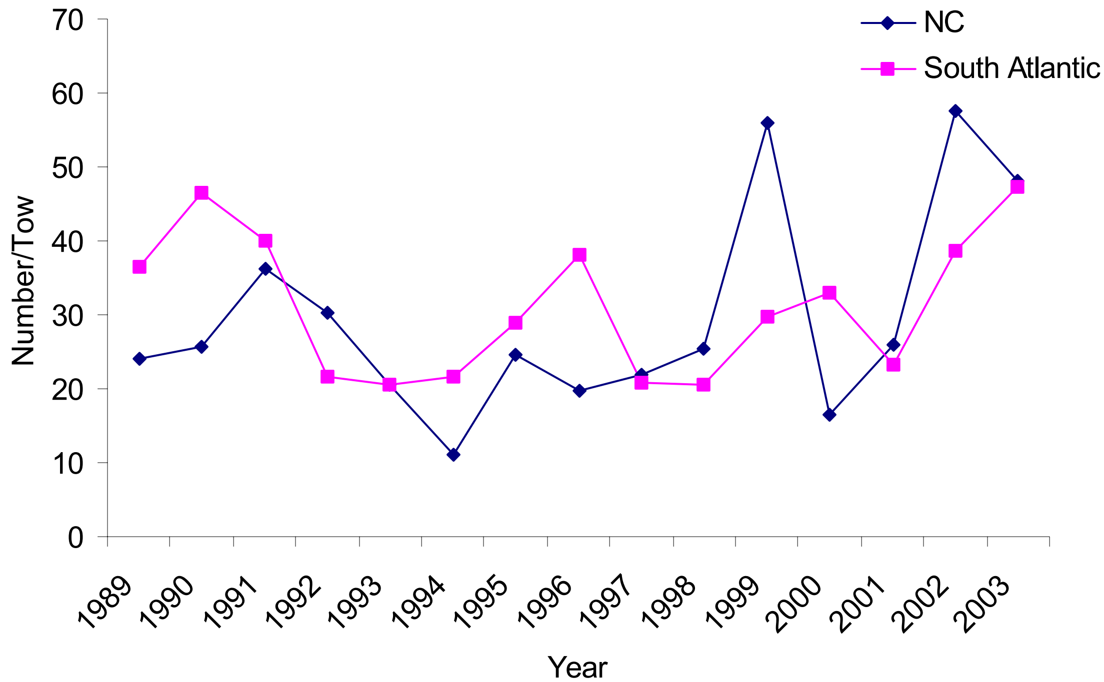

Figure 5.20 The catch (numbers) per tow of southern kingfish from the SEAMAP survey along the South Atlantic coast and NC, 1989 - 2003.

SEAMAP North Carolina CPUEs

SEAMAP collected 19,039 southern kingfish off NC from 1989 to 2004 during the summer and fall surveys (Table 5.5). A majority of kingfish were collected in the fall survey (80%). The SEAMAP CPUE was relatively stable from 1989 to 1998. Since 1998, the fluctuation in the CPUE has increased for both the YOY and adult indices (Figure 5.21). The regression analysis for the YOY index was not significant (p=0.578). The adult regression (p=0.081) was slightly below the acceptable alpha level of 0.10. The regression line predicted an increasing CPUE for adults over time; however, the variability in the data raises concern about the accuracy of the model (r^2=0.239).

Table 5.5 Catch data for YOY and adult southern kingfish in the NC portion of the SEAMAP Survey (1989 - 2004). YOY were less than 5.9 inches (150 mm) TL during the summer and 8.1 inches (205 mm) TL in the fall.

	Summer				Fall			
	YOY		Adult		YOY		Adult	
Year	N	Percent	N	Percent	N	Percent	N	Percent
1989	7	6.19	106	93.81	203	48.86	212	51.14
1990	75	14.23	450	85.77	241	44.82	297	55.18
1991	59	10.03	529	89.97	242	31.45	527	68.55
1992	2	0.73	278	99.27	77	17.16	374	82.84
1993	16	4.40	354	95.60	78	30.80	176	69.20
1994	19	44.19	24	55.81	260	55.16	211	44.84
1995	110	44.00	140	56.00	89	57.79	65	42.21
1996	56	32.18	118	67.82	206	68.44	95	31.56
1997	4	3.08	126	96.92	27	12.56	188	87.44
1998	43	31.78	93	68.22	191	46.10	223	53.90
1999	9	2.13	420	97.87	305	16.92	1,499	83.08
2000	11	8.94	113	91.06	172	35.83	308	64.17
2001	34	4.70	699	95.30	168	48.82	176	51.18
2002	11	5.88	170	94.12	255	6.38	3,734	93.62
2003	19	3.51	514	96.49	140	50.19	139	49.81
2004	62	4.07	1,462	95.93	973	47.98	1,055	52.02
Total	537		5,596		3,627		9,279	

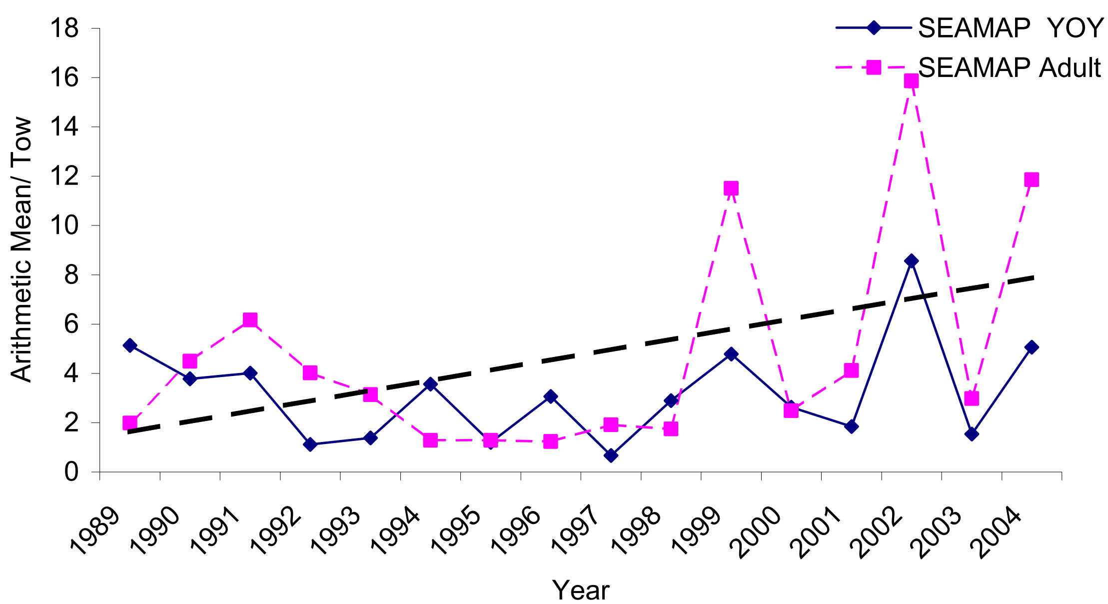

Figure 5.21 Arithmetic mean per tow from the NC portion of the SEAMAP Survey for southern kingfish YOY and adults, 1989 - 2004. The dashed line is the linearized regression of the adult CPUE.

Pamlico Sound Survey

The PSS captured 3,723 southern kingfish from 1989 to 2004 (Table 5.6). A majority (62%) was collected during the fall portion of the survey. There were 2,845 YOY collected: 2,227 in the fall and 618 in the summer. Most of the adults (73%) were collected in the summer (n = 878). The CPUE for the YOY index was variable from year to year but had a significant increase [p=0.089, r^2=0.193 (Figure 5.22)]. The adult index was more stable and also had a significant increase (p=0.024, r^2=0.316).

Table 5.6 Catch data for YOY and adult southern kingfish in the PSS (1989 - 2004). YOY were less than 6.9 inches (175 mm) TL during the summer and 7.5 inches (191 mm) TL in the fall.

	Summer				Fall			
	YOY		Adult		YOY		Adult	
Year	N	Percent	N	Percent	N	Percent	N	Percent
1989	43	81.13	10	18.87	81	93.1	6	6.9
1990	45	73.77	16	26.23	114	98.28	2	1.72
1991	48	88.89	6	11.11	162	98.78	2	1.22
1992	34	37.78	56	62.22	113	90.4	12	9.6
1993	30	27.03	81	72.97	47	77.05	14	22.95
1994	39	53.42	34	46.58	157	95.15	8	4.85
1995	40	60.61	26	39.39	263	89.76	30	10.24
1996	35	42.68	47	57.32	56	91.8	5	8.2
1997	33	36.67	57	63.33	52	82.54	11	17.46
1998	46	85.19	8	14.81	43	69.35	19	30.65
1999	40	61.54	25	38.46	135	90	15	10
2000	27	23.89	86	76.11	261	97.39	7	2.61
2001	38	44.71	47	55.29	166	95.95	7	4.05
2002	38	57.58	28	42.42	227	94.19	14	5.81
2003	46	54.12	39	45.88	204	93.58	14	6.42
2004	36	31.58	78	68.42	146	68.22	68	31.78
Total	618		644		2,227		234	

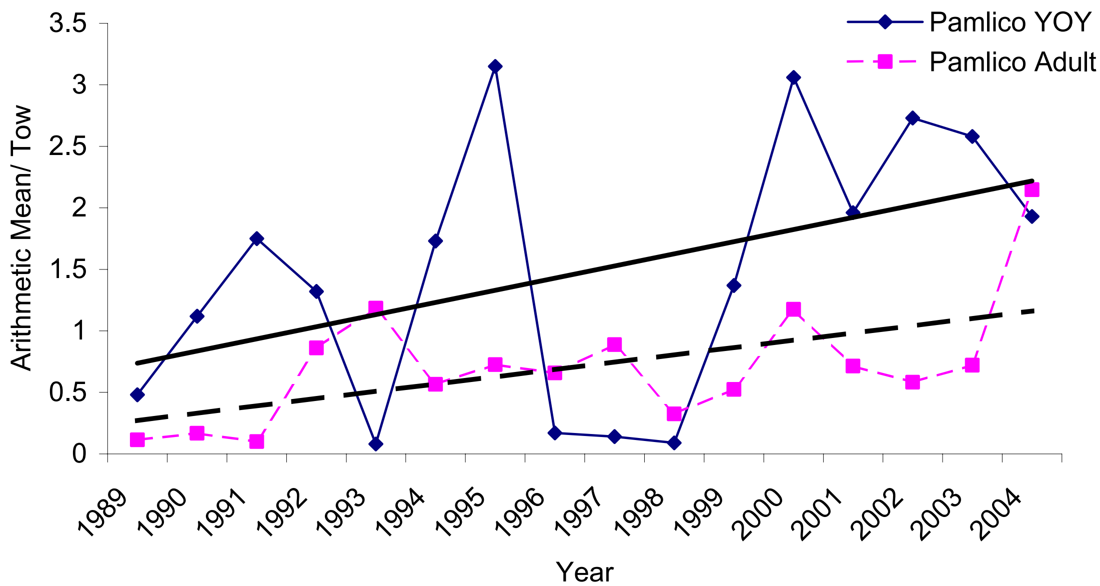

Figure 5.22 Arithmetic mean per tow of southern kingfish in the PSS for YOY and adults, 1989 - 2004. The solid line is the linearized regression of the YOY CPUE and the dashed line is the linearized regression of the adult CPUE.

The combined CPUEs for the NC portion of SEAMAP/PSS were standardized using the Z transformation and modeled for YOY and adults independently. The YOY regression model was not significant ($p=0.183$). However, the adult regression model was significant ($p=0.005$, $r^2=0.239$) and had an increasing trend (Figure 5.23).

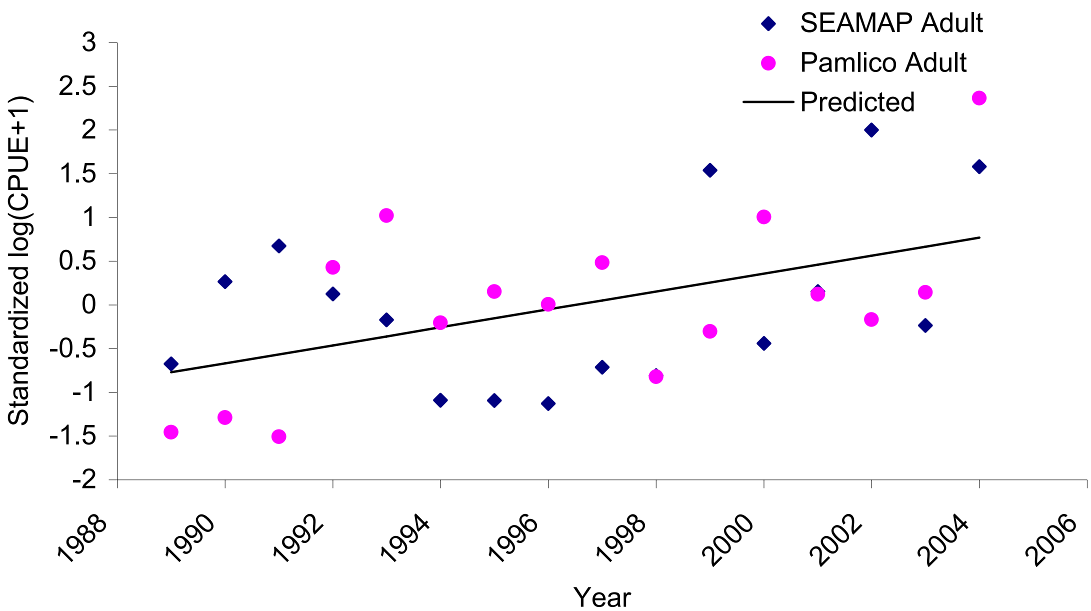

Figure 5.23. Predicted model developed using a GLM for the log transformed CPUE of SEAMAP/PSS adult southern kingfish indices ($p=0.005$).

5.3.5.5 Length Frequency

<u>Dependent</u>

Southern kingfish from the sink net fishery during the period 1992 to 2004 ranged from 8.7 to18.9 in TL (220 to 480 mm) with most fish (>70%) between 10.6 to12.6 inches [270 and 320 mm (See Appendix 4 Figure 1)]. The largest individual observed was an 18.9 inches (480 mm) but was not included in the length frequency plots. The modal size fluctuated between 11.0 and 13.4 inches (280 and 340 mm) with 11.8 inches (300 mm) modal size being most common. The largest modal size was in 1997 [13.4 inches (340 mm)]. All length frequency plots are in the Length Frequency Appendix (Appendix 4).

The southern kingfish in the ocean trawl fishery ranged from 8.7 to 17.7 inches (220 to 450 mm) with most fish between 9.8 and 12.6 inches [250 and 320 mm (App 4 Figure 2)]. The modal size fluctuated from 9.8 to13.0 inches (250 to 330 mm) with 11.4 inches (290 mm) being the most common modal size. The decrease in the harvest by fish trawls has reduced the harvest of small females.

Historically, the long haul seine fishery has accounted for only a small part (< 5%) of the southern kingfish landings. The size range of the kingfish retained for sale by the long haul seine fishery was 8.7 to 17.2 inches (220 to 430 mm) and a large percentage (>50%) of the fish were smaller than 11.4 inches [290 mm (App 4 Figure 3)]. Modal size was usually between 10.2 and 10.6 inches (260 and 270 mm).

The expanded length frequencies based on total landings from the sink net, ocean trawl, and long haul seine fisheries were combined for each year over the period from 1994 to 2004 (App 4 Figure 4). The modal size was consistently between 11.0 and 11.8 inches (280 and 300 mm) with the exception of 1997. The length distribution has remained stable due to the dominance of the sink net fishery, which is size selective and limited by minimum mesh size of 2 1/2” stretched mesh. This fishery has harvested the largest number of southern kingfish since 1997 and tended to retain larger kingfish than the other two fisheries.

Harvest numbers of southern kingfish in the ocean trawl fishery were highest in 1994 and 1996 when a large number of small kingfish were harvested. However, the number of fish harvested smaller than 9.8 inches (250 mm) from the combined harvest of sink net, ocean trawl, and long haul seine fisheries has decreased since the ocean fishery was eliminated south of Cape Hatteras in 1998. This increase in size has allowed a higher percentage of southern kingfish to reach sexual maturity prior to being harvested.

The southern kingfish in the recreational harvest had a larger size range (6.0 to 17.8 inches [150 to 440 mm]) than fish from the commercial fisheries (App 4 Figure 5). The modal size varied from 10.2 to 12.6 inches (260 to 310 mm) with 11 and 11.4 inches (280 and 290 mm) the most common modal lengths. There was no apparent trend due to low sample sizes in some years.

The average proportion of southern kingfish greater than 13.0 inches (330 mm) in the recreational fishery from 1992 to 2004 (14.4%) was similar to the percent frequency of kingfish in the sink net (16.7%) and ocean trawl fisheries (14.4%) greater than 13.0 inches. The long haul seine fishery had fewer fish greater than 13.0 inches (7.8%). The catchability of these larger/older fish may decrease as kingfish increase in length/age or fish may die due to natural and fishing mortality prior to reaching sizes larger than 13.0 inches. However, changes in the percent composition of the larger individuals overtime can provide evidence of growth overfishing. The yearly plots of the percent of southern kingfish greater than 13.0 inches did not have a consistent trend across fisheries (Figure 5.24). The sink net fishery had a decreasing trend in the percent greater than 13.0 inches while the MRFSS data were more positive. The decreasing trend in the sink net fishery could be explained by a shift of sampling effort by NCDMF and this shift in sampling effort was a major flaw in the attempt to conduct an age-based stock assessment. Most dependent samples prior to 2000 were from the weakfish fishery, which used sink nets with mesh sizes larger than mesh sized typically used to target kingfish. The length frequencies observed in more recent years are more representative of the harvested population than data from prior to 2000 yet a decreasing trend was still present (Figures 5.24 and App 4 Figure 1).

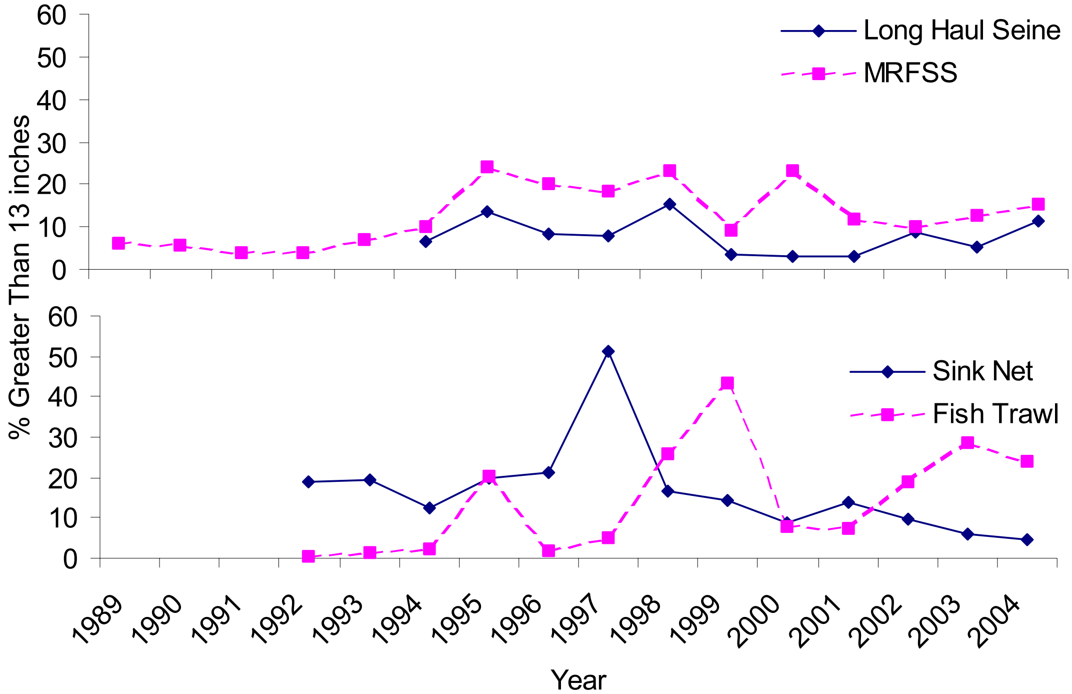

Figure 5.24 The yearly percent of southern kingfish greater than 13.0 in harvested in the sink net, long haul seine, fish trawl, and recreational (MRFSS) fisheries.

The percent of fish in MRFSS data greater than 13.0 inches was over 10% of the total fish measured every year since 1993 with the exception of 1999. The percent of fish greater than 13.0 inches was greater than 20% of the total fish measured from 1995 to 1998 and 2000. Also, the increasing trend in the number of citations issued by NCDMF indicates the presence of more fish larger than 13 inches. NCDMF awards citations for hook and line caught kingfishes that weigh 1.5 lb or greater. The number of citations issued since 1996 had an increasing trend with the exception of 2001, when only 102 citations were issued (Figure 5.25).

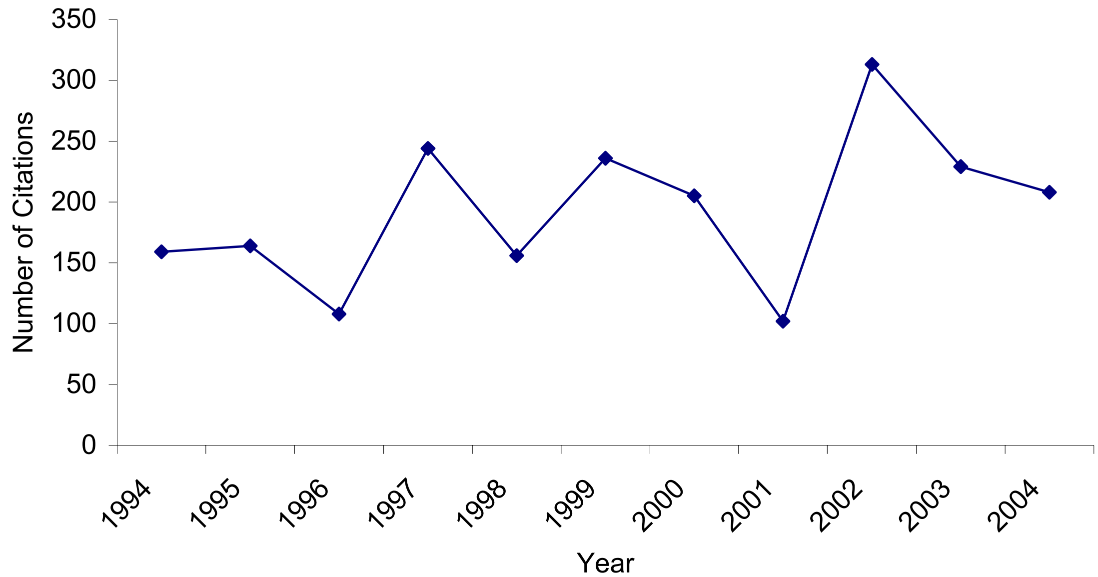

Figure 5.25. The number of citations rewarded by NCDMF to recreational fishermen for kingfishes greater than 1.5 lb.

Independent

The summer and fall SEAMAP surveys off NC caught 15,487 southern kingfish from 1989 to 2004. The SEAMAP survey captured a larger modal size fish than the PSS over the same time period. These differences could be an artifact of gear selectivities and/or sampling location. Southern kingfish lengths ranged from 2.4 to 15.3 inches (60 to 390 mm) with most fish (72%) being 7.9 inches (200 mm) and greater in SEAMAP surveys (App 4 Figure 6). The modal sizes ranged between 5.1 and 10.2 inches (130 and 260 mm) with 7.1 inches (180 mm) being the most common. No clear trend in the length distribution was evident.

The PSS caught 3,723 southern kingfish from 1989 to 2004. These ranged in length from 1.6 to 14.6 inches (40 to 370 mm) with greater than 70% smaller than 7.9 inches [200 mm (App 4 Figure 7)]. The modal size has fluctuated from 3.9 to 11.4 inches (100 to 290 mm) with a mode less than 5.9 inches (150 mm) in most years. There has been no discernable trend in the distribution of southern kingfish lengths in the PSS.

5.3.5.6 Population Age Structure

The theoretical survivorship curves indicated few individuals (<15%) would be remaining in the populations of kingfishes after age 3 even if no fishing occurred (Table 5.7). The model predicted the population would have 57.7% of the starting population remaining at age 1 and only 33.3% remaining after age 2 assuming no fishing mortality. Few kingfish would survive to age 4 (11%). The number surviving to each age class decreased as the fishing mortality (F) rate increased with an F of 1.0 having less than 1% alive at age 4 (Table 5.7 and Figure 5.26).

Table 5.7 Percent surviving at age for kingfishes with a constant natural mortality rate of 0.55 over a range of fishing mortality rates.

	Fishing Mortality				
Age	0	0.25	0.5	0.75	1
0	100	100	100	100	100
1	57.7	44.9	35.0	27.3	21.2
2	33.3	20.2	12.2	7.4	4.5
3	19.2	9.1	4.3	2.0	1.0
4	11.1	4.1	1.5	0.6	0.2
5	6.4	1.8	0.5	0.2	0.0
6	3.7	0.8	0.2	0.0	0.0
7	2.1	0.4	0.1	0.0	0.0
8	1.2	0.2	0.0	0.0	0.0

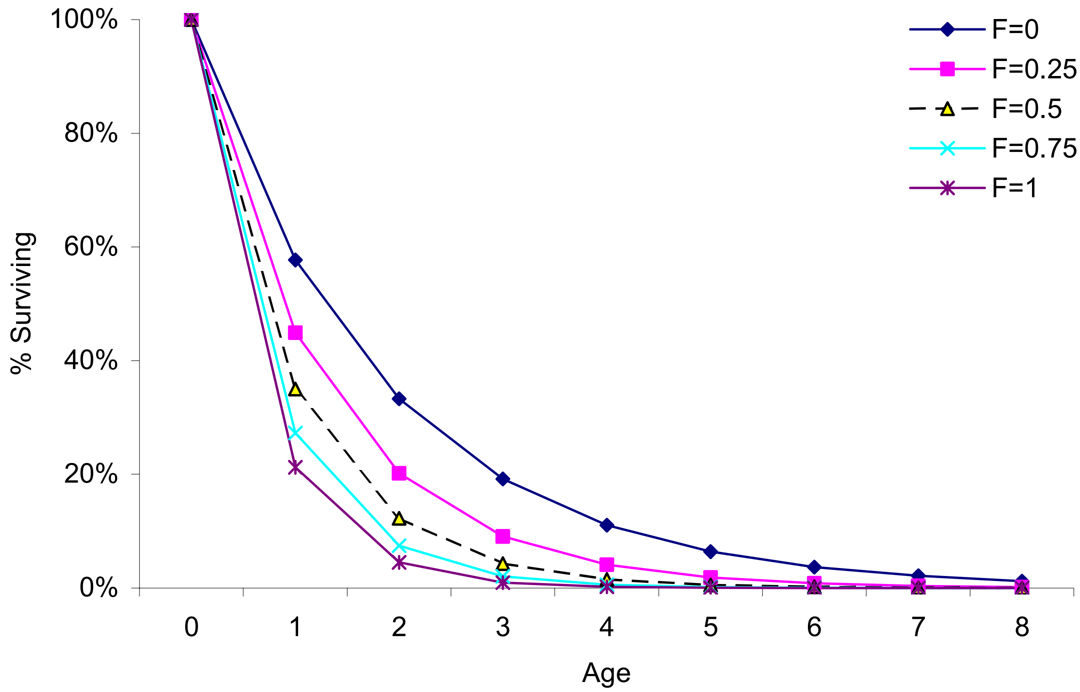

Figure 5.26 Survivorship curves for kingfishes experiencing a constant natural mortality rate of 0.55 and a range of fishing mortality rates.

The hypothetical lines where no fishing occurred and with a fishing mortality rate of 1.0 are displayed with the percent age composition of 1996 and 2002 SEAMAP aging data (Figure 5.27). Although a fishing mortality rate of 1.0 is high for a population with a natural mortality rate of 0.55, this curve indicates that the fishing mortality rate is likely below 1.0 and the age structure was improving in more recent years. The 2002 SEAMAP female aging data had higher percentage of fish at age 2 and 3 compared to the 1996 data set, which is indicative of a population that is recovering. Males also had a higher percent at age in the 2002 data set for ages 2, 3, and 4 (1996 n=1,065 and 2002 n=552). These data can be heavily influenced by changes in the recruitment in any year class since the number in the other year classes influences the percent in each year class.

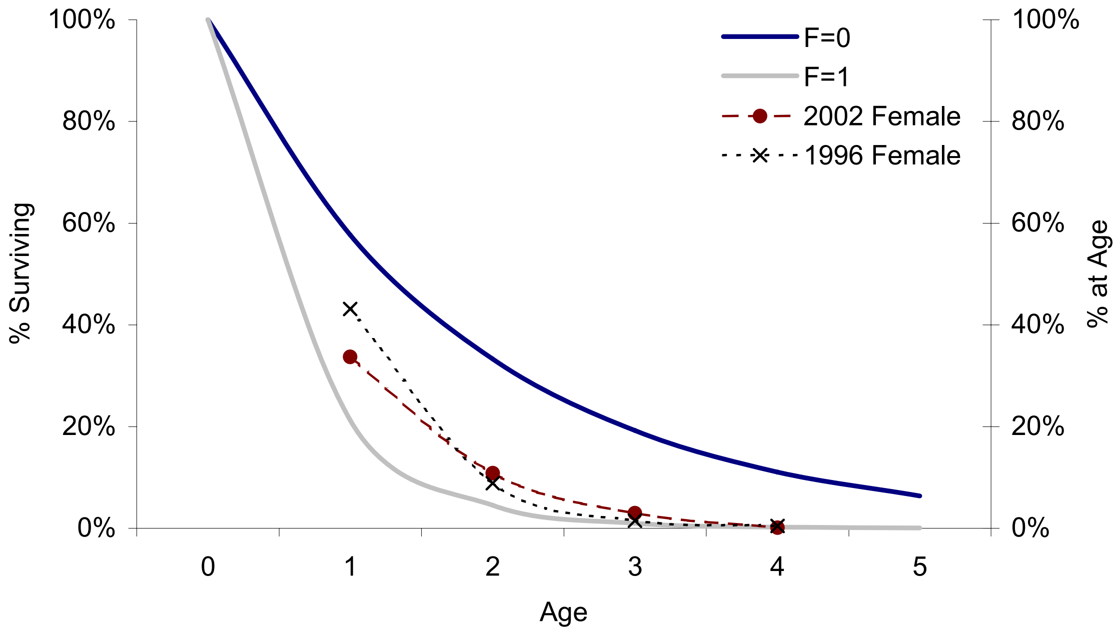

Figure 5.27 Survivor curves and percent at age for female southern kingfish aged in the SEAMAP Survey (1996 n=1,488 and 2002 n=735).

The catch at age keys developed for southern kingfish females caught in the ocean sink net (Figure 5.28) and recreational (Figure 5.29) fisheries indicated fish from age 0 to age 6 were present. Ages 1 to 3 were the most common and accounted for 91% of the harvest. From the survivorship curve, it was predicted that few fish (<10%) would survive to age 3 with a fishing mortality rate of 0.25. The catch at age for these fisheries indicated that 23% of the average of total number caught from 2002 to 2004 were age 3, 6% were age 4, and 1% were age 5. This catch at age for these fisheries represent landings from a population that appears to have a healthy age distribution. Additionally, age 6 was the maximum observed age for females from 2002 to 2004, which was the same maximum age observed in a past study of southern kingfish in the South Atlantic (Smith and Wenner 1985).

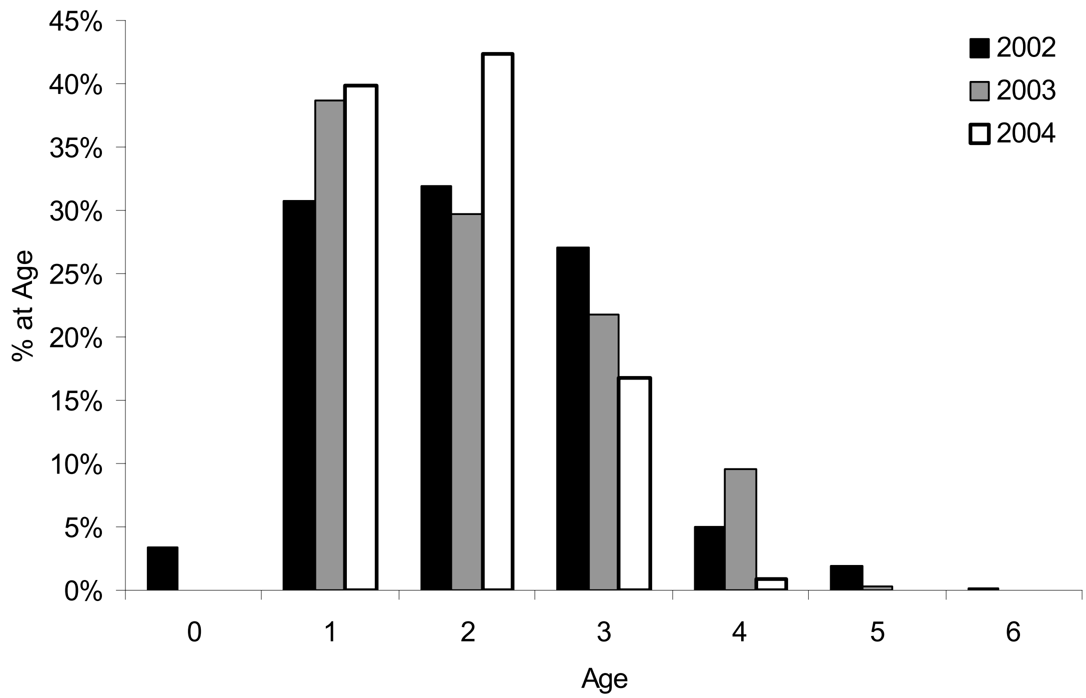

Figure 5.28 Catch at age of southern kingfish for the NC sink net fishery, 2002 - 2004.

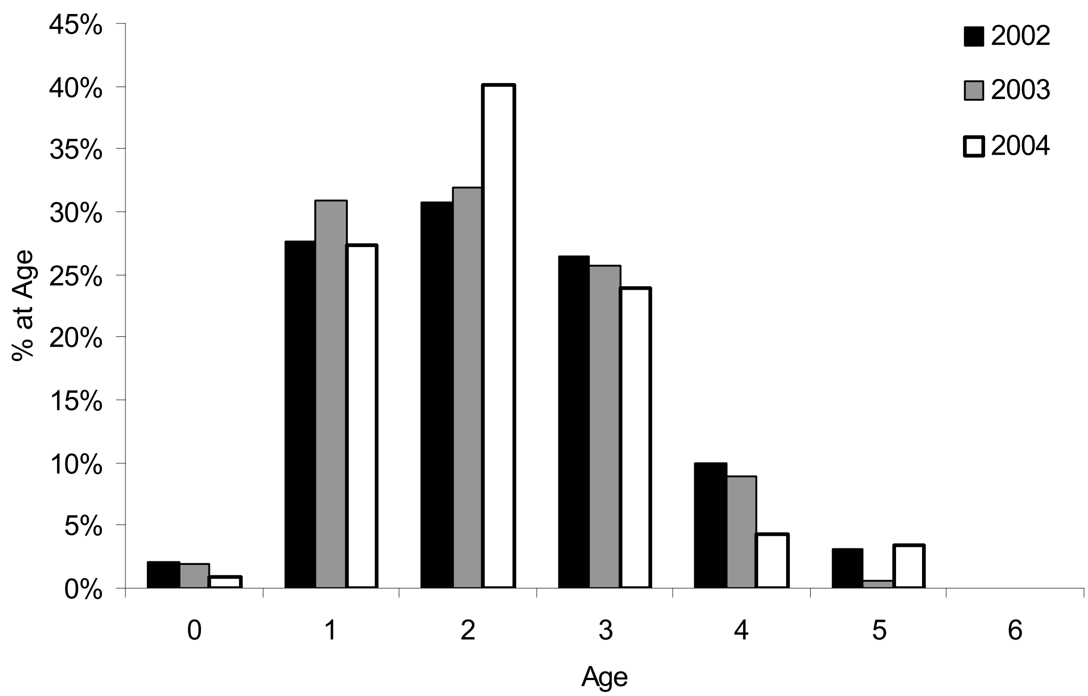

Figure 5.29 Catch at age of southern kingfish for the NC recreational harvest, 2002 - 2004.

5.3.6 Discussion

A concern for the kingfish population was the sharp decline in the combined recreational and commercial landings for the South Atlantic from 1986 to 1998 (Figure 5.30) and for NC from 1993 to 1998 (Figure 5.31). The decline may have been due to a decrease in the kingfish population, decreasing effort in the fisheries, and/or regulations on the shrimp trawl, gillnet, and ocean trawl fisheries. This concern is somewhat offset since negative trends were not observed in any of the regression analyses for fishery dependent and independent data from the South Atlantic, FL, or NC. The Z transformed GLM of the CPUE for sink net and MRFSS from NC had an increasing trend. The combined GLM approach for the SEAMAP/PSS for adults had a significant increase in the CPUE. Additionally, both the adult SEAMAP and PSS surveys had an increasing trend in arithmetic mean per tow.

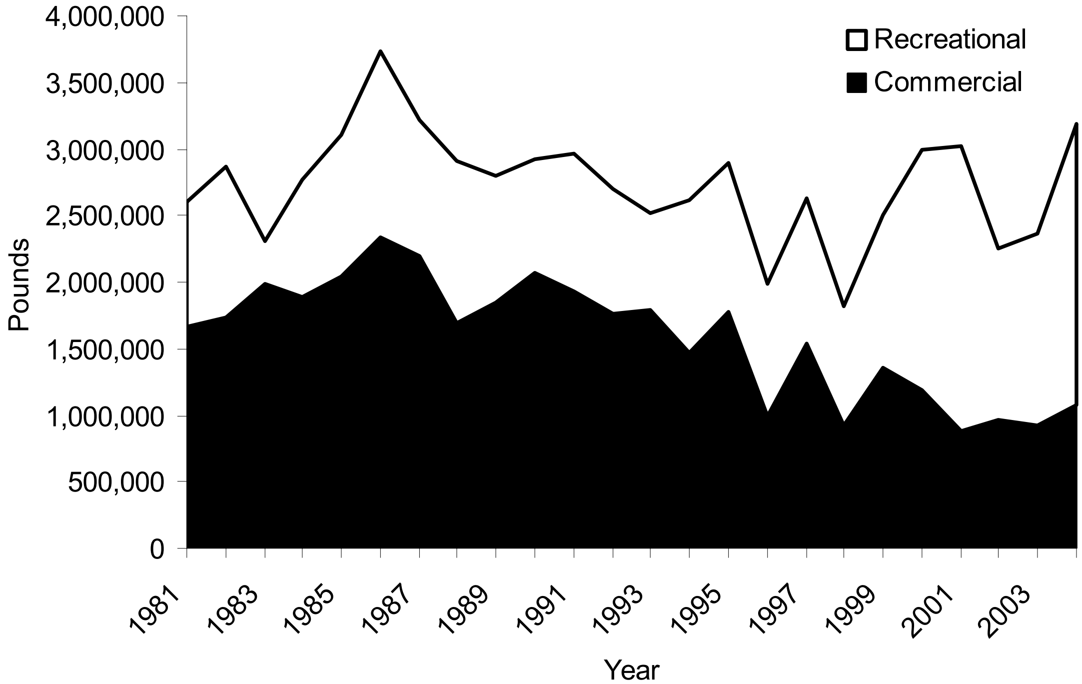

Figure 5.30 Recreational and commercial landings of all kingfishes in the South Atlantic, 1981 - 2004.

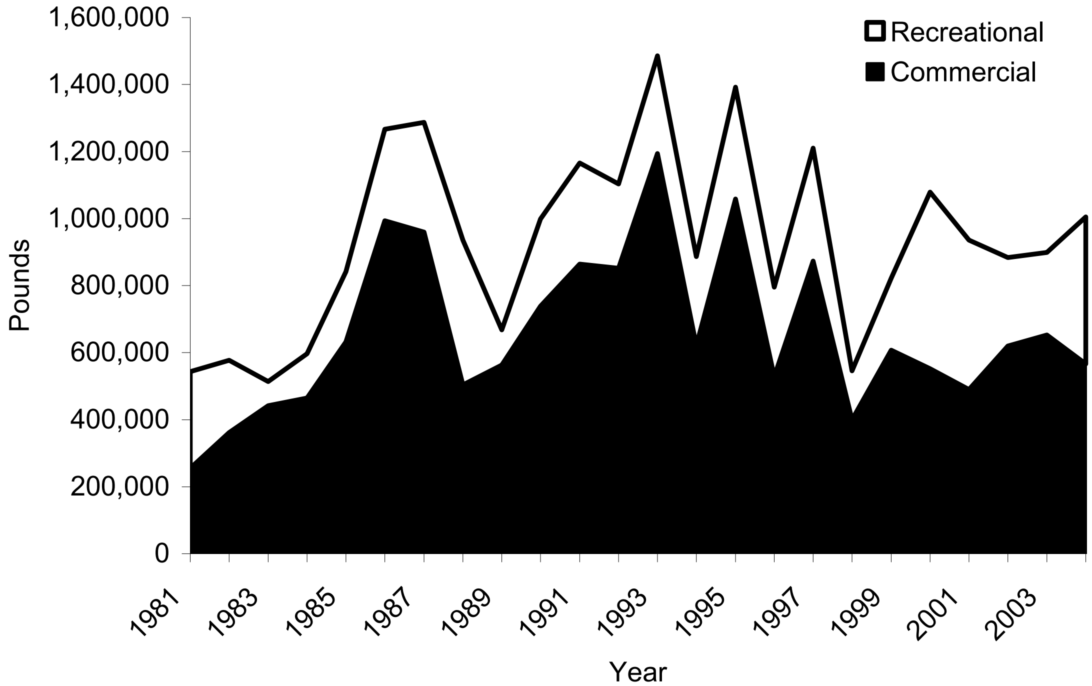

Figure 5.31 Recreational and commercial landings of all kingfishes in NC,1981 - 2004.

Although the annual range in the length frequency data for NC southern kingfish has not changed from 1992 to 2004 as one might expect from a population that shows positive trends in abundance, the interpretation of length frequencies from commercial fisheries can be misleading. Commercial gears are often size selective (Hilborn and Walters 1992; Haddon 2001). Despite the selective nature of the commercial fisheries, both the commercial and recreational fisheries have similar length frequencies and a similar percent of fish greater than 13 inches. The similar length frequencies among the different fisheries through time indicate that growth overfishing may not be occurring. However, the sexually dimorphic growth rate observed in kingfish and selectivity of commercial gear may limit our ability to detect changes in the length frequency distributions. Therefore, age data should provide more insight into the health of the population.

The age structure of the population of southern kingfish appears healthy in the South Atlantic and in NC. Evidence of this was supported by the increase in percent at age greater than 2 for the survivorship curve with SEAMAP aging data and the distribution of ages in the harvest ranging from age 0 to 6. Fish aged in 2002 in the SEAMAP data set had a higher percentage of age 2 and 3 individuals for females and age 2, 3, and 4 for males when compared to 1996. The age distribution of female southern kingfish indicated that a majority of the harvest was individuals age 1 to 3 with a maximum age of 6. Combined, these data indicate older, more fecund females are present in the population and the current maximum age observed in the harvest is the same as observed in a past aging study on southern kingfish (Smith and Wenner 1985).

The apparent expansion of the age structure from 1996 to 2002 could be due to several regulations that impacted commercial fisheries since 1992. The incorporation of bycatch reduction devices (BRD) into shrimp trawls was initiated in October of 1992. The flynet closure south of Cape Hatteras beginning in 1993 significantly reduced the harvest of small individuals. Although both of these regulations were passed to protect weakfish stocks, the regulations had a positive impact on stocks of kingfishes by reducing the overall number harvested and protecting smaller fish.

The shrimp trawl fishery also had regulations passed that helped to reduce the harvest of kingfishes. The mandatory use of excluder devices (TED and BRD) in the shrimp trawl fishery decreased the bycatch in this fishery. The "50-50" rule (1998) limited the shrimp and crab trawl fisheries to a possession limit of no more than 50% of the total catch biomass could be finfish (from December 1 to March 31). The final and only rule directed for kingfishes was a bycatch trip limit of kingfish not to exceed the harvest of shrimp or crabs by 300-pound in trawls south of Bogue Inlet (December 1 to March 31). These rules have had a positive impact on the stock of kingfishes and ensured that a targeted trawl fishery for kingfishes would not be initiated.

Additionally, the gillnet ban in FL (< 3 miles) was enacted during the time period of the apparent improvement of the kingfishes stock and likely had a positive impact on kingfish populations. In 2004, FL had a rapid expansion in a gillnet fishery targeting kingfish (> 3 miles), and landings were similar to those prior to the inshore gillnet ban. However, the gillnet fishery for kingfishes off FL was restricted in 2006 due to a take of a right whale (*Eubalaena glacialis*) in the gillnet fishery off FL (Southeast Fishery Bulletin FB06-007). The ocean west of 80° 00' W longitude and between 27° 51' N (near Sebastian Inlet, FL) and 32° 00' N (GA/SC border) latitude was closed to gillnetting from February 2006 to March 2006. Another emergency rule was enacted from November 15th 2006 until April 15th 2007, which eliminated gillnet fishing in the ocean from west of 80° 00' W longitude between 29° 00' N (New Smyrna Beach, FL) and 32° 00' N (GA/SC border) (US Office of the Federal Register 2006b). A permanent rule is now in effect.

The majority of the signs for the southern kingfish stock are encouraging: increasing trends in dependent and independent CPUEs, regulatory protection in the trawl fisheries, an increase in the number of citation fish being captured by recreational fishermen, no clear sign of growth overfishing, and a healthy age structure. A more detailed analysis using a stock assessment for the Atlantic coast unit stock would provide a more precise estimate of the current status of the stock.

5.3.7 Research Recommendations

A stock assessment should be completed for the Atlantic coast unit stock of southern kingfish using an age-structured population model and complemented with a biomass dynamic model or other accepted stock assessment model. The stock assessments that were attempted by NCDMF were not accepted in peer review due to deficiencies in the data. Research should be initiated to address these deficiencies. First, fishery dependent and independent sampling for age structures and length distribution should be continued and expanded to provide more extensive and better quality data for the next assessment. The collection of age data from these two survey types should be designed differently. The collection of aging data from an independent survey should use a random sampling design while the dependent sampling would continue as currently designed to collect fish based on length. The age structure for fish collected in the independent study could be used to describe the age structure in the population through time where as the dependent sampling could be used to develop growth curves and get estimates of maximum age. These additional data will allow NCDMF to have more flexibility in the choice of an appropriate stock assessment model. It should be noted that a sufficient time span (one generation) of quality data will be required before the suggested age structured model would be applicable.

Second, the landed and discarded catch of kingfishes in shrimp trawls has not been adequately sampled. Several studies have been conducted to address the bycatch in the shrimp trawl fishery but the results documented few kingfishes as bycatch (Diamond-Tissue 1999; Taylor and Donello 2000; Ingraham 2003; Johnson 2003). Shrimp trawl landings and discards need to be sampled for length frequencies to increase the accuracy of an age-structured assessment. The lack of reliable discard data was a major deficiency in data available for an assessment since this non-directed fishery accounted for 23% of the NC commercial harvest from 1994 to 2004.

Third, discard estimates from all commercial and recreational fisheries should be improved. The current at-sea observer program should continue and be evaluated for improved effectiveness. Since the amount of discards and mortality rate of the discards are likely to be highly dependent on gear type and time of year, the number of discards (with size) and mortality rate should be determined for each gear type by season.

Fourth, gear used in fishery dependent and independent surveys may exclude the largest/oldest fish and limit conclusions drawn using these adult indices. The NCDMF conducts an independent gill net program that targets various adult finfish species, however kingfish sample sizes are small and the program has only been conducted since 2001. This program should be expanded to include statewide coastal coverage. A sampling methodology should be developed to incorporate all habitats of kingfishes, particularly the near shore ocean. The development of an adult specific fishery independent survey would greatly improve estimates from a stock assessment.

Finally, this trend analysis concentrated on the NC portion of the southern kingfish stock. It assumed that kingfish stocks would be affected primarily by regional regulations and management. It is extremely important to define the stock structure and mixing of populations, if any. This will determine if regional management or coast wide management is required. A tagging study would provide the most useful information, but would need to be conducted at a minimum along the South Atlantic. A properly designed tagging study would provide data to determine the amount of mixing along the coast, to estimate the population size, and to estimate mortality rates with increased accuracy.

6. STATUS OF FISHERIES

6.1 COMMERCIAL FISHERIES

Kingfishes are commercially important to the state of North Carolina due to the high quality of their flesh. Landings increased during the early 1900's reaching a peak in 1954 at 1.8 million lb (Figure 6.1). Landings dropped after 1954 and fell to a low in 1976 of 123,700 lb. Landings rebounded in the 1980's and 1990's. After 1993, the landings decreased again. The landings have stabilized at approximately 500,000 lb per year since 1999. These fluctuations may be due to changes in environmental conditions (i.e. water temperatures and salinities that prevail in nursery areas (see Life History Section)), fishing pressures, population size, and/or regulations.

Landings reported in the following commercial sections will be reported for all three species as a single unit. Commercial fishermen rarely differentiate the kingfishes since all three species occur in the same general areas. Southern kingfish are the most common of the three species in North Carolina based on observations of commercial fisheries.

The gears that harvest the majority of the landed kingfishes are fish trawls, gill nets, and shrimp trawls. Historically, the fish trawl fishery landed the majority of landings from 1950 to 1979. The targeted gill net fishery for kingfishes became the dominant gear in 1981. The gillnet has remained the dominant gear since 1984.

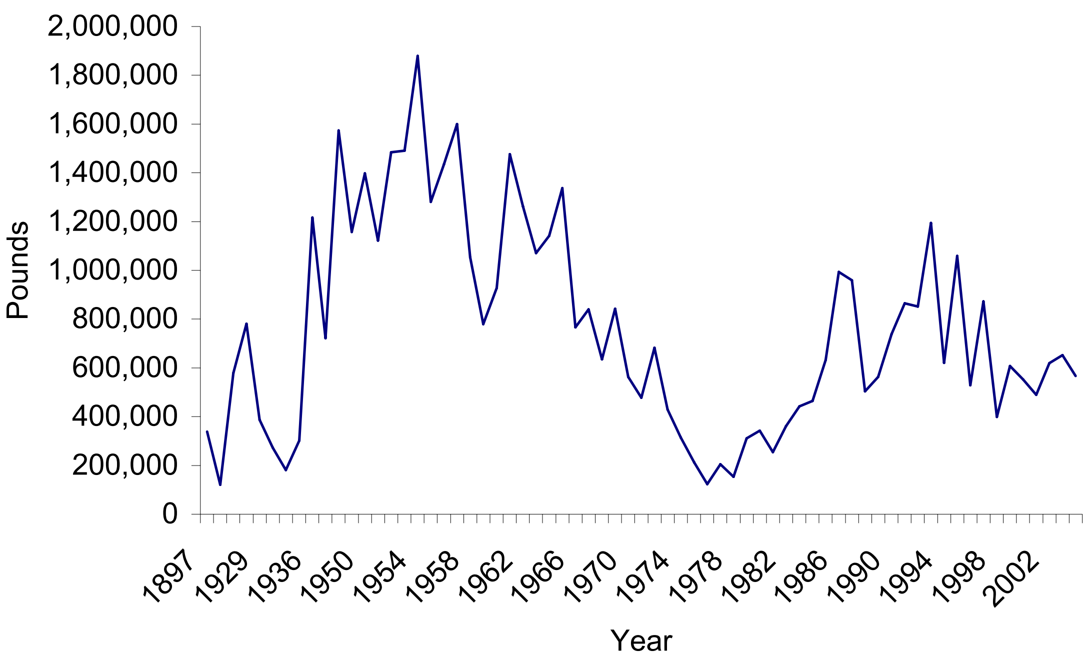

Figure 6.1 Commercial landings of kingfishes, 1897 - 2004. Prior to 1950 data were not reported annually.

6.1.1 Collection of Commercial Statistics

North Carolina commercial fishery landings and harvest data were collected by the

NMFS and a study by Chestnut and Davis (1975) from 1950 to 1977. Landings data were expanded to include information on additional commercially important species in 1972. A cooperative statistics program between NMFS and North Carolina Cooperative Statistics Program obtained harvest data from 1978 to 1993 (Lupton and Phalen 1996). Data were gathered by surveying fish dealers for landings and value information. Although the survey provided managers with needed data, there were concerns over the reliability of the data. These concerns arose since cooperation was voluntary and not all dealers agreed to participate, which resulted in unreported landings. Another shortcoming of the program was the lack of effort data. Therefore, beginning in 1992, NCDMF began to design a mandatory trip ticket program that would provide reliable harvest and effort data at the gear/trip level. Legislation that created the NCTTP program was passed by the North Carolina legislature and data collection began January 1, 1994 (Lupton and Phalen 1996). The program requires dealers to complete a trip ticket on each transaction and to submit these reports to the NCDMF. Data collected since 1994 is considered the most reliable due to the mandatory reporting requirements of the dealers. Therefore, managers have less confidence in the data collected prior to 1994 and caution should be exercised when comparing these data to NCTTP data.

6.1.2 Primary Waters Fished

The majority of kingfishes landings from 1962 to 2004 came from the ocean (84%) and, to a lesser extent, Pamlico (9%) and Core (4%) Sounds (Figure 6.2). Landings from other water bodies only represented 3% of the total kingfishes landings. Since the inception of the NCTTP, these numbers changed little from the historical percentages. Landings from the Pamlico Sound increased slightly from 9% to 12%, while the ocean and Core Sound decreased less than 1% each.

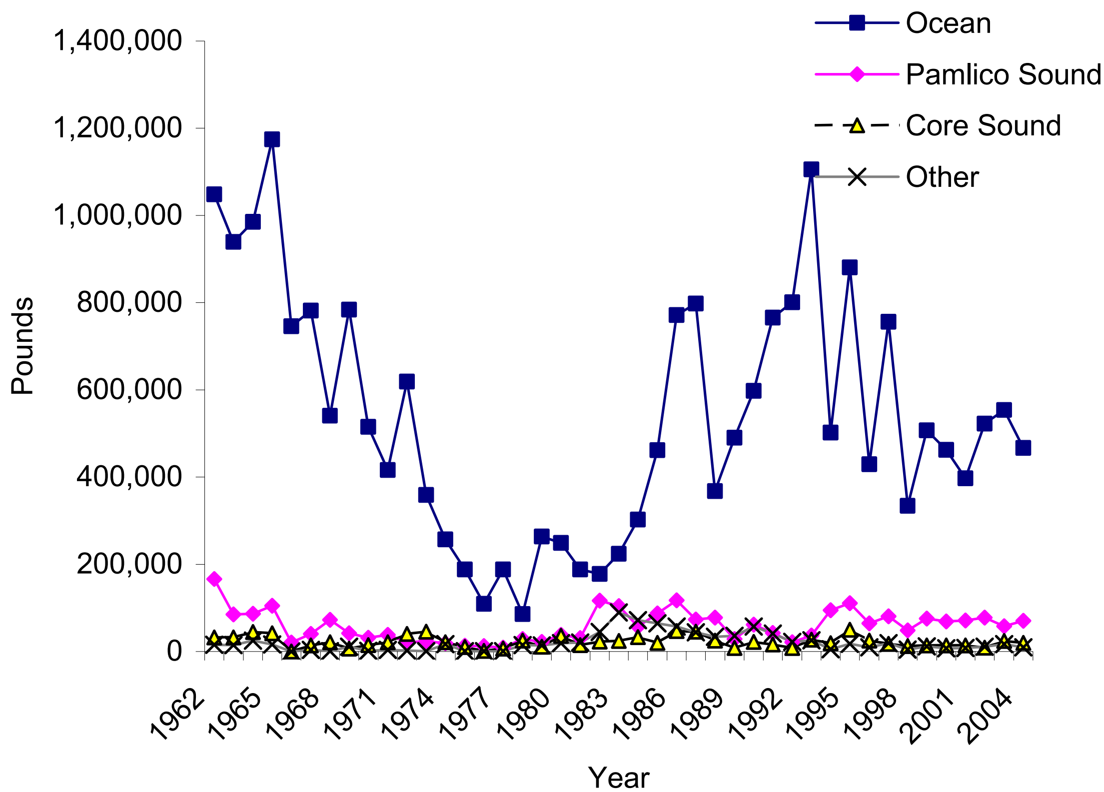

Figure 6.2 Harvest of kingfishes by water body, 1962 - 2004.

6.1.3 Primary Counties of Landings

The top five counties in landings of kingfishes over the 43-year period (in descending order) were Carteret, Onslow, Dare, Pamlico and Brunswick/New Hanover (tie). Landings by counties were examined during three different time frames: 1962 – 1971, 1972 – 1993, and 1994 – 2004 (Figure 6.3). Carteret has consistently been the highest producer of kingfishes averaging 46% of the landings since 1962. Carteret County's proportion of total landings decreased from 55% (1962-1971) to 38% (1994-2004). Onslow, Dare, Brunswick and New Hanover counties' shares increased. Onslow County had the second highest landings (15%). Landings in Onslow County were only 1% of the total landings from 1962 to 1971 but increased to 20% between 1972 and 1993. The percent contribution for Onslow County from 1994 to 2004 further increased to 24% of the landings.

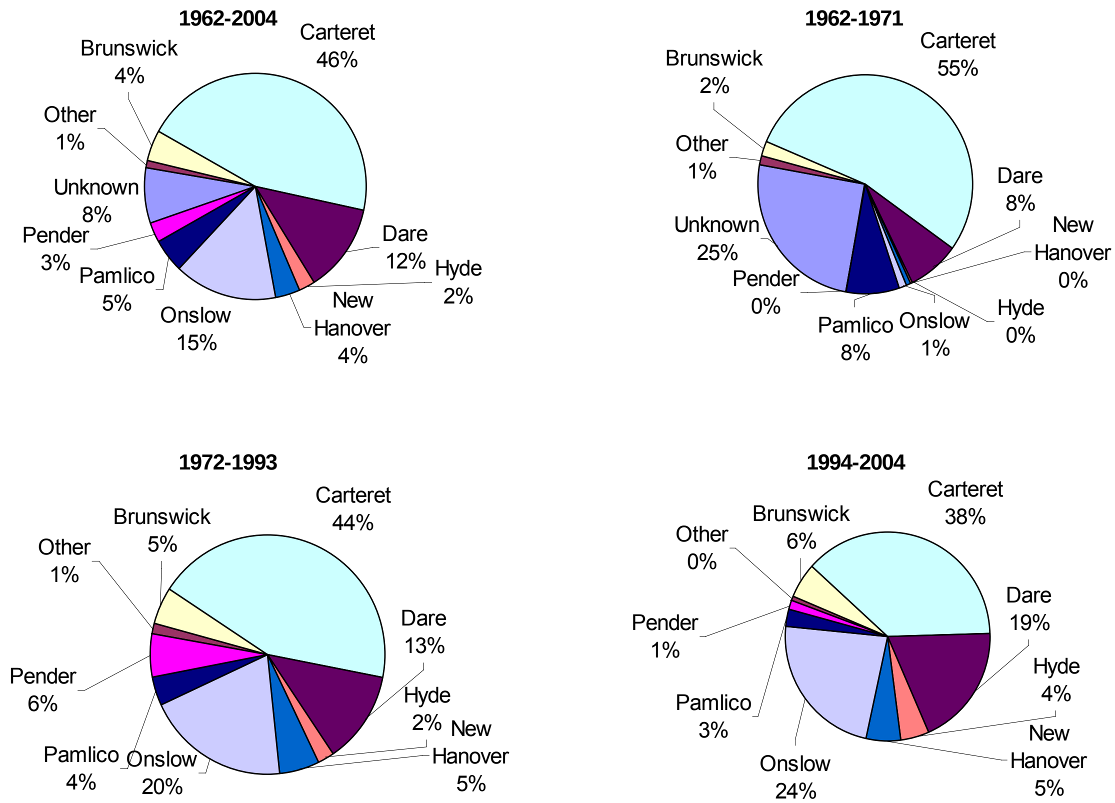

Figure 6.3 Percent of total kingfishes landings by county for 1962 - 2004, 1962 - 1971, 1972 - 1993, and 1994 - 2004.

6.1.4 Seasonal Harvest and Effort

Harvest and effort in the kingfishes fishery is seasonal with peak landings and effort occurring in the spring and fall (Figure 6.4). Peak landings (24%) and effort (17%) occurred in April from 1994 to 2004. Effort and landings decreased in May, remained low during the summer months (June through September), and then increased in October and November. November accounts for 21% of the landings and 13% of trips. The April and November peaks coincide with seasonal movements of kingfishes along the Atlantic coast (Smith and Wenner 1985).

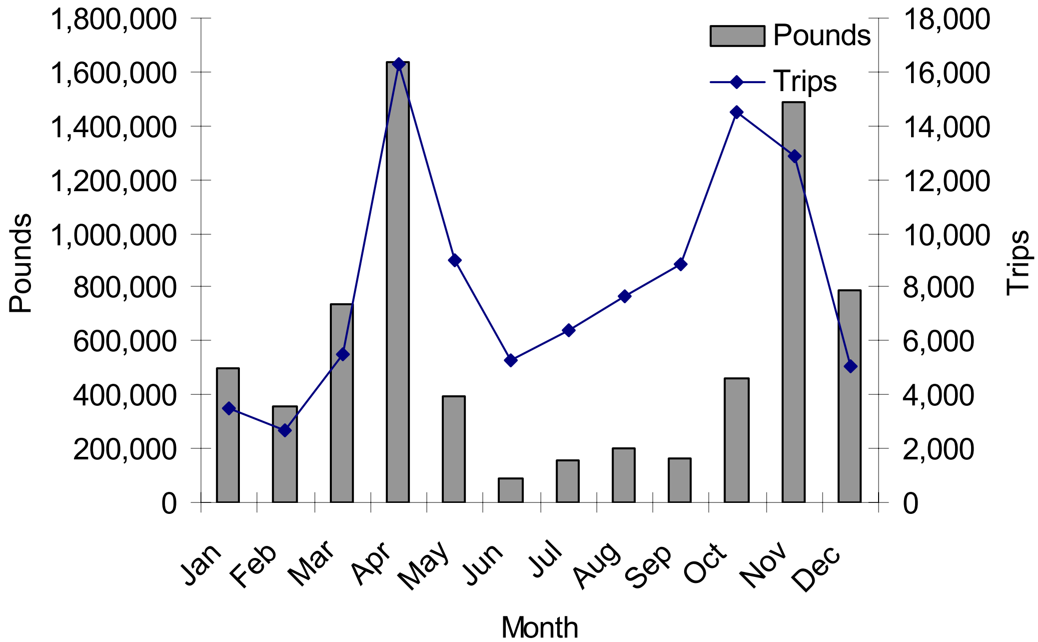

Figure 6.4 Total catch of kingfishes and trips catching kingfishes by month, 1994 - 2004.

6.1.5 Primary Gears Fished

Since 1962, fish trawls (combination of flounder trawl and flynet), gill nets, and shrimp trawls were the primary gears used to harvest kingfishes (Figure 6.5 and Table 6.1). However, the percent of kingfishes harvested with gillnets and shrimp trawls increased while the share harvested with fish trawls decreased. The mean catches for the primary gears from 1962 to 2004 were: 38% for gill nets, 30% for fish trawls, and 16% for shrimp trawls. Since 1994, the gill net fishery has dominated the landings (62%) while shrimp trawls ranked second (23%) and fish trawls third [8% (Figure 6.6)]. Fish trawls were restricted beginning in 1993 and a rule was implemented in 1996 banning fish trawls (specifically flynets) south of Cape Hatteras to the South Carolina line. This rule has reduced the number of kingfishes harvested by fish trawls.

The landings by gear differed among water bodies. Fish trawls were used almost exclusively in the ocean (Figure 6.7). Gill nets, shrimp trawls, long haul seines and other gears had catches in the ocean, Pamlico and Core sounds, and other areas. Landings in gill nets (87%) and shrimp trawls (68%) were highest in the ocean. Long haul seines had their highest landings in the Pamlico and Core sounds. The other category (including beach seines, hook and line, crab pots, etc.) had most of its landings come from the beach seine fishery (83%), which was primarily prosecuted in the ocean.

The length of the vessel varied by the fishery and was analyzed by combining all gear trips and landings. Boats between 10 and 30 ft using gillnets were the most common vessel/gear combination (39%) and boats between 30 and 50 ft using gillnets made an additional 10% of the trips. Fish trawl trips were most frequently made in boats greater than 50 feet but only accounted for 1% of the trips. Shrimp trawl trips were made in boats ranging from 10 to greater than 50 feet with boats greater than 50 ft making the largest percent of the trips.

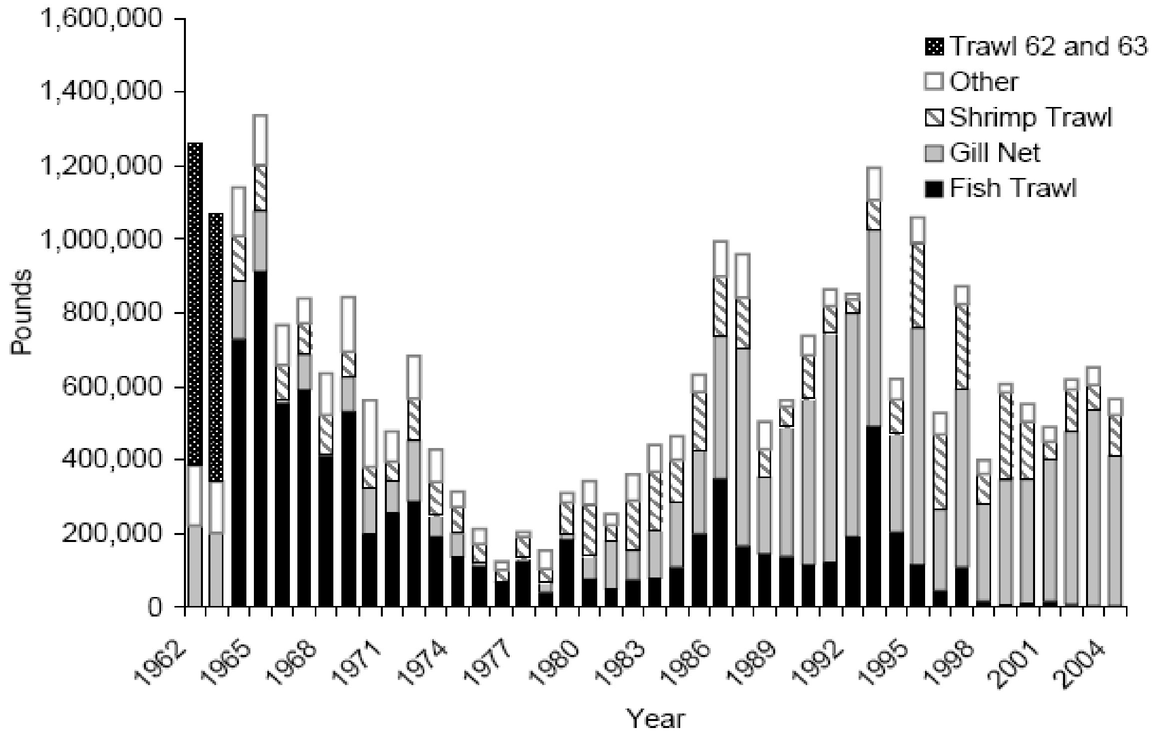

Figure 6.5 Landings of kingfishes (lb) by gear, 1962 - 2004. The trawl fisheries were not distinguished between shrimp and fish trawls in 1962 and 1963.

Table 6.1 NC commercial landings (lb) by gear from 1962 to 2004.

Year	Gill Net	Trawl*	Fish trawl	Shrimp trawl	Long haul seine	Beach seine	Other	Total
1962	222,400	877,500			151,900	0	10,500	1,262,300
1963	202,300	729,300			134,700	0	5,000	1,071,300
1964	157,400		729,500	120,400	82,800	51,200	0	1,141,300
1965	163,800		912,500	124,700	85,000	51,000	0	1,337,000
1966	11,400		553,200	93,900	10,100	95,000	3,000	766,600
1967	95,600		591,600	83,700	23,400	37,000	8,000	839,300
1968	3,600		411,400	106,100	15,600	92,000	6,700	635,400
1969	93,300		532,000	69,900	4,600	133,000	9,900	842,700
1970	127,200		198,300	56,000	19,200	153,800	8,500	563,000
1971	87,800		256,500	51,200	31,600	48,200	2,900	478,200
1972	164,812		287,979	114,950	22,340	68,892	24,075	683,048
1973	57,565		191,901	90,999	47,472	36,404	4,306	428,647
1974	64,918		136,641	70,755	24,301	15,597	2,372	314,584
1975	11,743		111,067	48,596	15,514	23,373	2,237	212,530
1976	1,906		68,459	31,068	3,659	16,583	2,221	123,896
1977	9,972		124,426	56,540	7,310	5,291	1,064	204,603
1978	25,126		41,574	38,286	41,168	2,730	5,070	153,954
1979	17,855		183,348	83,755	19,268	0	6,277	310,503
1980	62,165		77,081	139,103	54,717	**	9,414	342,605
1981	130,831		49,787	43,026	27,809	0	3,198	254,651
1982	80,927		74,573	133,508	54,384	308	17,352	361,052
1983	129,925		78,781	158,945	44,450	19,072	10,708	441,881
1984	175,815		109,917	114,745	51,534	5,270	7,070	464,351
1985	225,199		199,811	160,075	40,268	2,299	4,788	632,440
1986	387,691		349,175	162,440	84,993	3,334	5,757	993,390
1987	536,566		167,130	137,750	96,120	14,213	8,149	959,928
1988	208,958		144,644	75,218	64,554	7,479	3,096	503,949
1989	351,193		138,338	54,143	13,772	3,836	1,142	562,424
1990	451,023		115,625	117,732	35,891	14,464	3,877	738,612
1991	622,381		121,753	73,913	29,097	15,050	2,457	864,651
1992	606,721		192,143	38,006	2,203	10,316	2,319	851,708
1993	534,047		490,679	80,652	32,289	54,109	2,448	1,194,224
1994	265,730		204,606	94,716	28,894	22,370	4,572	620,889
1995	643,314		115,974	229,930	25,437	40,529	3,601	1,058,785
1996	219,150		46,363	203,158	22,102	34,960	2,528	528,260
1997	484,830		109,552	229,096	17,993	28,057	3,360	872,888
1998	263,834		17,295	80,470	17,143	17,250	3,321	399,313
1999	339,097		7,146	237,542	13,274	7,633	2,774	607,465
2000	335,063		11,702	156,961	15,570	30,236	2,409	551,940
2001	384,821		17,024	47,564	17,143	20,081	3,109	489,743
2002	468,439		9,239	114,947	10,828	14,361	1,922	619,737
2003	532,742		3,785	68,093	29,318	9,857	8,841	652,636
2004	407,870		4,515	109,009	29,014	14,358	1,893	566,659

*Trawl was only used in 1962 and 1963. Afterwards trawls were separated to shrimp and fish trawl.
** Indicates confidential data.

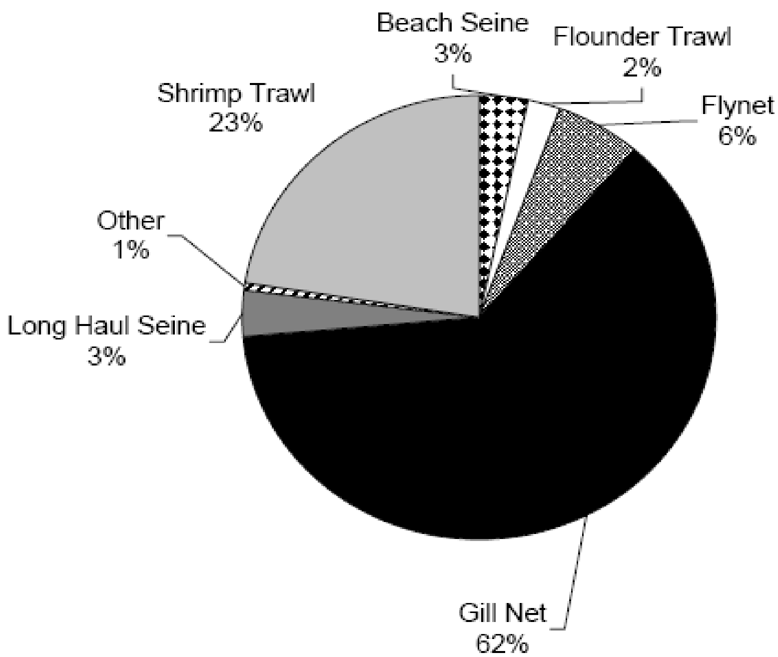

Figure 6.6 Percent landings of kingfishes by gear type, 1994 - 2004.

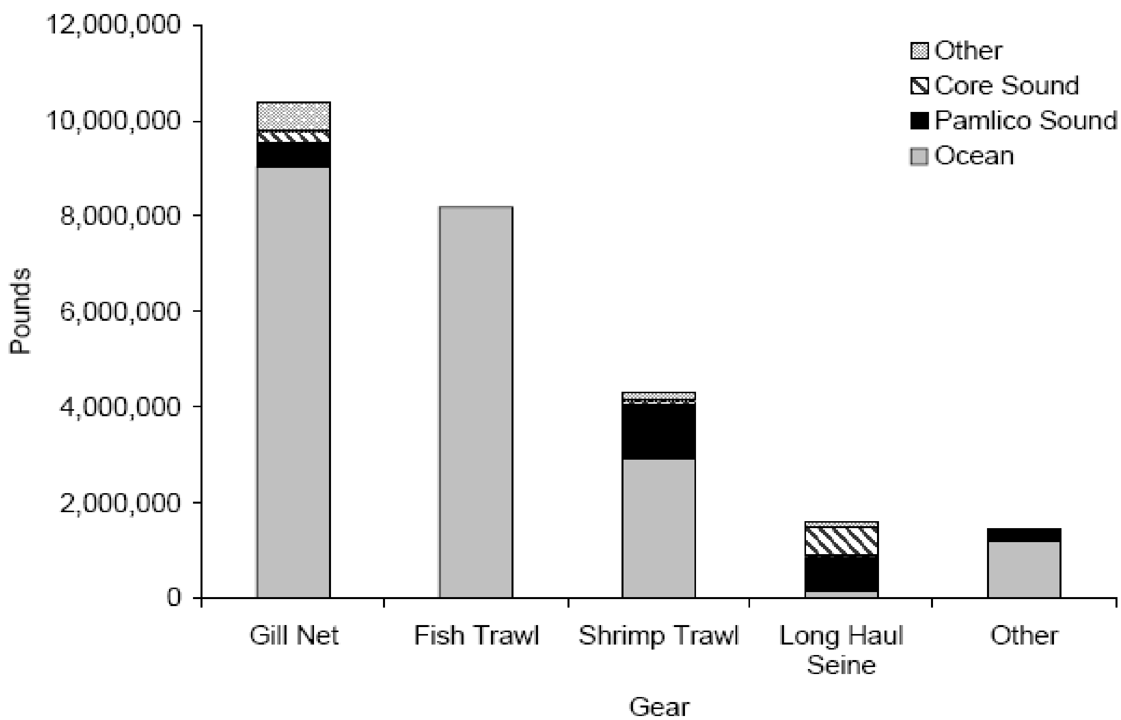

Figure 6.7 Combined catches of kingfishes by water body and gear, 1962 - 2004. Excludes landings from trawls from 1962 and 1963 since the landings were not designated as shrimp or fish trawl.

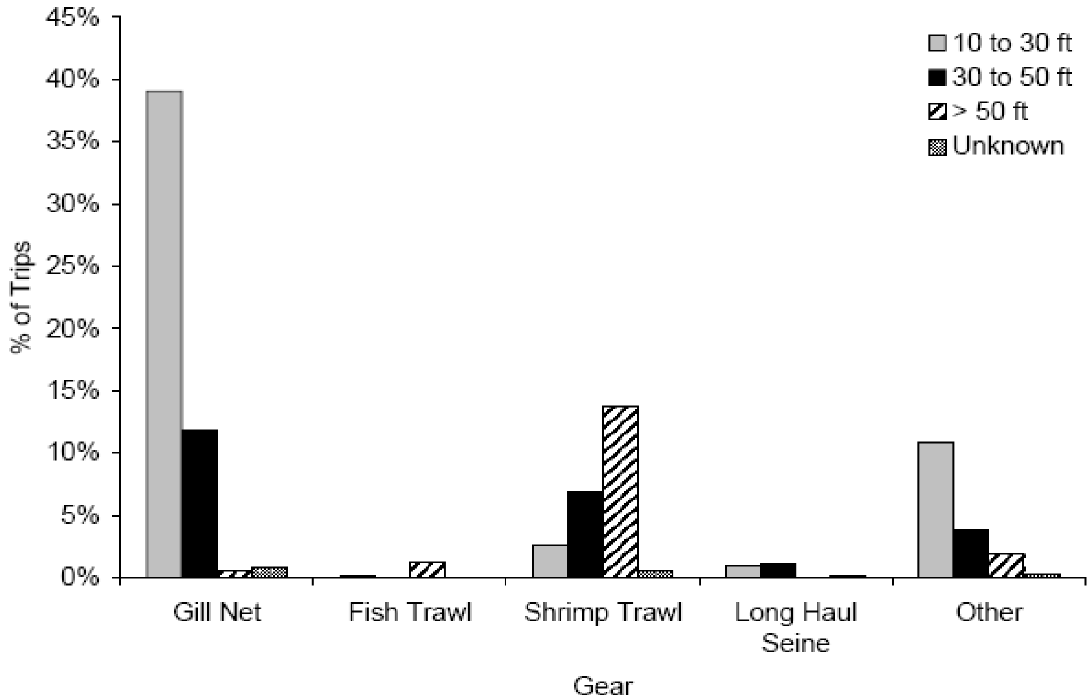

Figure 6.8 The percent of all trips catching kingfishes for the top four fisheries and other fisheries grouped by vessel length (feet), 1994 - 2004.

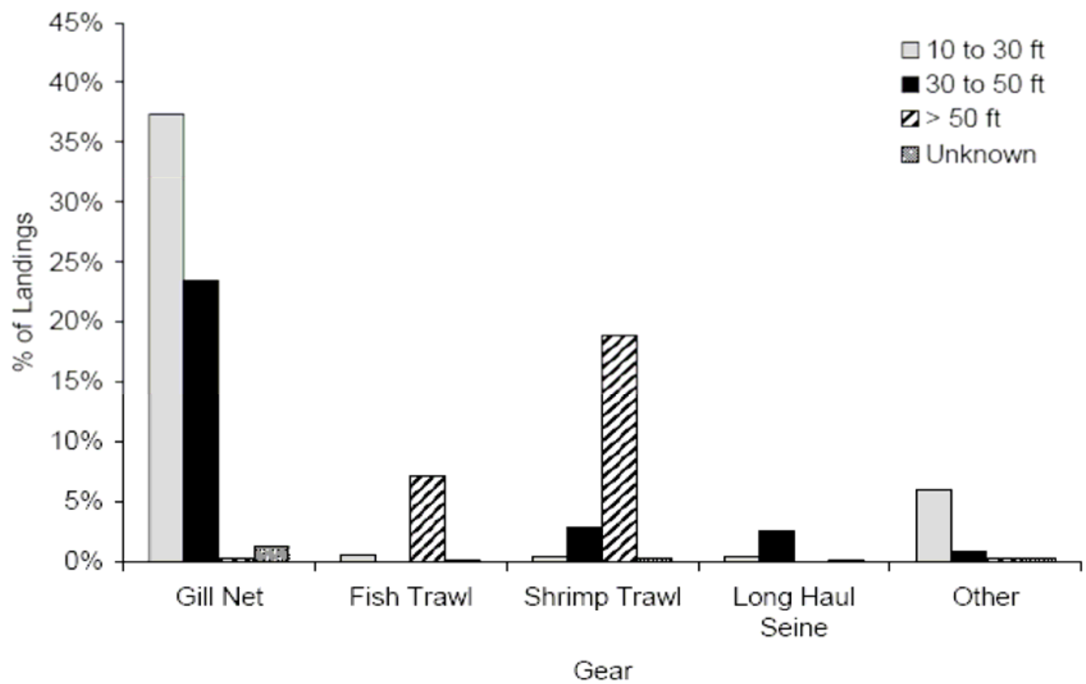

Figure 6.9 The percent of the total landings for the top four fisheries and other grouped by vessel length (feet), 1994 - 2004.

6.1.5.1 Gill Net Fishery

Gill nets dominated the kingfishes catch from 1994 to 2004 accounting for an average of 62% of the total commercial harvest. Landings from the gill net fishery fluctuated widely from 1994 to 1998, then increased steadily to 2003 before decreasing in 2004 (Figure 6.10). The number of trips landing kingfishes also fluctuated until 1998 when trips began to decrease.

Most of the gillnet harvest occurred in the ocean. The catch of kingfishes in the inside waters including Pamlico and Core sounds has been low (Figure 6.11). The harvest in these areas is likely a bycatch from other fisheries. Gill net landings in the ocean and Core Sound are seasonal with most of the catch occurring in April and November as the fish were intercepted during their seasonal movements (Figure 6.12).

The three counties with the highest gill net landings were Carteret, Onslow, and Dare counties [in descending order (Figure 6.13)]. The other category was made up of 22 other counties with catches that contributed only a small portion to the total catch.

Catches were placed into 50 lb categories based on the weight of kingfishes landed for each trip and then summed from 1994 to 2004 (Figure 6.14). The trips that had the highest summed landings were trips that harvested over 1,000 lb. These trips accounted for 1% of the trips and landed 21% of the total landings of kingfishes. Trips that landed less than 50 lb had the second highest landings. These trips with very low catch per trip accounted for 76% of the trips landing kingfishes but only landed 8% of the catch.

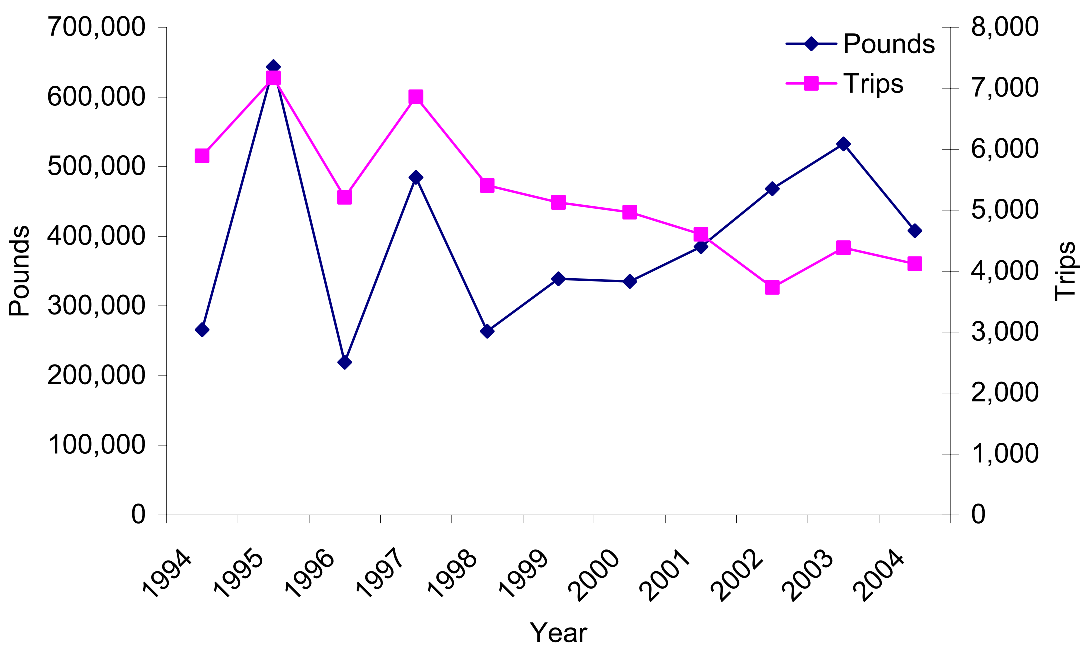

Figure 6.10 Gill net landings of kingfishes and number of gill net trips catching kingfishes, 1994 - 2004.

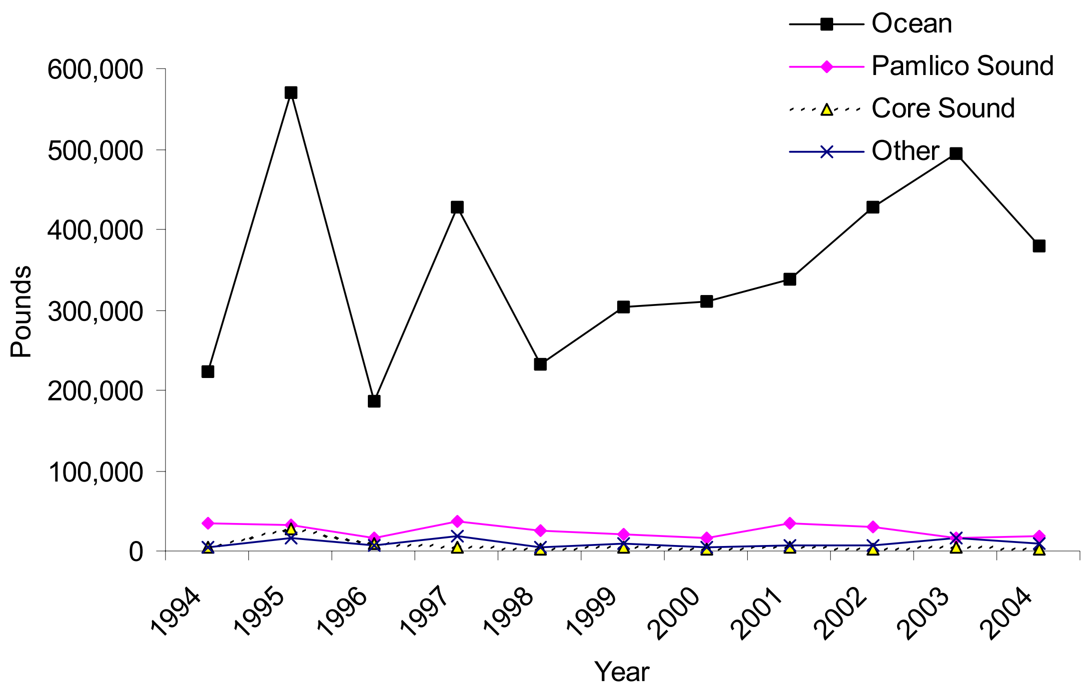

Figure 6.11 Gill net landings of kingfishes in the ocean, Pamlico Sound, Core Sound, and other inside waters, 1994 - 2004.

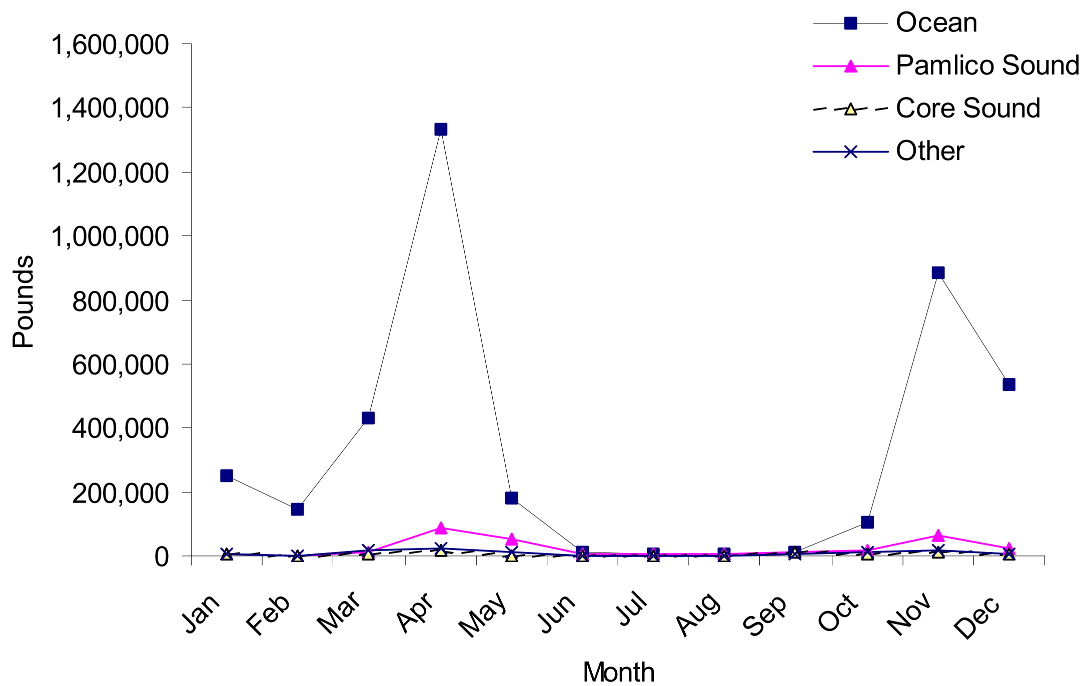

Figure 6.12 Gill net landings of kingfishes by month in the ocean, Pamlico Sound, Core Sound, and other inside waters, 1994 - 2004.

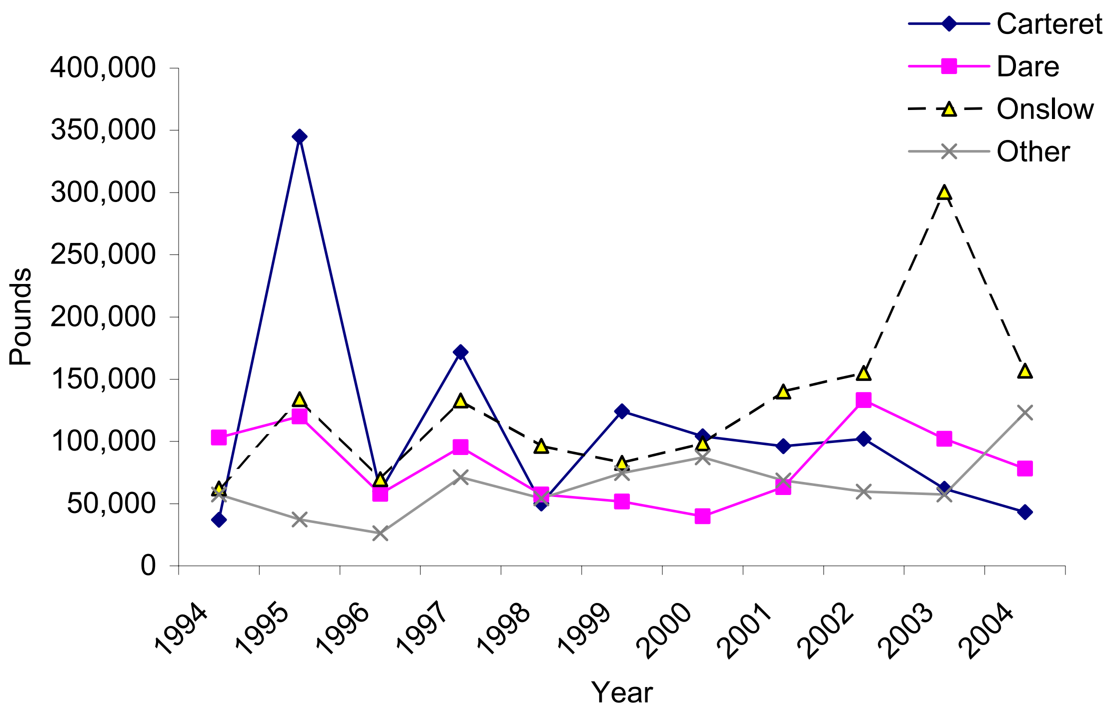

Figure 6.13 Gill net landings of kingfishes by Carteret, Dare, Onslow, and other counties, 1994 - 2004.

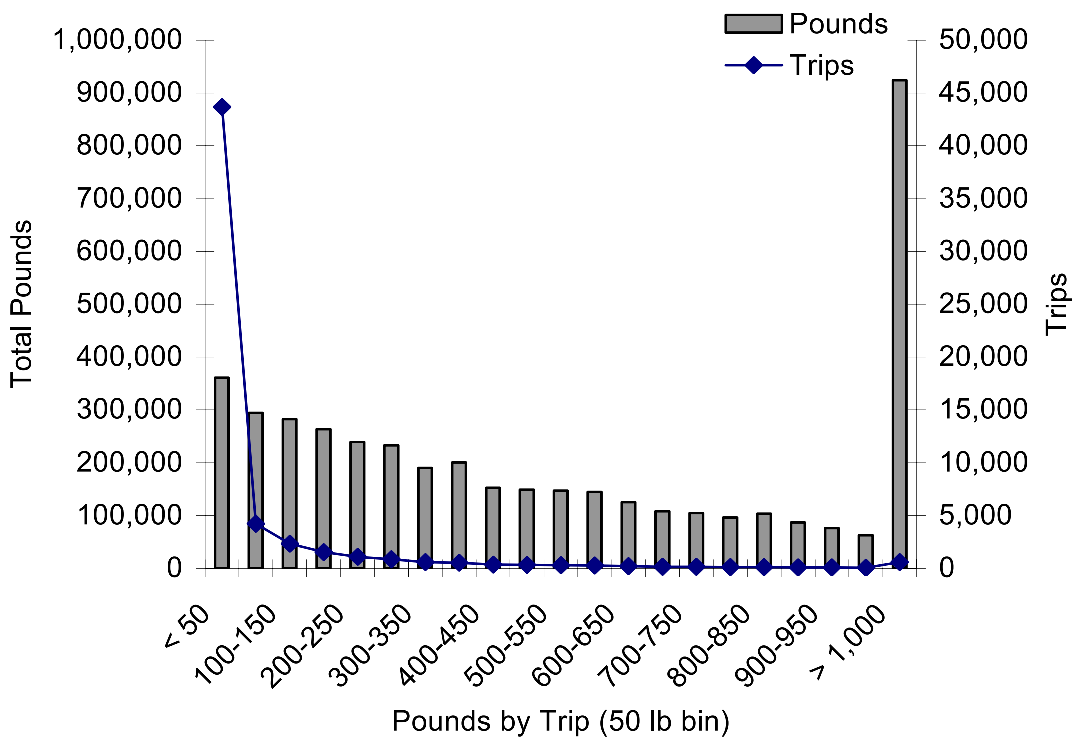

Figure 6.14 Total landings of kingfishes landed and trips catching kingfishes in the gill net fishery by lb caught on each trip (50 lb. increments), 1994 - 2004.

6.1.5.2 Shrimp Trawl Fishery

Historically, the shrimp trawl fishery, which operates in both inshore and ocean waters, has been a significant contributor to landings of kingfishes in North Carolina. Since 1962, shrimp trawls accounted for an average of 15.6% of the total landings. Kingfishes were the top finfish species by weight that were sold as bycatch from ocean shrimp trawls from 1994 to 2003 (Figure 6.15, NC Shrimp FMP 2006). Ocean shrimp trawl landings of kingfishes have fluctuated since 1994 (Figure 6.16), which may have been caused by the availability of kingfishes in a given year, the amount of effort in the spring pink shrimp (*Farfantepenaeus duorarum*) fishery and the fall white shrimp (*Litopenaeus setiferus*) fishery, and/or regulation changes. The banning of flynets south of Cape Hatteras in March 1996 (rule 3 j /.0202) caused some fishermen to modify shrimp trawls in order to target finfish south of Cape Hatteras. This targeting of finfish by shrimp trawls led to higher landings of kingfishes in 1996 and 1997 and resulted in the NCMFC passing the 50 – 50 rule for shrimp and finfish that was implemented in December 1997 (see Legal Authority Section). High ocean catches of kingfishes in 1999 coincided with a strong white shrimp year in the fall. Shrimp trawl landings of kingfishes from 1994 to 2004 by water body indicate that 71% of the fish were harvested from the Atlantic Ocean while 28% were harvested from the Pamlico Sound. Small amounts of kingfishes (less than 1 %) were landed from Core Sound and other coastal water bodies (Figure 6.17).

The ocean shrimp trawl fishery landed the greatest amount of kingfishes while prosecuting the pink shrimp fishery in the spring and the brown (*F. aztecus*) and white shrimp fishery in the fall. Catches of kingfishes were low in the Pamlico Sound until the brown and white shrimp fishery began in June. Pamlico Sound trawl landings peaked in August and gradually decreased as the inside shrimp fishery subsided (Figure 6.18). Landings in other water bodies of the state are small relative to the ocean and Pamlico Sound (Figure 6.17). The majority of kingfishes in the state are landed in Carteret County followed by Onslow and Pamlico counties (Figure 6.19).

Most (80%) of trips harvesting kingfishes with shrimp trawls caught less than 50 lb. These trips only accounted for 20% of the total kingfishes landed in trawl fisheries, which is expected in a bycatch fishery. However, large portions of the landings (trips > 1000 lb) were harvested by only a few trips. This is attributed to large catches of kingfishes during 1996 and 1997 when shrimp trawls were used to target finfish by some boats that were circumventing flynet rules (Figures 6.19 and 6.20).

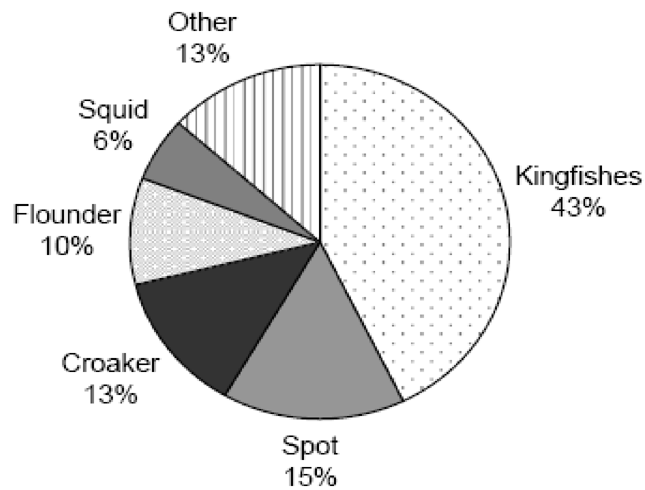

Figure 6.15 Percent contribution of top 5 species captured and sold in ocean (< 3 miles) shrimp trawls by weight, 1994 - 2004.

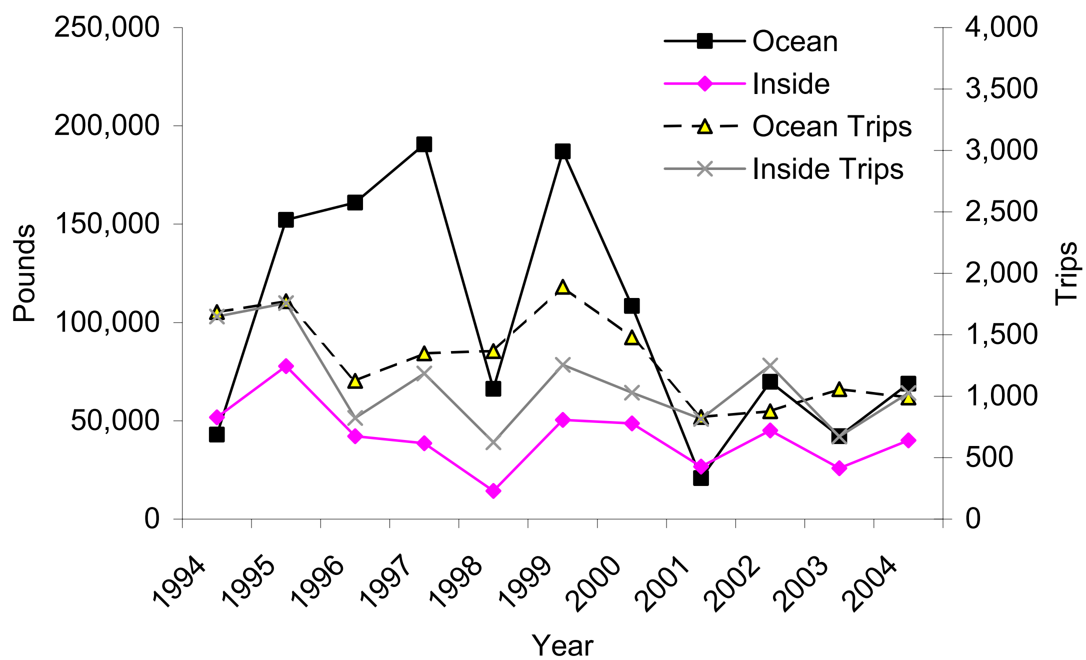

Figure 6.16 Landings (lb) and number of trips landing kingfishes from the shrimp trawl fishery in the ocean and inside waters, 1994 - 2004. Inside waters included all North Carolina waters other than the ocean.

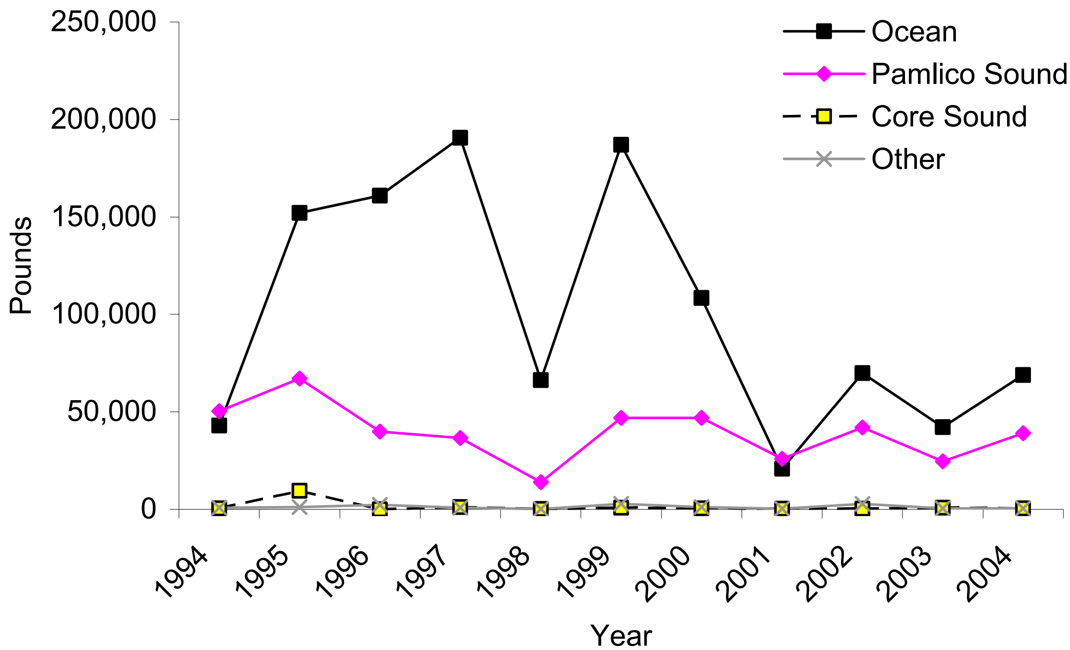

Figure 6.17 Shrimp trawl landings of kingfishes in the ocean, Pamlico Sound, Core Sound, and other inside waters, 1994 - 2004.

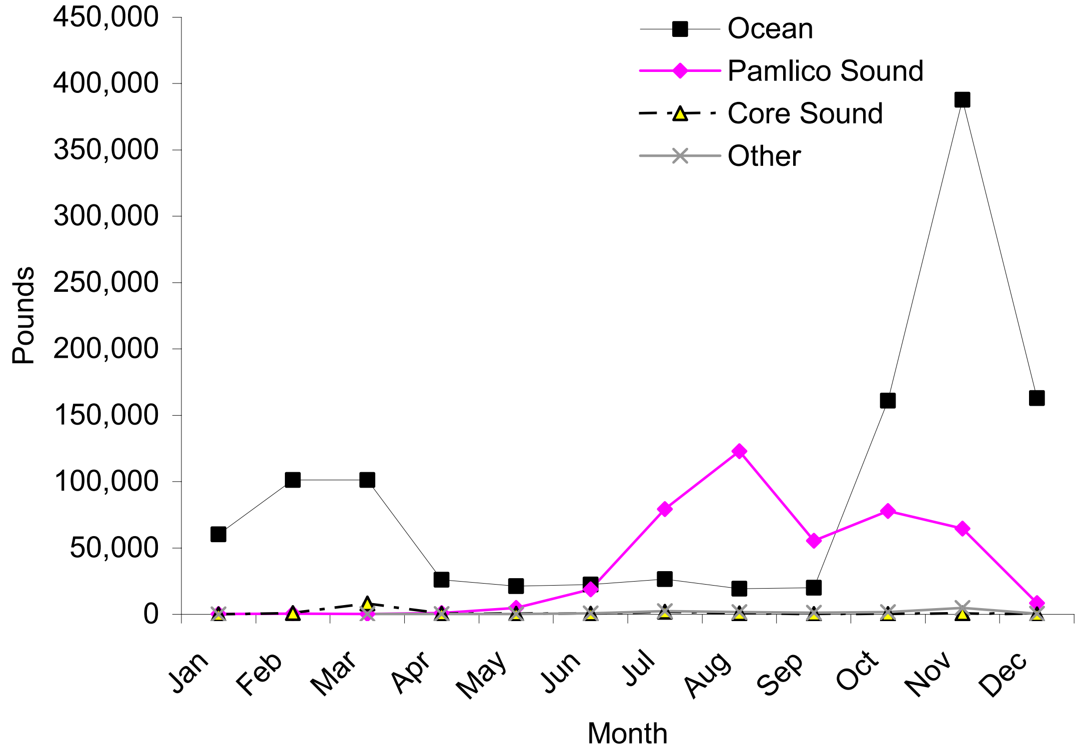

Figure 6.18 Landings of kingfishes (lb) in the shrimp trawl fishery combined by month for the ocean, Pamlico Sound, Core Sound, and other inside waters, 1994 - 2004.

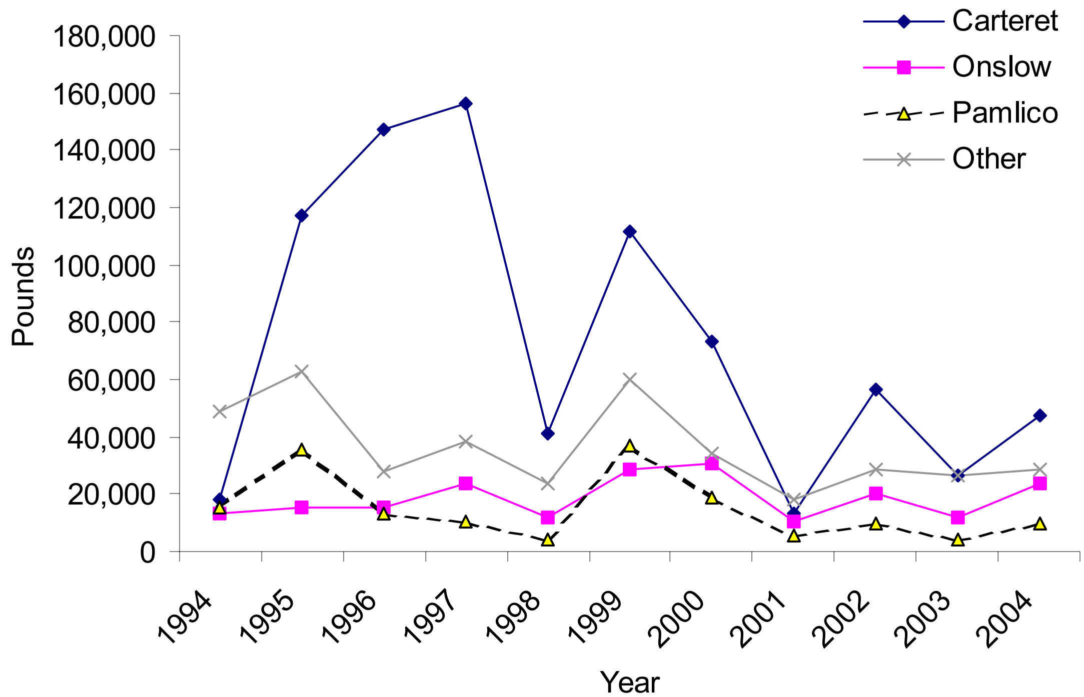

Figure 6.19 Shrimp trawl landings of kingfishes for Carteret, Onslow, Pamlico, and other NC counties, 1994 - 2004.

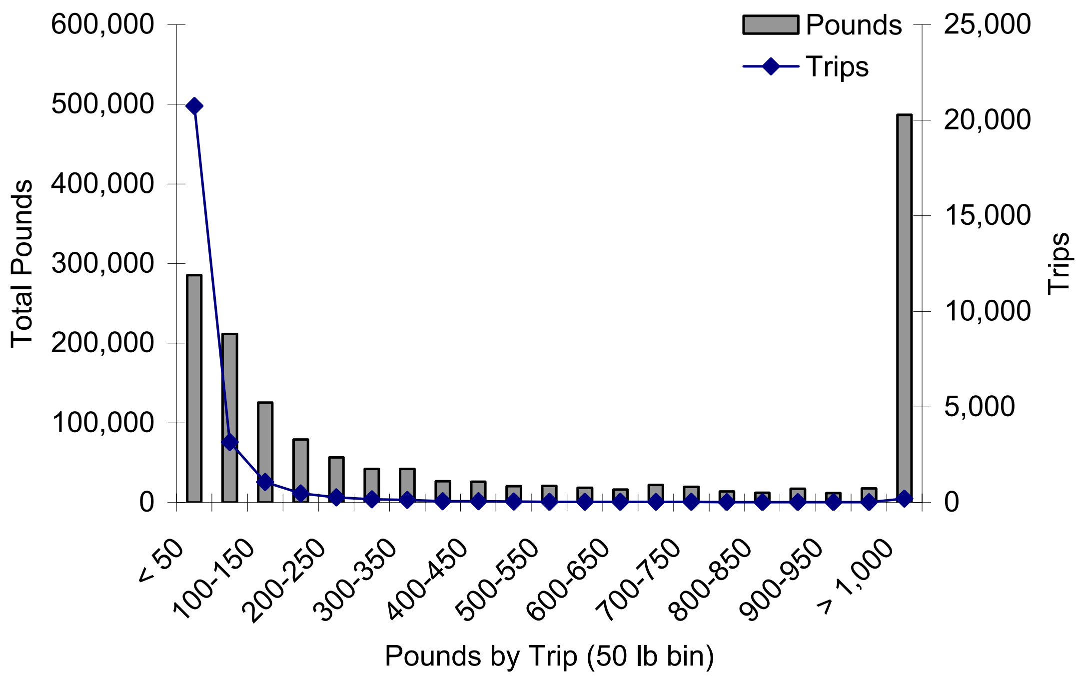

Figure 6.20 Total pounds of kingfishes and trips catching kingfishes in the shrimp trawl fishery by pound caught on each trip (50 lb. increments), 1994 - 2004.

6.1.5.3 Fish Trawl Fishery

Fish trawls (composed of flynets and flounder trawl) were the dominant gear used to capture kingfishes prior to 1980 (Figure 6.5 and Figure 6.21). The contribution of landings from fish trawls declined after 1993. This decline was due to area closures in the flynet fishery. Flynets were banned beginning in 1993 west of Cape Lookout, which limited the fishery to north of Cape Lookout (Proclamation FF-6-93). In 1995, the flynet fishery was excluded south of Cape Hatteras with the exception of the first three weeks of January, February, and March (Proclamation FF-18-94 and FF-31-94). After 1995, the flynet fishery was banned south of Cape Hatteras (Proclamation FF-22-95) and a rule was passed by the NCMFC banning flynets south of Cape Hatteras in March 1996 (rule 3J/.0202 (4)).

Landings of kingfishes in fish trawls decreased ten-fold from 1994 at 204,606 lb to a low of 3,785 lb in 2003 (Figure 6.22). Since 1996, landings from this gear landed less than 50,000 lb with the exception of 1997. Landings from fish trawls have not exceeded 10,000 lb since 2002.

Most of the harvest of kingfishes in fish trawls (79%) was centered in Carteret County from 1994 to 2004 (Figure 6.23). Dare County ranked second and accounted for 12% of the total landings. In recent years, with the elimination of the flynet fishery, Dare County has accounted for a higher percentage of the landings (Figure 6.24).

Most of the harvest of kingfishes with fish trawls (81%) occurred in the winter months [January-March (Figure 6.25)]. Fish trawls generally targeted fish in the ocean that have moved out of the sounds or are migrating southward during the winter. The summer and early fall harvest is very small. Of the trips that harvested kingfishes, the largest percent by weight of landings was from trips with greater than 1000 lb, even though these trips accounted for only 5% of the total trips (Figure 6.26).

Flynets and flounder trawls averaged 8% of the commercial landings in 1994-2004 period. Flynets averaged 6% and flounder trawls averaged 2%. Flynet landings of kingfishes declined after restrictions limiting harvest areas for the fishery were passed (Figure 6.27). Since 1998, the highest landings of kingfishes occurred in 2000 with 6,283 lb. This pales in comparison to the high of 199,372 lb between 1994 and 2004. The number of trips in the flynet fishery also decreased. Trips declined from an average of 128 trips per year (1994 to 1997) to an average of 50 trips per year after 1997.

Flynet landings for kingfishes (1994-2004) primarily occurred in Carteret County (Figure 6.28). However, Dare County has accounted for the largest percent landing of kingfishes since 1998, averaging just over 3,000 lb.

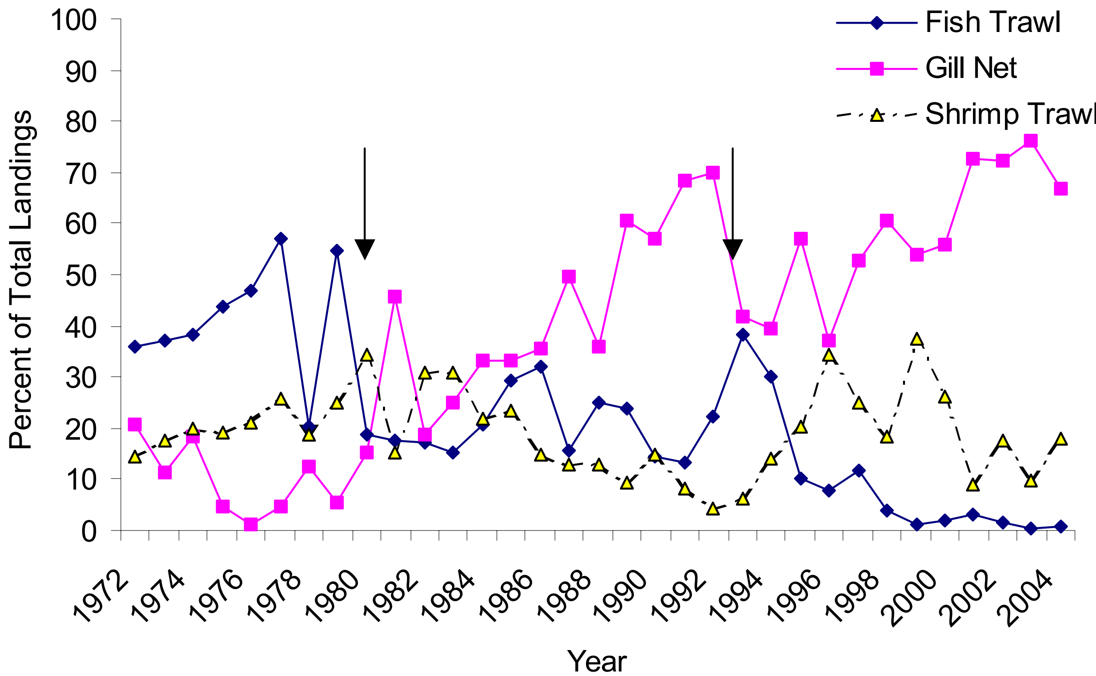

Figure 6.21 Percent of kingfishes landings from the three dominant gears used to harvest kingfishes, 1972 - 2004. The arrow on the left hand side of the figure indicates the first year fish trawls were not the dominant gear. The arrow toward the right hand side of the figure indicates 1993, the year when regulations were initiated on the fish trawl (flynet) fishery.

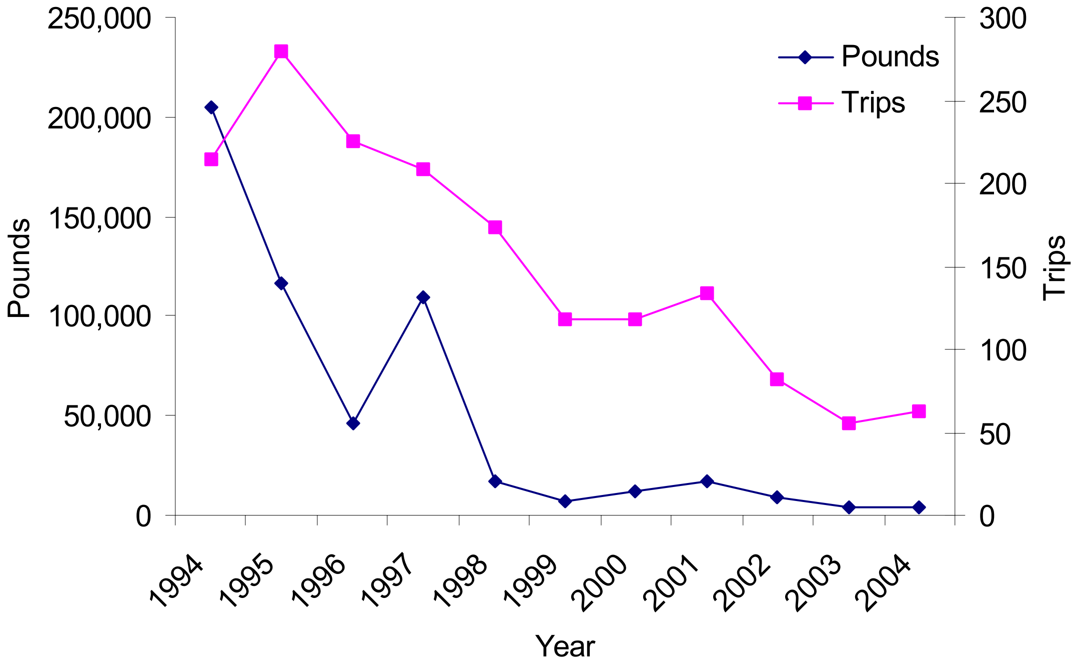

Figure 6.22 Landings of kingfishes and trips catching kingfishes using fish trawls, 1994 - 2004.

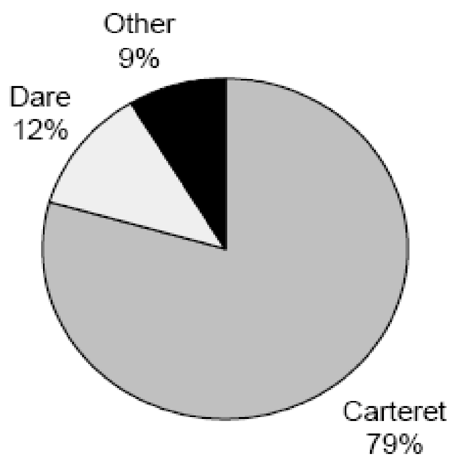

Figure 6.23 Percent landings of kingfishes by county in the fish trawl fishery, 1994 - 2004.

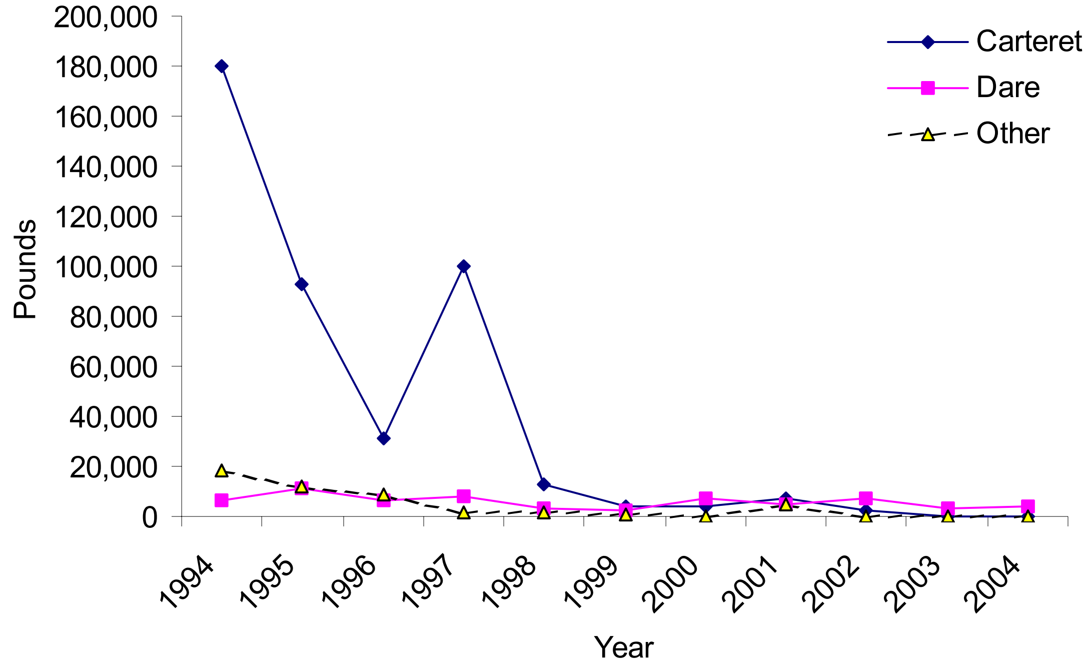

Figure 6.24 Landings of kingfishes from fish trawls for Carteret, Dare, and other NC counties, 1994 - 2004.

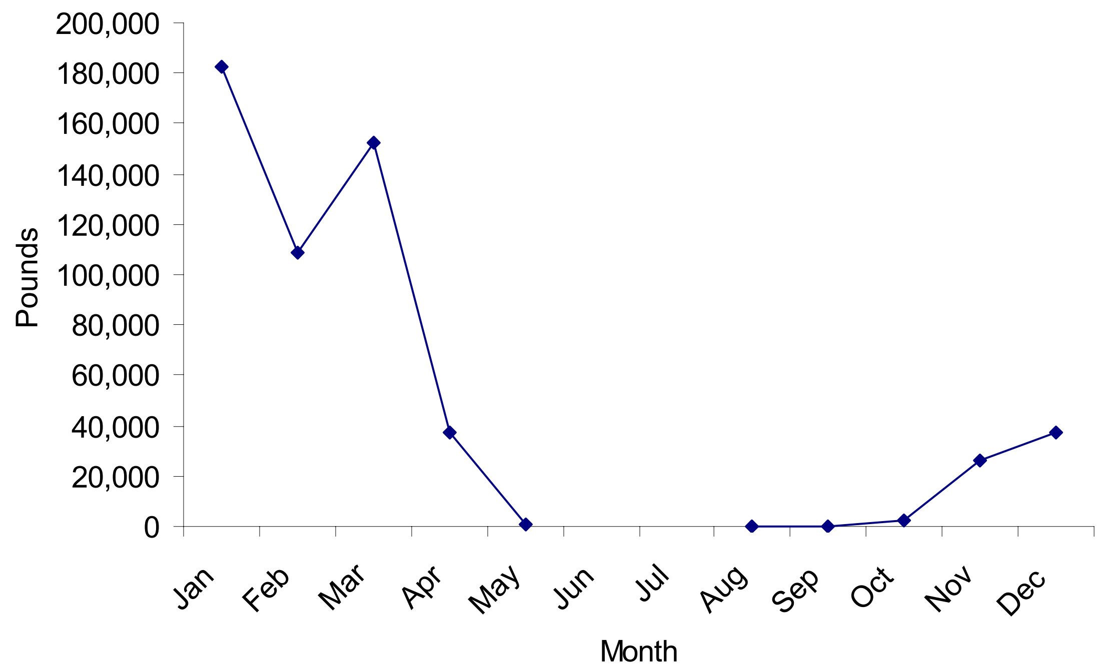

Figure 6.25 Landings of kingfishes by month in the fish trawl fishery, 1994 - 2004.

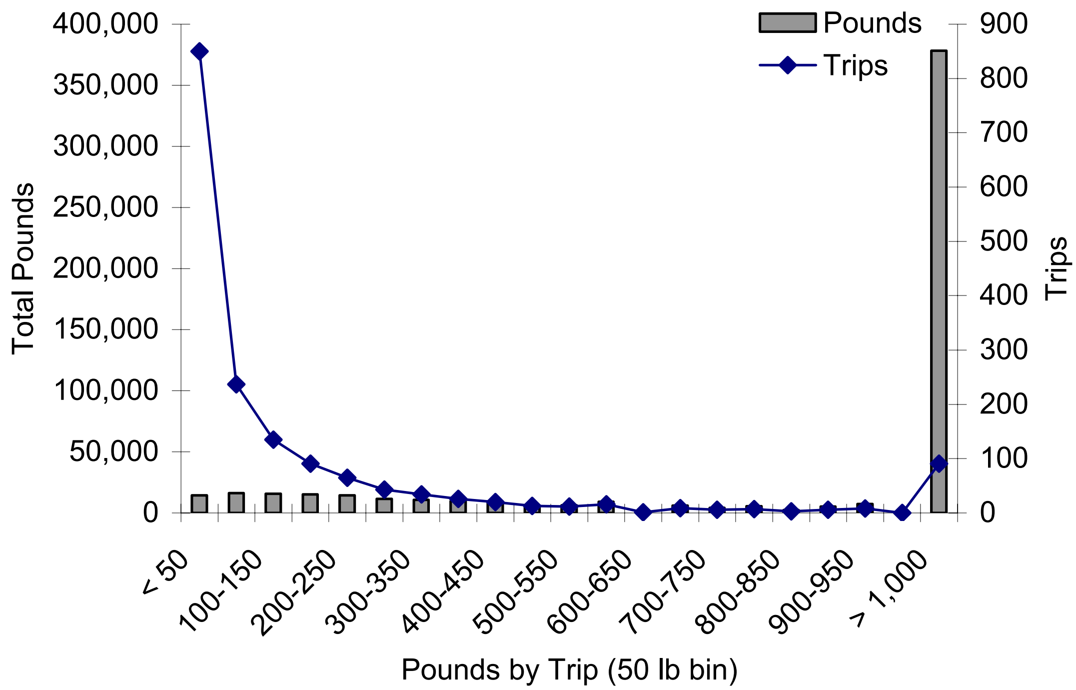

Figure 6.26 Total pounds of kingfishes and trips catching kingfishes in the fish trawl fishery by pounds landed on each trip (50 lb. increments), 1994 - 2004.

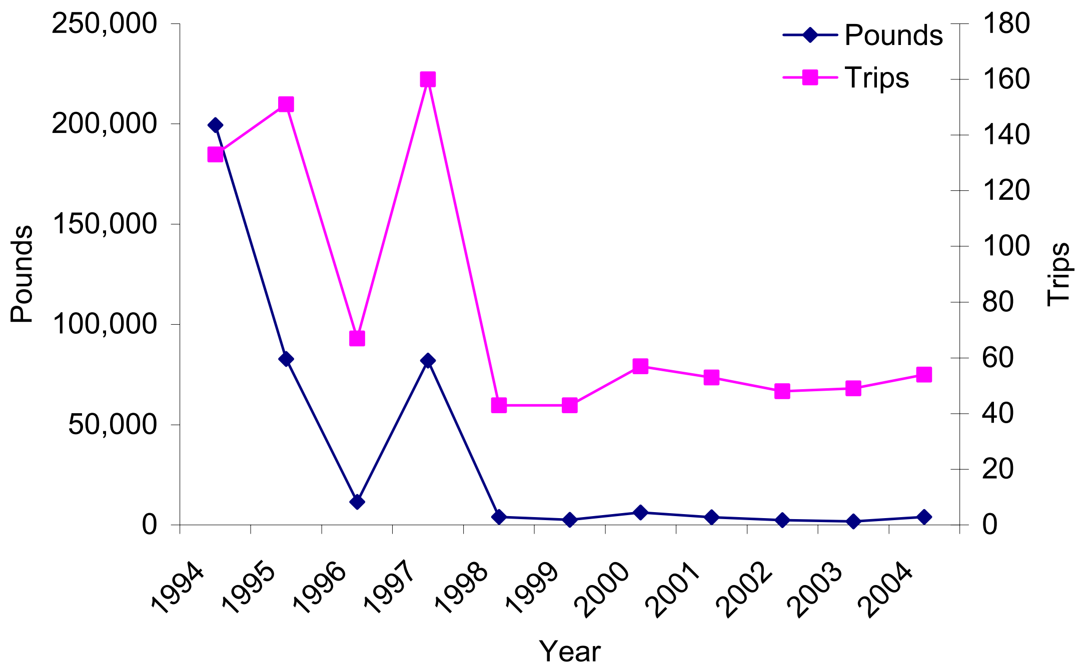

Figure 6.27 Landings of kingfishes and trips catching kingfishes in the flynet fishery, 1994 - 2004.

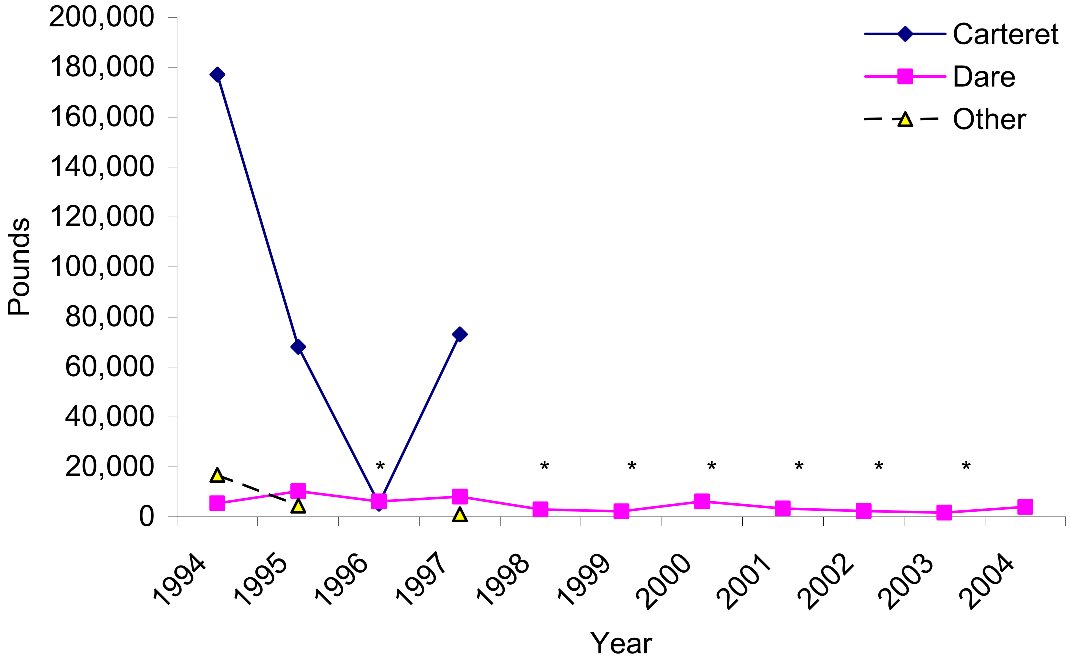

Figure 6.28 Landings of kingfishes from flynet fishery for Carteret, Dare, and other NC counties, 1994 - 2004. Asterisks indicate confidential data.

Flounder trawl landings were variable from 1994 to 2004. Flounder trawls are not efficient at catching kingfishes due to large mesh in the tailbag (5.5 inches), which enables escapement and the area fished (greater than 200 feet deep) does not seem to be a preferred habitat for kingfishes. The peak in landings occurred in 1996 with 34,951 lb after a low of 5,234 lb in 1994. Since 1996, landings have decreased, with the lowest landings occurring in 2004 (515 lb). The number of trips that caught kingfishes had a similar trend (Figure 6.29). Carteret County had the majority of the flounder trawl fishery landings from 1994 to 2004 with most of the landings occurring from 1995 to 1997. Dare County landings have increased in more recent years (2002-2004) but flounder trawl landings of kingfishes are low [<10,000 lb (Figure 6.30)].

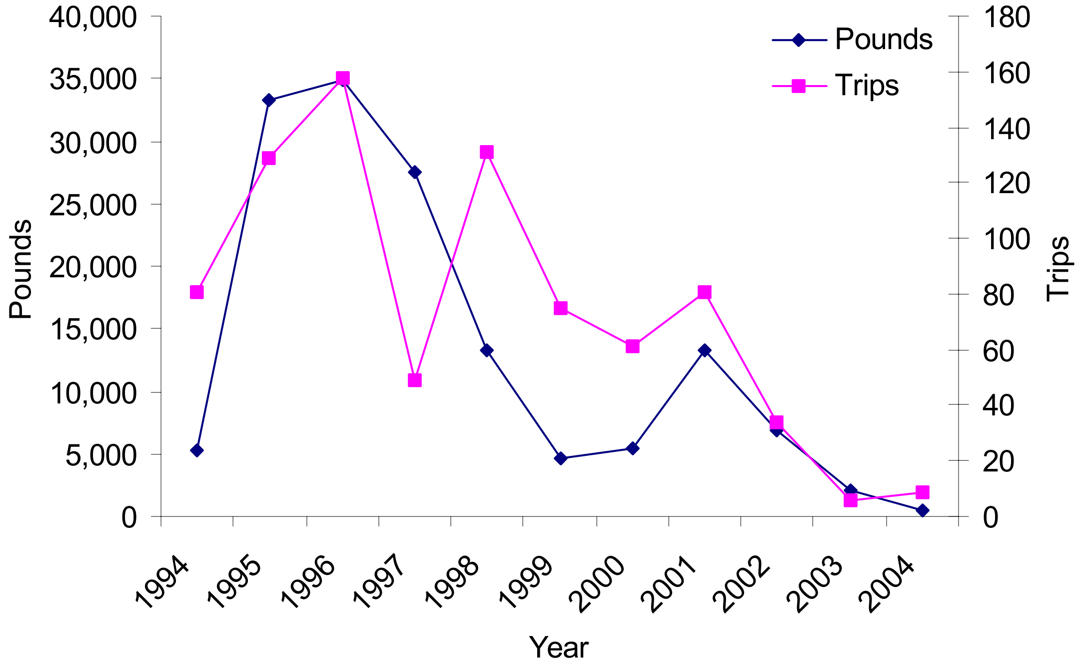

Figure 6.29 Landings of kingfishes and trips catching kingfishes in the flounder trawl fishery, 1994 - 2004.

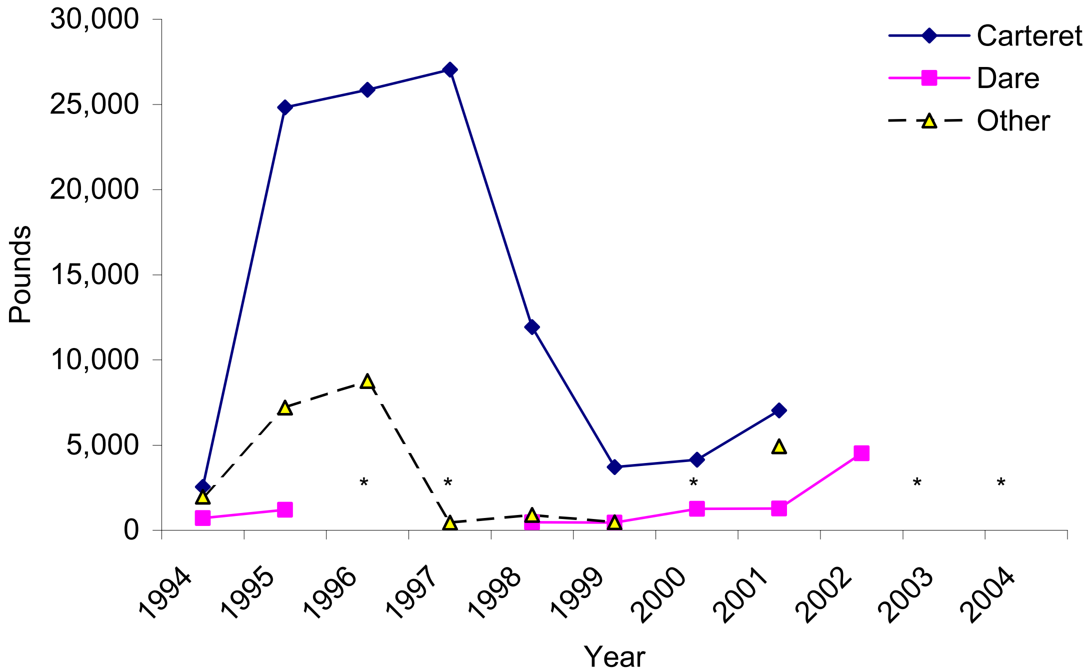

Figure 6.30 Landings of kingfishes in the flounder trawl fishery for Carteret, Dare, and other NC counties, 1994 - 2004. Asterisks indicate confidential data.

6.1.5.4 Long Haul Seines, Beach Seines and Other Fisheries

Traditionally, the beach and long haul seines accounted for as much as 23% of the total landings from 1962 to 2004 (Figure 6.31). Beach and long haul seines each have averaged 3% of total kingfishes landings in North Carolina since 1994. Other commercial gears (gears other than gill nets, fish trawl, shrimp trawl, beach seine, and long haul seine) fished in North Carolina accounted for an average of 1% of the landings (Figure 6.6).

The NC long haul seine fishery operates primarily in Core and Pamlico sounds with most of the activity occurring in northern, and southern Pamlico Sound and, to a lesser extent, Core Sound. Target species are weakfish, Atlantic croaker, and spot while kingfishes are landed incidentally to the target species. The majority of trips landed between 100 and 150 lb of kingfishes. Annual landings of kingfishes in the long haul seine fishery decreased from 28,895 lb in 1994 to 10,829 lb in 2002, then rebounded in 2003 and 2004 (Figure 6.32). The number of trips landing kingfishes demonstrated a similar pattern (Figure 6.33).

Kingfishes are landed in long haul seines from April through December. In Core Sound, monthly landings increased through the spring and early summer, peaked in August, and declined until ending in November. Landings in Pamlico Sound slowly increased April through August, followed by a peak in October, and then rapidly declined into December (Figure 6.34).

The beach seine fishery, which operates in ocean waters along the beach in the northern coastal counties, targets Atlantic croaker, bluefish (*Pomatomus saltatrix*), butterfish, spot, weakfish and striped bass (during a limited season). Most trips (70%) landed between 1 and 50 lb of kingfishes. Landings and number of trips both decreased from 1994 to 2004 (Figure 6.32 and 6.33). Landings were highest in 1995 at 40,529 lb and decreased to 7,633 lb in 1999. Trips landing kingfishes were the highest in 1994 (599 trips) but declined reaching a low of 111 trips in 2003. Most of the beach seine catch occurred in April and May with a smaller seasonal peak in October and November (Figure 6.34).

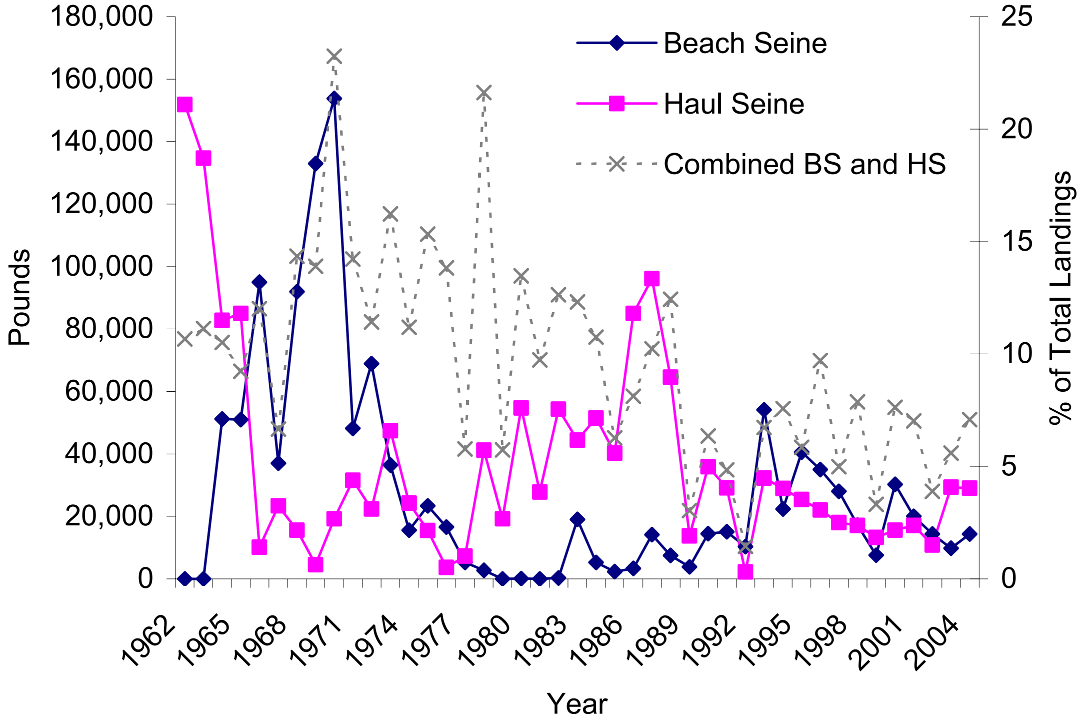

Figure 6.31 Landings in the beach seine and long haul seine fisheries and the combined percent of beach and long haul seines to the total landings (Combined BS and HS) for kingfishes, 1962 - 2004.

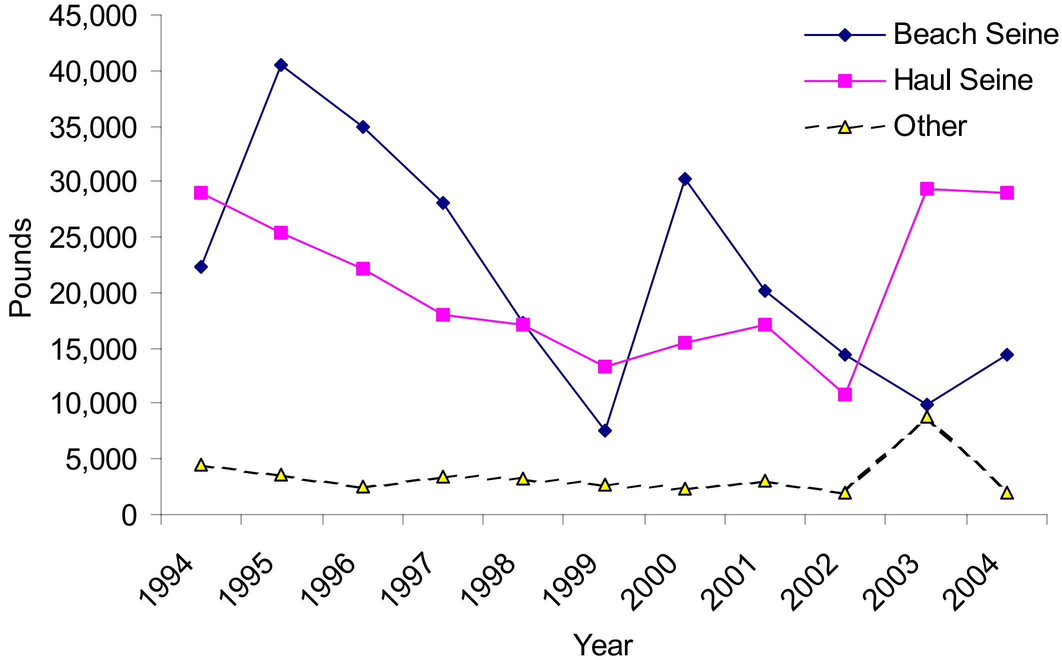

Figure 6.32 Landings of kingfishes in the beach seine, long haul seine, and other fisheries, 1994 - 2004.

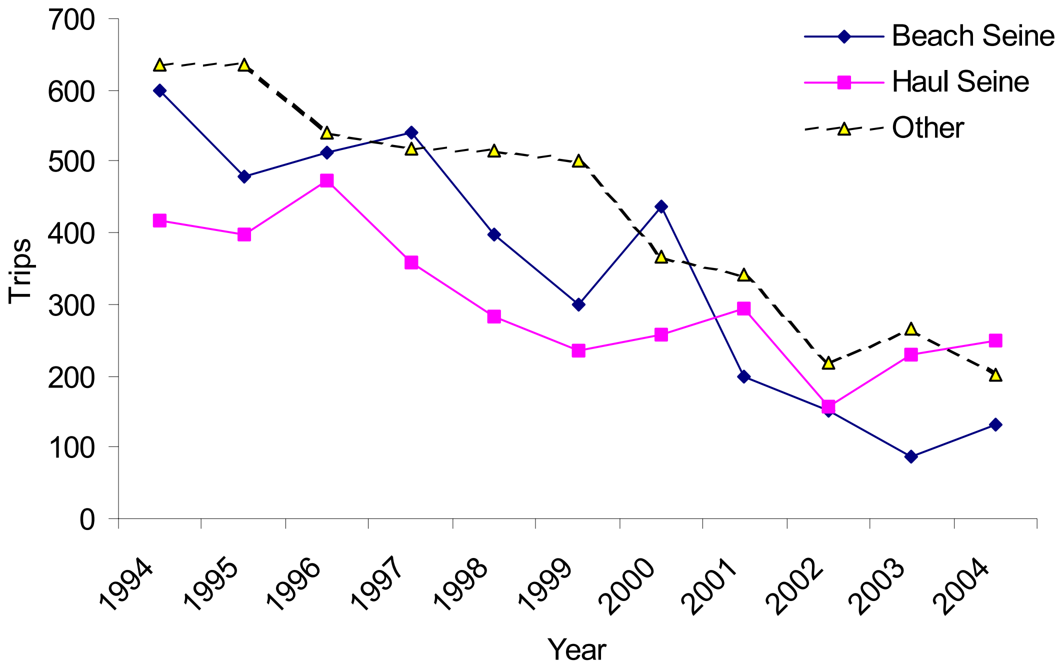

Figure 6.33 Trips catching kingfishes in the beach seine, long haul seine, and other fisheries, 1994 - 2004.

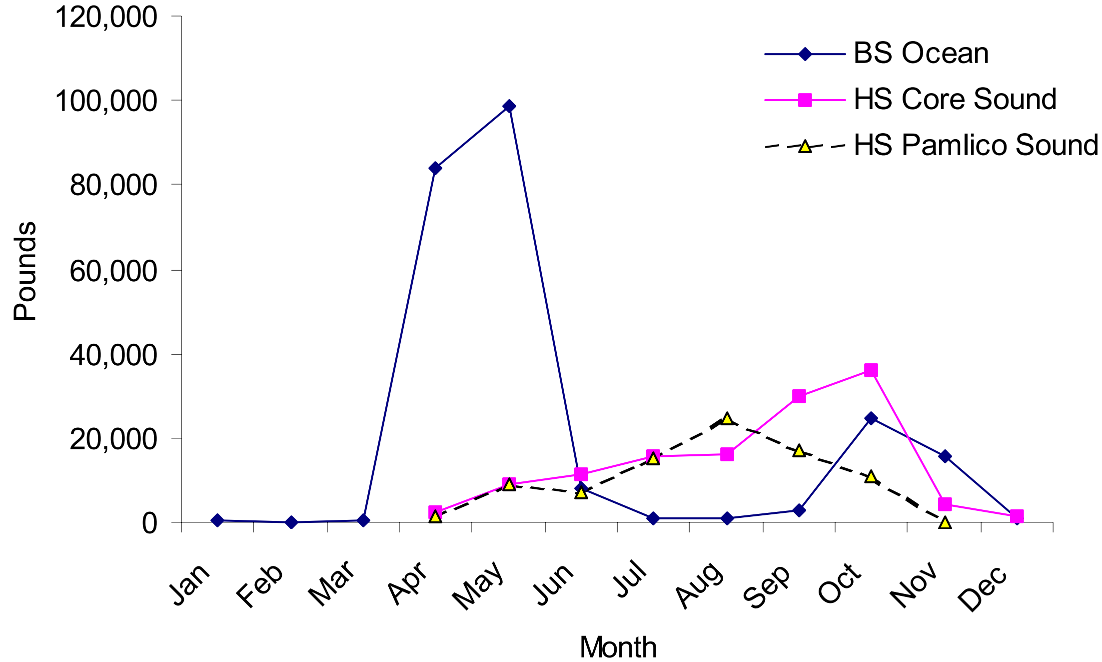

Figure 6.34 Landings of kingfishes (lb) in the beach seine in the ocean (BS Ocean) and long haul seine fishery in Core (HS Core Sound) and Pamlico (HS Pamlico Sound) sounds combined by month, 1994 - 2004.

6.2 RECREATIONAL FISHERY

Kingfishes are highly sought after recreational fishes along the Atlantic coast. They are generally caught by anglers on bottom fishing rigs using natural baits such as sand fleas, bloodworms or shrimp. North Carolina has two surveys that collect data on the recreational finfish harvest. The MRFSS collects data on angler landings from ocean and inside waters along the entire North Carolina coast. In addition, beginning in 2002, NCDMF began collecting data from recreational fishermen who are allowed to harvest recreational limits of finfish while using commercial gear if they posses a Recreational Commercial Gear License (RCGL). However, since the inception of the RCGL survey, kingfish harvested by these users has been negligible. Consequently, all data from recreational fishing is derived from the MRFSS survey.

MRFSS provides data that are used to estimate the impact of marine recreational fishing on marine resources (NCDMF 2005). Data gathered from telephone surveys combined with an intercept survey of anglers from charter/ head boats, manmade structures such as piers, bridges and jetties, private rental boats and the shoreline provide managers with information on effort and catch rates. The intercept data are collected from March – December (in two month waves) by creel clerks who interview anglers who have just completed fishing in one of the four modes. Harvest estimates include the PSE, which is a measure of the precision of the estimate. Small PSEs indicate precise estimates while high PSEs are less reliable. Estimates with a PSE of 20 or less are considered reliable while PSEs greater than 20 are less reliable.

6.2.1 Historical Trends in Landings and Effort

Recreational landings of all kingfishes have been trending upward but not without fluctuations over the last 16 years (Figure 6.35). During the period from 1989 to 2004, the kingfish recreational catch has equaled 45.2% of the commercial catch with an average of 293,646 lb landed by anglers. Recreational landings approached 439,000 lb in 2004, an amount that was equal to 77.4% of the total commercial landings during that year. Relative to other recreational species, kingfish ranked fourth by number and ninth by weight in 2004. DMF awards citations for hook and line caught kingfish that weigh 1.5 lb or greater. With the exception of 2001, when only 102 citations were processed, the number of citations issued since 1989 shows an increasing trend (Figure 6.36).

Unlike NCDMF's trip ticket program, kingfish data are collected at the species level in the MRFSS survey. By number, southern kingfish accounted for 55.4% of the fish landed while northern kingfish constituted 37.0% and Gulf kingfish the remaining 7.6% (Figure 6.36). Species composition is variable between years in ocean and inside waters (Figures 6.37 and 6.38). Since kingfish species are morphologically and meristically similar, taxonomic identification is difficult and this difficulty may be compounded in the field as fish become discolored and fins broken. Although length frequencies from both inside and ocean fisheries are presented for each species, any catch restrictions recommended would not differentiate among species. Therefore, length frequencies of all kingfishes measured in the MRFSS survey from 1989 to 1994 are presented (Figure 6.39).

Estimates of angler CPUE in North Carolina were calculated by analyzing areas and modes that consistently contributed to the kingfishes harvest from 1989 to 2004. CPUE values are based on the kingfishes caught per angler trip and was calculated for trips in the ocean (< 3 miles), sounds, and rivers from piers, docks, bridge/causeway, private boats, and rental boats. The MRFSS CPUE data showed a slightly increasing trend during the sixteen-year period (Figure 6.40).

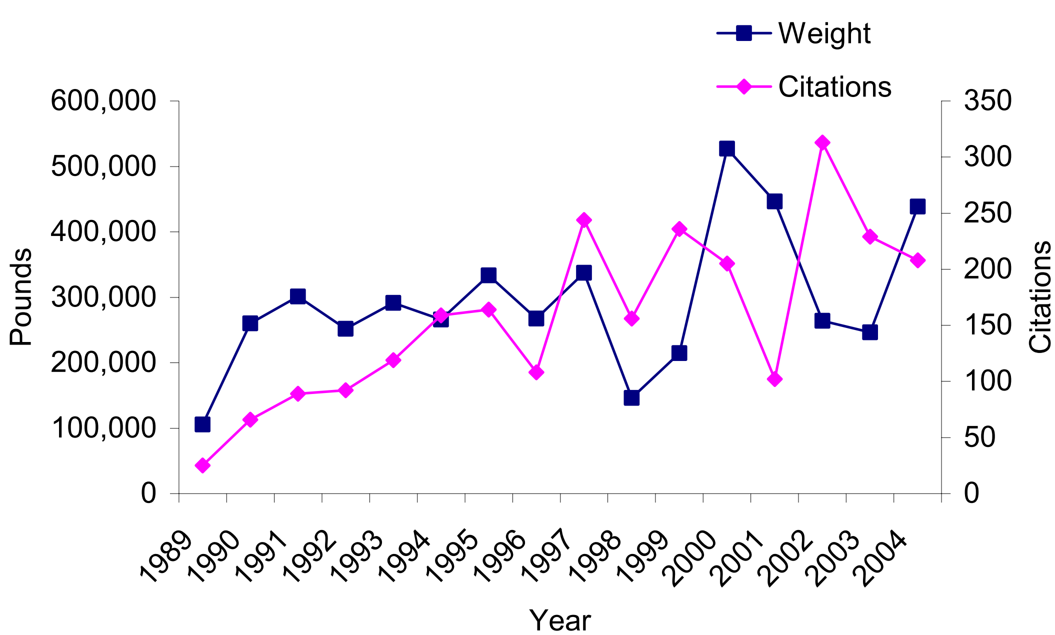

Figure 6.35 North Carolina recreational kingfish landings and citations, 1989 - 2004.

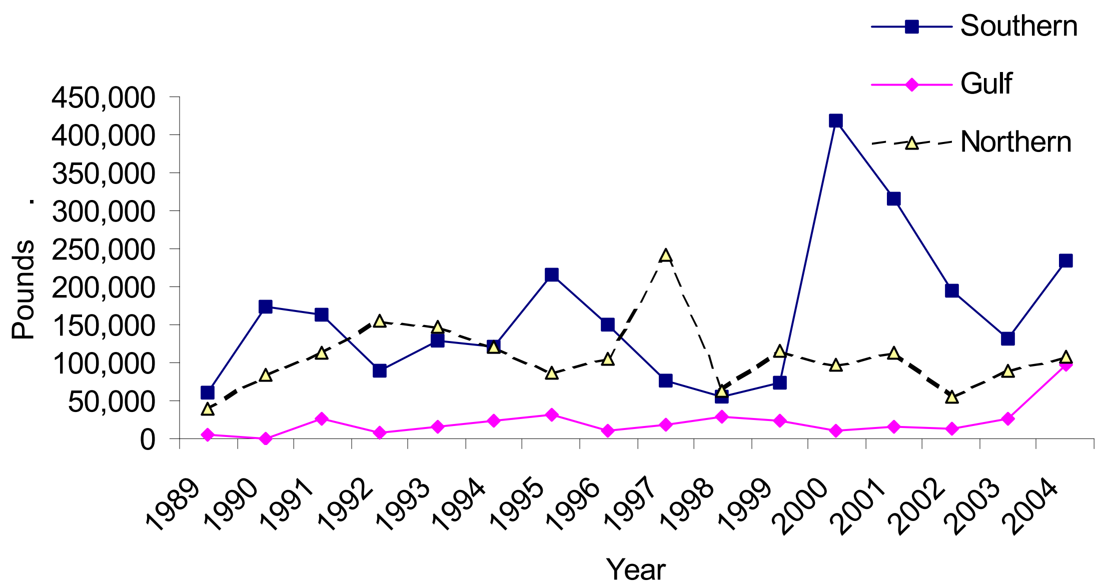

Figure 6.36 North Carolina recreational landings (pounds) of the three kingfish species, 1989 - 2004.

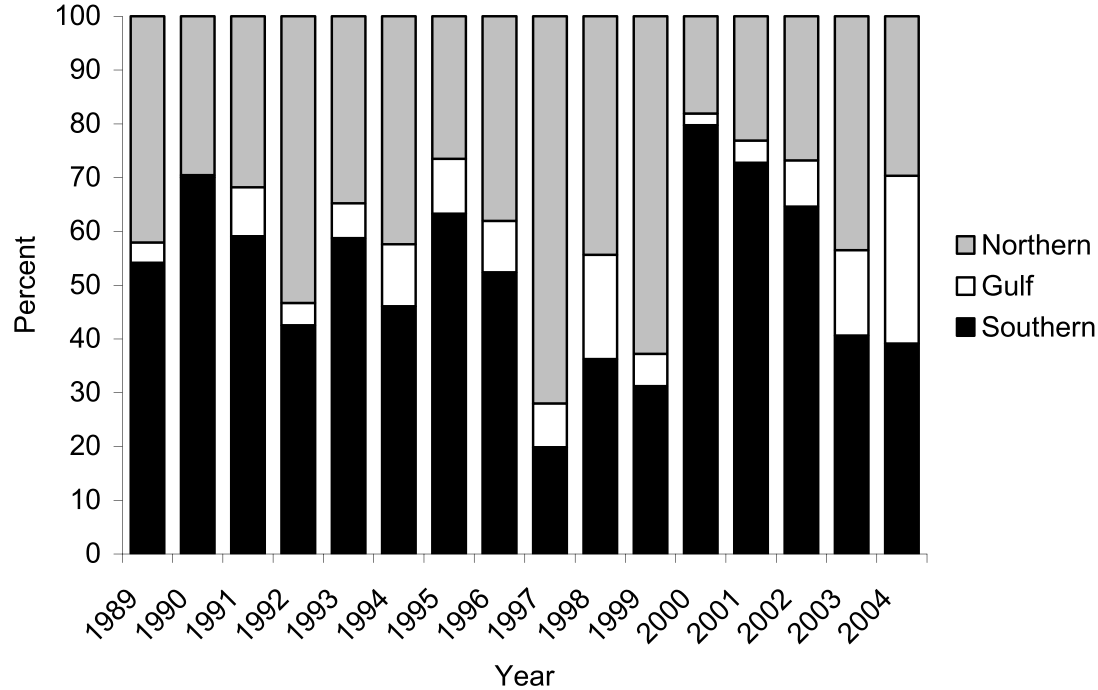

Figure 6.37 Species composition, by number of ocean captured kingfishes, 1989 - 2004.

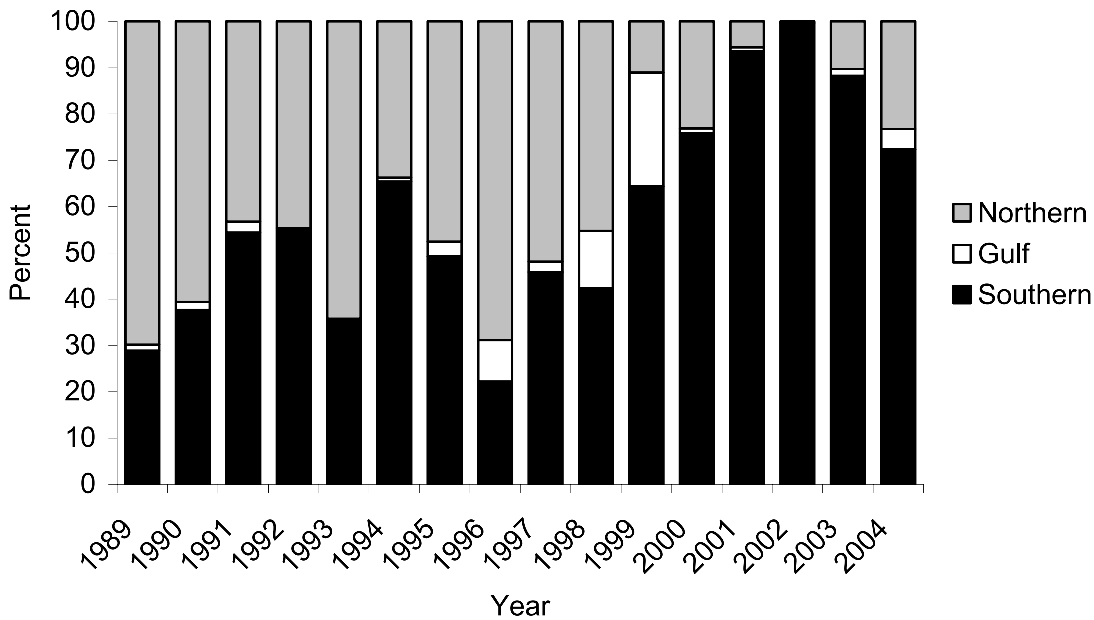

Figure 6.38 Species composition, by number of kingfishes captured in inside waters, 1989 - 2004.

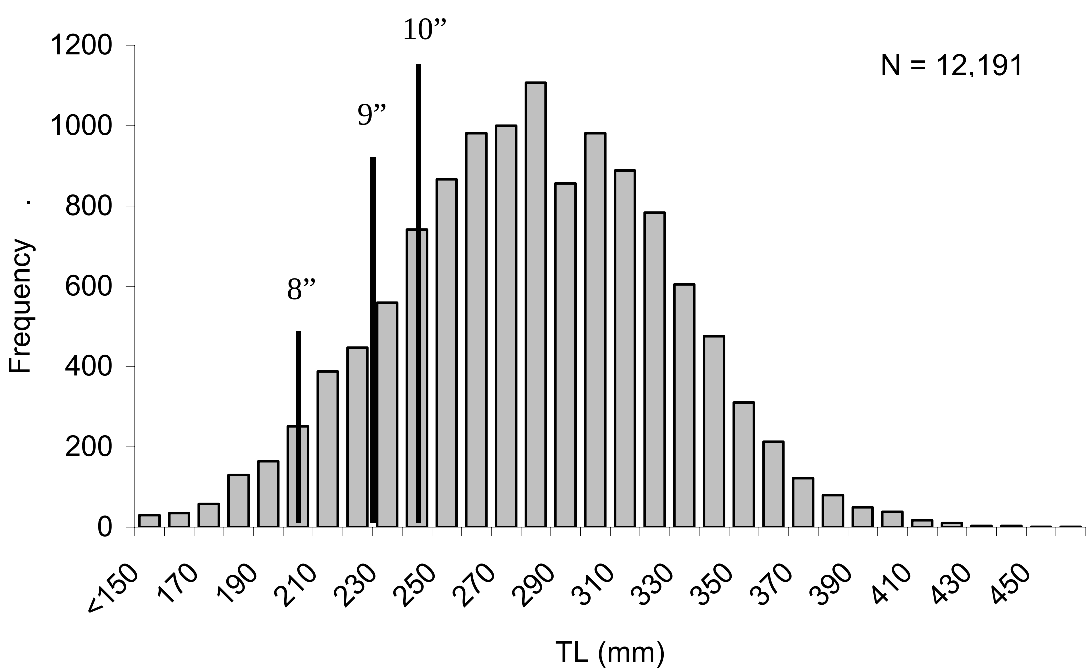

Figure 6.39 North Carolina MRFSS total length (TL) frequencies of all kingfishes measured, 1989 - 2004.

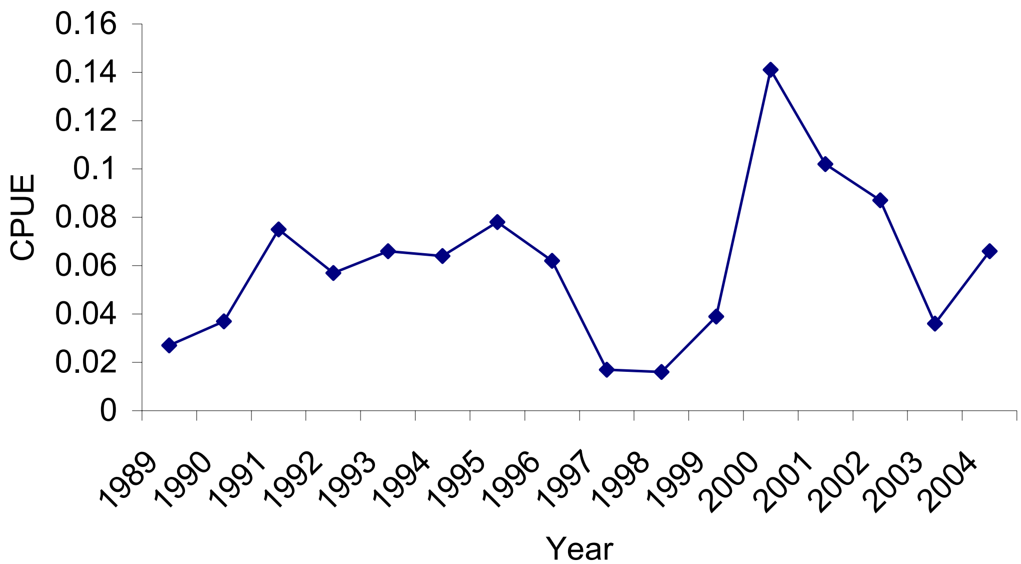

Figure 6.40 North Carolina MRFSS CPUE (catch per trip), 1989 - 2004.

6.2.2 Southern Kingfish

Recreational landings have fluctuated since 1989 averaging 162,807 lb and 289,392 fish (Table 6.2). Catches of southern kingfish ranged from 54,478 lb in 1998 to 418,440 lb in 2000. Mean lengths of retained fish ranged from 9.7 inches in 1990 to 11.7 inches in 2004. Mean weights ranged from 0.4 lb to 0.7 lb over the same period (Table 6.2).

Although southern kingfish were landed from all four modes represented in the MRFSS survey, the majority of fish were caught from man made structures such as piers, jetties, bridges etc. and private/rental vessels (Figure 6.41).

Table 6.2 Southern kingfish North Carolina recreational catch, 1989 - 2004.

Year	Harvest Number	PSE	Weight (lb)	PSE	Mean Length (inches)	Mean Weight (lb)	PSE	Releases
1989	103,955	14	59,983	16	10.2	0.7	18	39,178
1990	388,756	19	174,970	19	9.7	0.4	27	186,936
1991	361,242	16	163,544	16	9.9	0.4	23	146,660
1992	186,588	15	89,277	18	10.3	0.4	28	75,955
1993	299,733	19	129,752	15	9.9	0.4	24	86,237
1994	250,552	12	121,024	12	10.4	0.4	18	164,559
1995	364,686	15	215,081	15	11.1	0.7	19	230,494
1996	243,639	27	149,789	31	11.4	0.7	37	114,758
1997	117,640	15	77,505	15	11.2	0.7	21	33,566
1998	86,485	14	54,478	14	11.5	0.7	18	52,965
1999	138,566	24	74,635	24	11.4	0.4	42	86,413
2000	612,867	18	418,440	20	11.6	0.7	28	377,236
2001	637,195	22	316,201	21	11.0	0.4	36	314,904
2002	311,868	16	195,323	27	11.5	0.7	35	178,440
2003	188,912	14	130,792	16	11.5	0.7	22	263,487
2004	337,595	14	234,166	14	11.7	0.7	21	359,274

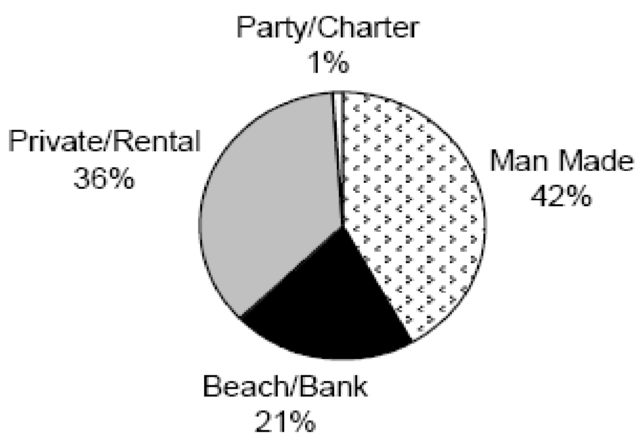

Figure 6.41 Southern kingfish recreational landings (lb) by mode combined from 1989 to 2004.

Between 1994 and 2004, coastwide catches showed a decreasing harvest trend with increasing latitude. East Florida had the highest catch accounting for 31.8% followed by Georgia (25.3%), South Carolina (19.8%) and North Carolina 18.2% (Table 6.3).

Table 6.3 Recreational southern kingfish landings, combined from 1994 to 2004.

State	Harvest (number)	Mean PSE	Weight (lb)	Mean PSE	Percent	Mean Length (inches)
East Florida	5,597,651	15	3,478,849	15	31.8	11.4
Georgia	4,962,802	16	2,764,473	17	25.3	10.9
South Carolina	4,094,782	18	2,169,005	20	19.8	10.6
North Carolina	3,236,914	18	1,987,434	19	18.2	11.3
Virginia	1,202,092	35	533,017	35	4.9	10.4

Fish caught in the estuarine and ocean waters from 1994 to 2004 were measured by creel clerks, and unweighted length frequency distributions were developed based on these measurements. Ocean caught fish showed a normal (bell shaped) distribution with a mode of 11 inches [280mm (Figure 6.42)]. Lengths ranged from a minimum of 5 inches (127mm) to a maximum of 17.7 inches (450mm). A total of 3,463 ocean landed southern kingfish was measured during the 11-year period.

Southern kingfish that were captured in the estuarine waters of North Carolina showed a similar distribution but with a modal peak of 11.4 inches (290mm). Lengths of retained fish caught in inside waters ranged from 6.7 to 16.9 inches (170mm to 430mm). A total of 602 fish was measured during the same 11-year period (Figure 6.43).

Catches by weight and wave were examined from 1994 to 2004. Southern kingfish catches indicated a consistent pattern during waves 2 (Mar-Apr) through 4 (Jul-Aug) with peak catches in wave 5 (Sep-Oct) followed by a significant drop during wave 6 [Nov-Dec (Figure 6.44)].

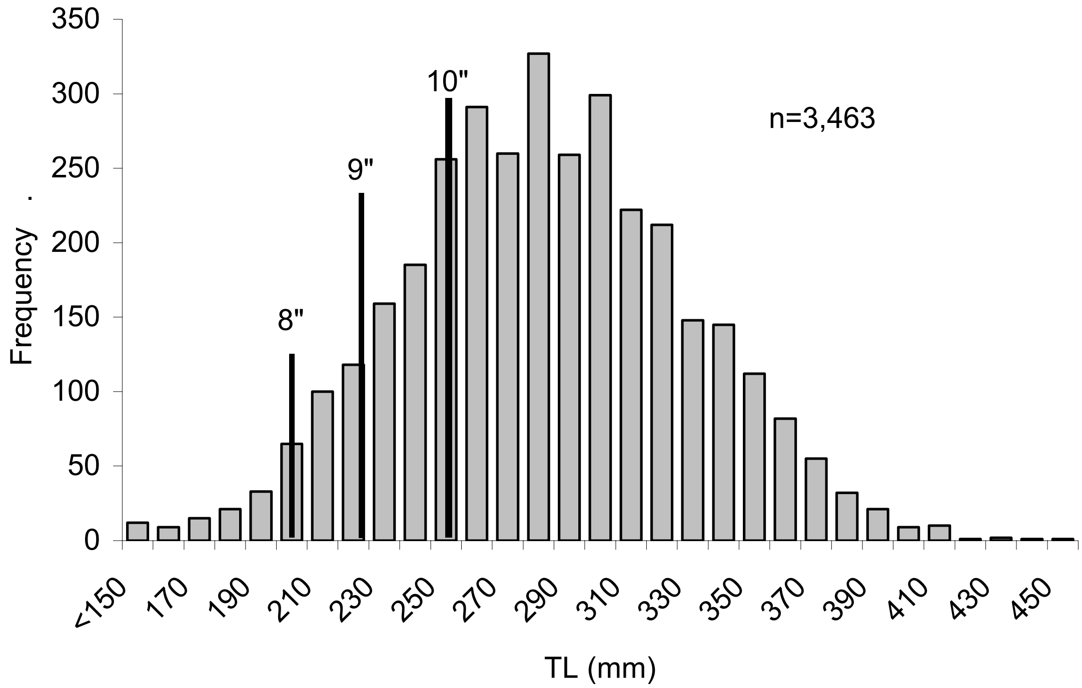

Figure 6.42 Length frequency of ocean caught southern kingfish, 1994 – 2004.

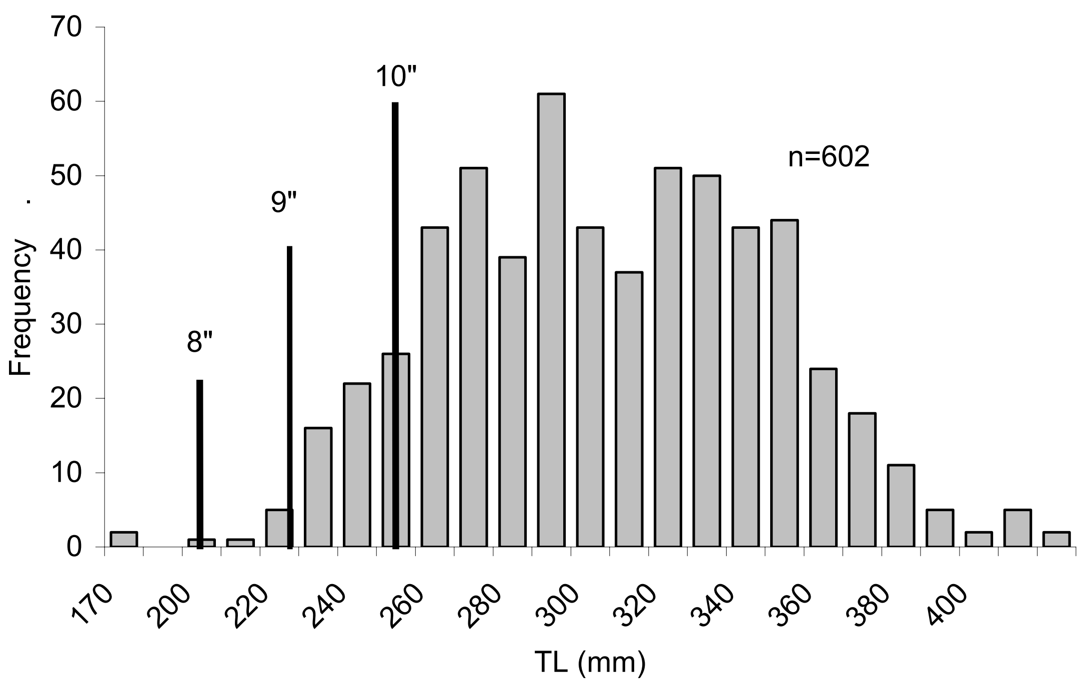

Figure 6.43 Length frequency of estuarine caught southern kingfish, 1994 – 2004.

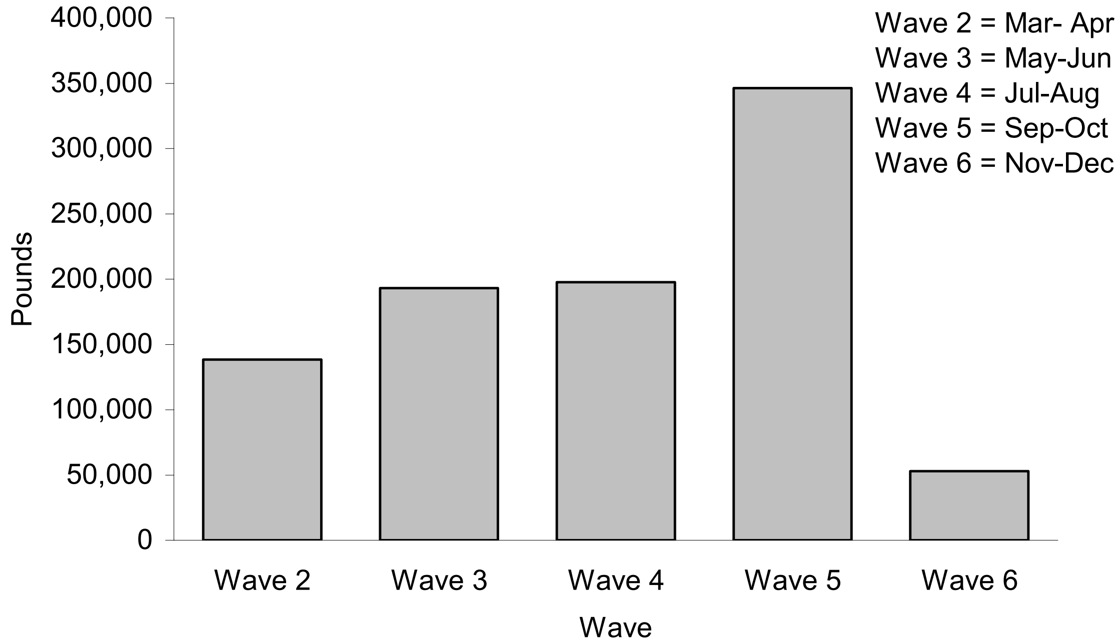

Figure 6.44 MRFSS North Carolina catch of southern kingfish (lb) by wave, 1994 - 2004.

6.2.3 Gulf Kingfish

Since 1989, recreational landings of Gulf kingfish have been the lowest of the three species, averaging 22,192 lb from 1989 to 1994 (Table 6.4 and Figure 6.39). However, 2004, Gulf kingfish landings increased to 97,492 lb (164,477 fish) a four-fold increase over the 16-year average. The PSE calculated in the 2004 recreational catch was the lowest of the period, indicating the most precise estimate. The lowest landings during the 11-year period occurred in 1990 (1,307 lb). Mean weights have ranged from 0.4 to 0.7 lb over the same time (Table 6.4).

Gulf kingfish prefer the surf zone and to a lesser extent the near shore ocean bottom (Irwin, 1970). Data from MRFSS survey indicates more fish are captured from man made structures such as piers and jetties than from the beach bank or private rental operations (Figure 6.45).

According to MRFSS survey, North Carolina and Florida are the two states that catch the greatest number of Gulf kingfish. Other Atlantic coast states may harvest significant quantities of Gulf kingfish but the data are not captured in the survey. PSEs in the Florida survey data and for the latter years in the North Carolina data imply more reliable estimates (Tables 6.4 and 6.5).

Table 6.4 Gulf kingfish North Carolina recreational catch, 1994 - 2004.

Year	Harvest Number	PSE	Weight (lb)	PSE	Mean Length (inches)	Mean Weight (lb)	PSE	Releases
1989	7,110	35.6	5,192	37.3	11.2	0.7	55	2,671
1990	2,987	57.0	1,307	48.9	9.9	0.4	69.2	1,481
1991	53,150	14.5	25,840	15.4	9.6	0.4	23.2	21,671
1992	15,801	23.3	7,573	25.3	10.4	0.4	36.8	6,979
1993	30,437	21.1	15,560	22.2	10.6	0.4	35.1	9,149
1994	53,772	23.0	23,250	25.2	9.9	0.4	33	37,824
1995	56,479	52.1	30,613	57.4	10.4	0.4	87.9	36,475
1996	45,884	19.5	11,737	42.4	10.3	0.4	43.1	21,806
1997	38,978	24.0	18,942	27.6	9.3	0.4	39.7	9,809
1998	44,200	40.2	28,203	46.9	10.6	0.7	56.8	26,332
1999	34,589	31.6	24,046	45.8	9.8	0.7	56.4	19,073
2000	15,972	34.0	10,227	36.3	10.6	0.7	46.6	9,440
2001	31,700	22.1	16,153	22.7	10.6	0.4	36.1	16,321
2002	30,983	25.9	12,593	27.6	9.9	0.4	34.2	18,840
2003	48,918	20.2	26,338	22.1	10.4	0.4	36.2	89,148
2004	167,477	17.1	97,492	18.2	10.8	0.7	21.9	202,087

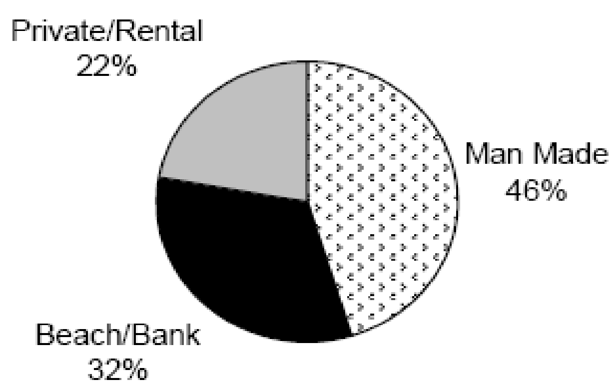

Figure 6.45 North Carolina Gulf kingfish landings (lb) by mode combined from 1994 to 2004.

Table 6.5 Recreational Gulf kingfish landings, combined from 1994 to 2004

State	Harvest (number)	Mean PSE	Weight (lb)	Mean PSE	Percent	Mean Length (inches)
East Florida	4,965,861	16	3,236,351	17	91.5	12
North Carolina	568,952	28	299,594	34	8.5	10

Unweighted length frequencies of Gulf kingfish landed by anglers from the ocean peaked from 9.4 to 9.8 inches (240 and 250 mm) with a greater proportion of smaller fish than the northern or southern kingfishes (Figure 6.46). Since Gulf kingfish are found almost exclusively in the surf zone, shore based anglers catch very few fish in inside waters. During 1994 – 2004, creel clerks in the intercept survey measured only 28 Gulf kingfish from inside waters but 576 were measured from ocean waters.

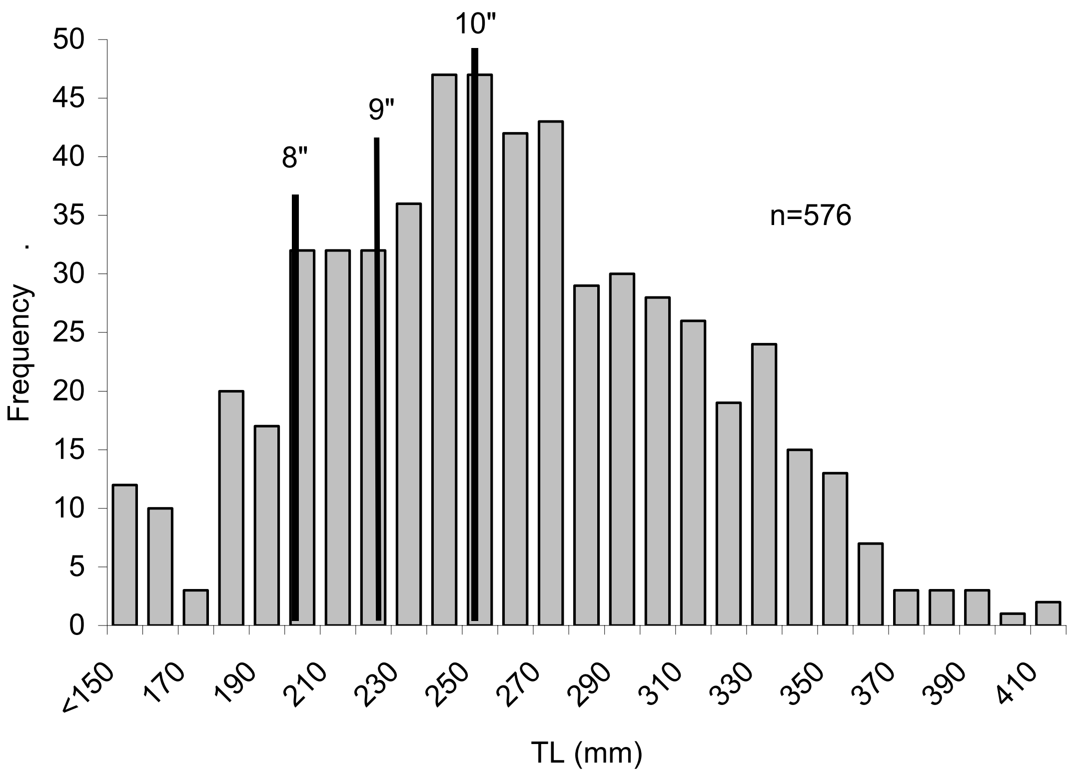

Figure 6.46 Length frequency of North Carolina ocean caught Gulf kingfish, 1994 - 2004.

Catch by wave data for Gulf kingfish indicate most fish are caught in Wave 5 (Sep-Oct) followed by Wave 3 (May-Jun). The fewest number of fish were caught during the summer months (Figure 6.47).

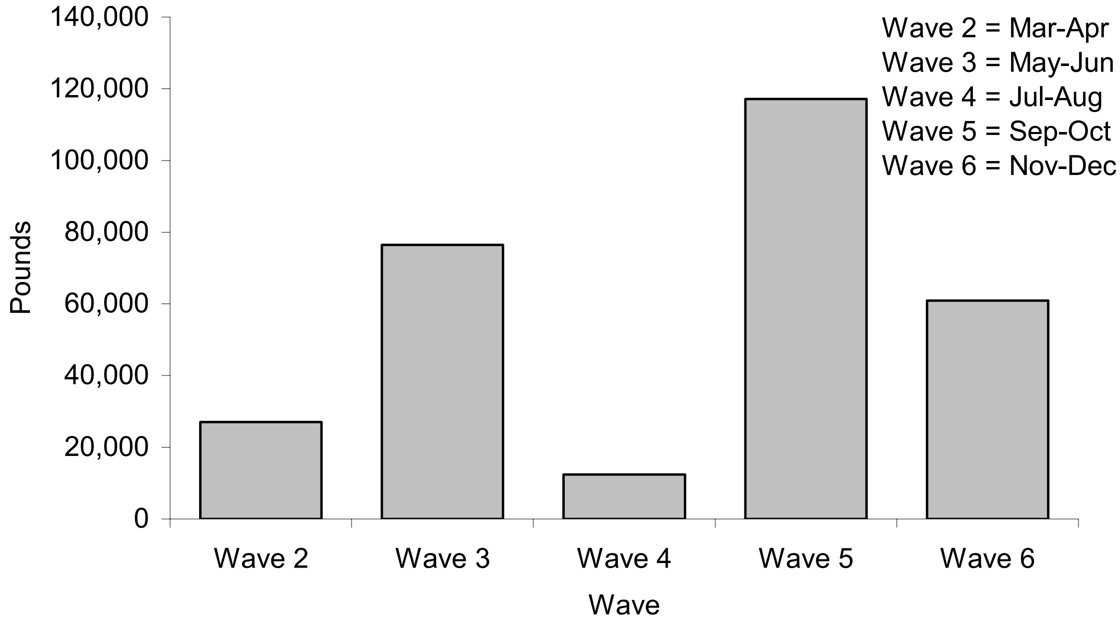

Figure 6.47 North Carolina Gulf kingfish catch by wave, 1994 – 2004 estimated from MRFSS.

6.2.4 Northern kingfish

With the exception of 1997 when 240,912 lb of northern kingfish was harvested, recreational landings since 1989 have been mostly stable averaging 108,647 lb and 181,269 fish (Figure 6.39 and Table 3). The lowest recreational catch was in 1989 when 40,565 lb was caught. Mean lengths of retained fish ranged from 10.8 inches (275 mm) in 1994 to 12.0 inches (305 mm) in 2000. Mean weights ranged from 0.4 to 0.7 lb over the sixteen years (Table 6.6).

Northern kingfish were captured almost equally from beaches, piers and private/rental boats (Figure 6.48). However, PSEs from this portion of the MFRSS survey are high (range 20-45) implying wide confidence intervals. Northern kingfish are available to anglers from all different modes with the exception of charter boats.

Table 6.6 Northern kingfish North Carolina recreational catch, 1994 - 2004.

Year	Harvest number	PSE	Weight (lb)	PSE	Mean length (inches)	Mean weight (lb)	PSE	Releases
1989	89,613	16	40,565	23	9.4	0.4	28	34,376
1990	186,632	21	83,792	20	10.5	0.4	29	91,045
1991	200,793	11	112,029	12	10.6	0.7	14	81,303
1992	221,871	15	154,999	16	11.7	0.7	24	92,791
1993	209,347	13	146,244	12	11.3	0.7	19	55,425
1994	215,406	10	121,599	10	11.3	0.7	12	145,751
1995	164,847	15	87,875	15	10.8	0.4	25	99,721
1996	191,357	17	105,940	18	11.3	0.7	20	92,192
1997	362,226	29	240,912	31	11.7	0.7	41	94,287
1998	104,529	25	63,715	28	11.3	0.7	34	63,543
1999	201,041	29	115,876	32	10.8	0.7	37	149,569
2000	143,242	15	98,396	15	12.0	0.7	22	90,352
2001	178,052	21	113,876	24	11.6	0.7	30	91,538
2002	96,741	29	56,178	29	11.6	0.7	35	58,791
2003	139,085	19	89,231	20	11.7	0.7	26	247,430
2004	195,519	20	107,122	18	11.3	0.4	33	222,187

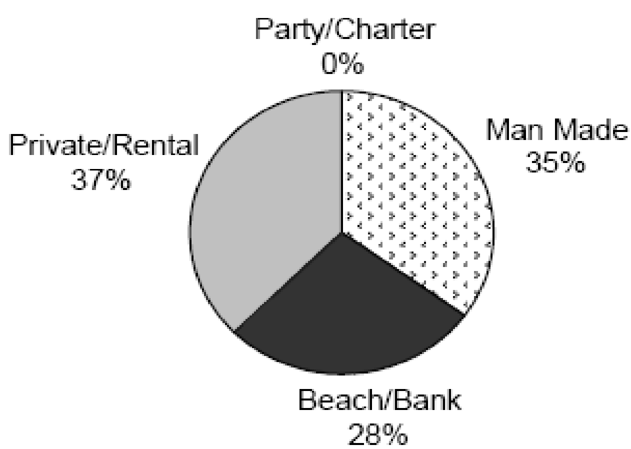

Figure 6.48 North Carolina northern kingfish landings (lb) by mode, 1994 - 2004.

Along the Atlantic coast, northern kingfish landings were concentrated in three states: New Jersey, Virginia, and North Carolina. North Carolina landed the most pounds of northern kingfish accounting for 48.8% of the catch. New Jersey and Virginia followed with 26.7% and 25.5% of the catch (Table 6.7).

Table 6.7 North Carolina recreational northern kingfish landings, combined from 1994 to 2004.

State	Harvest (number)	Mean PSE	Weight (lb)	Mean PSE	Percent	Mean Length (inches)
New Jersey	89,337	43	57,126	44	25.5	11.9
Virginia	112,359	44	57,314	44	26.7	11.4
North Carolina	181,095	21	109,156	22	48.8	11.5

During 1994-2004, measurements of northern kingfish retained by anglers were recorded by creel clerks and used to generate length frequencies in the ocean and estuarine fisheries (Figures 6.49 and 6.50). Ocean captured northern kingfish exhibited a normal distribution with a modal peak of 11 inches (280mm). Lengths ranged in size from 5.5 to 16.9 inches (140mm to 430mm) and 3,166 northern kingfish were measured by creel clerks over the 11-year time frame, 1994–2004.

The estuarine frequency indicates a modal peak of 13.4 inches (340 mm) which is larger than the modal peaks of southern and Gulf kingfish. The distribution is shifted more towards larger fish. This may be function of the size of fish in the estuary or it may be due to the smaller sample size. Distributions are unweighted and based on measurements of 280 fish over the 11 years.

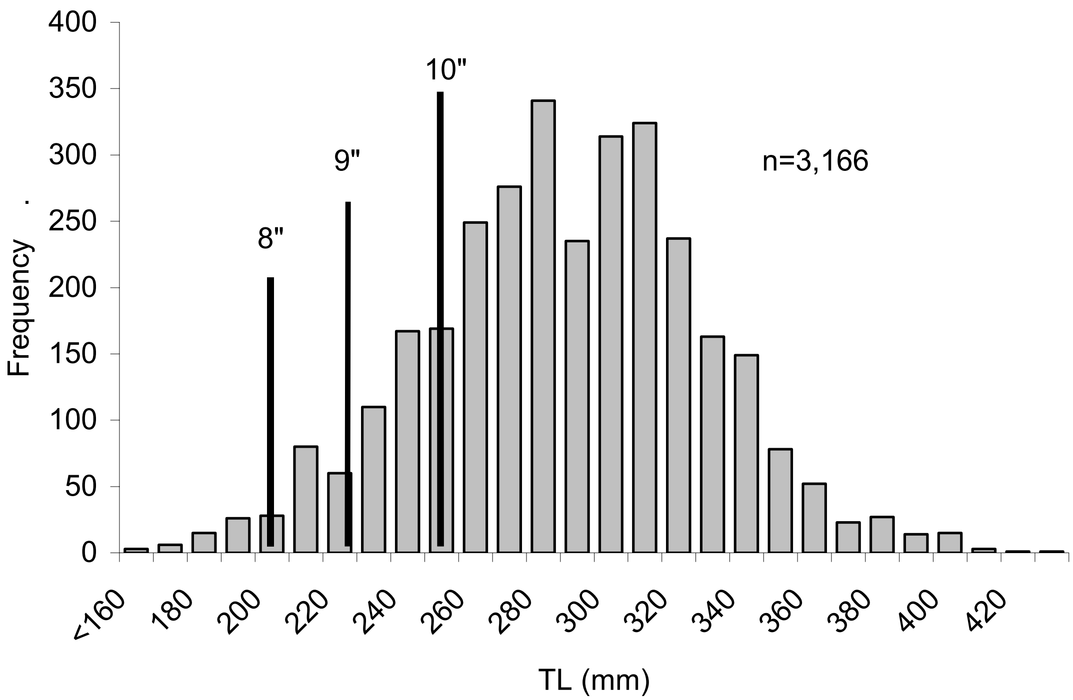

Figure 6.49 Length frequency of North Carolina ocean caught northern kingfish, 1994 - 2004.

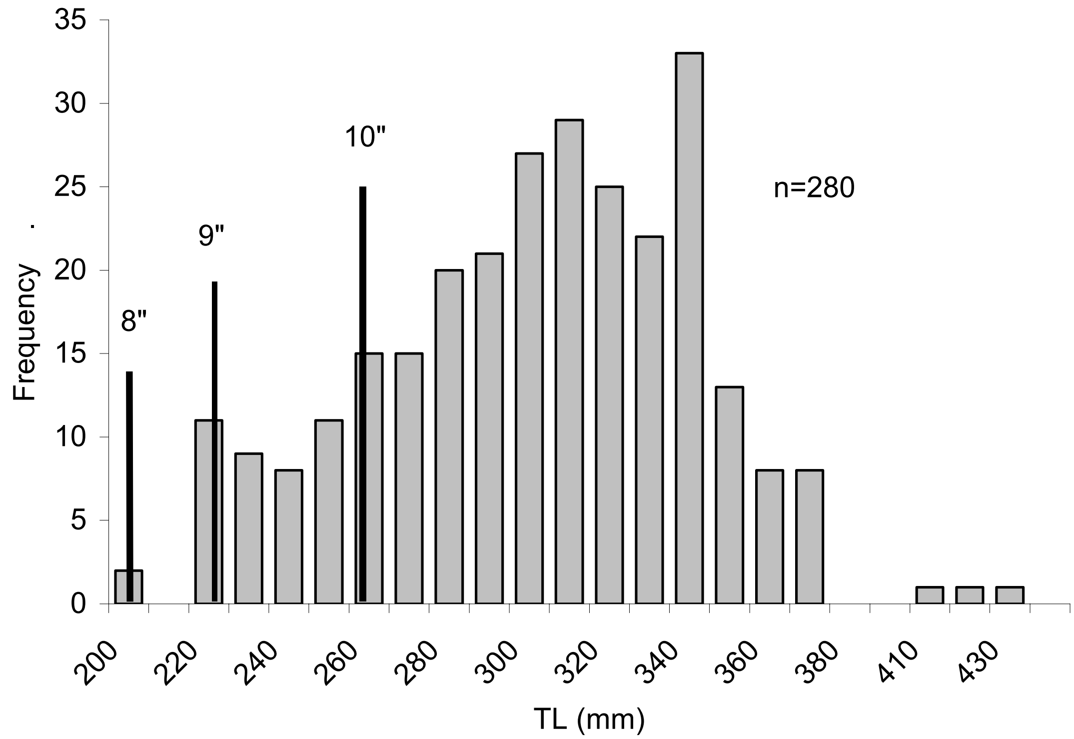

Figure 6.50 Length frequency of estuarine caught northern kingfish, 1994 – 2004.

The catch by wave indicates that northern kingfish are captured during all sampling regimes with the greatest catches occurring during waves 2 and 3 (Mar–May) and the least during wave 4 [Jul-Aug (Figure 6.51].

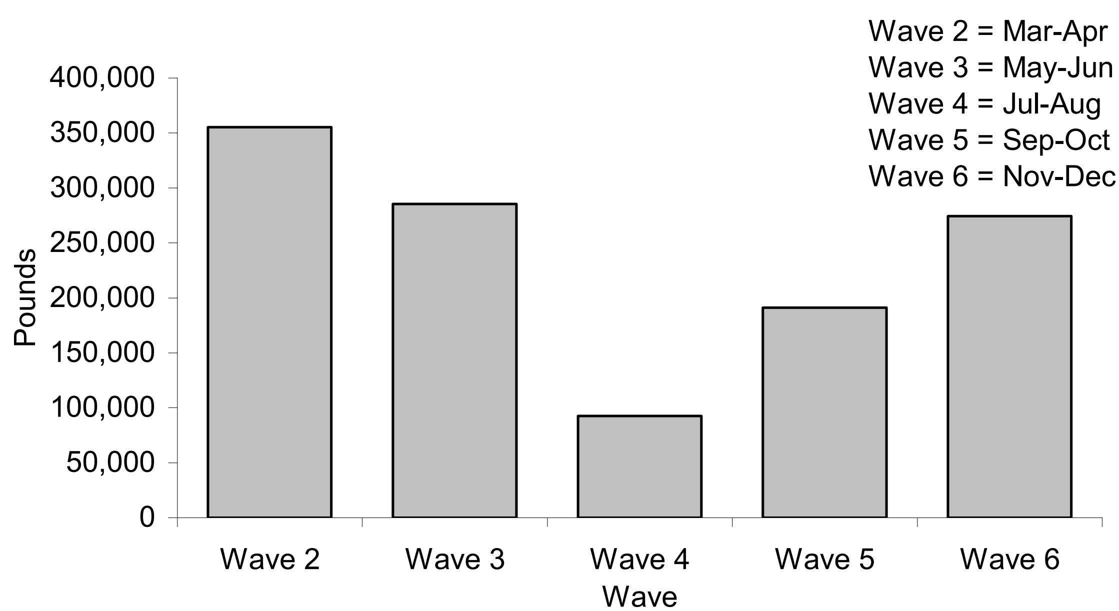

Figure 6.51 North Carolina Northern kingfish by wave, 1994 – 2004, estimated by MRFSS.

6.3 BYCATCH ASSOCIATED WITH COMMERCIAL CATCHES OF KINGFISHES

6.3.1 History

Fishery managers continually face the issue of bycatch and discards in fisheries throughout the world (Gray 2002). Discards impact fishery yields and fishery managers' ability to accurately assess fishery stocks (Fennessy 1994, Hall 1999). The NCMFC adopted a policy in November 1991 directing the NCDMF to establish the goal of reducing bycatch to the absolute minimum and incorporates that goal into actions. Bycatch is defined as "the portion of a catch taken incidentally to the targeted catch because of non-selectivity of the fishing gear to either species or size differences" (ASMFC 1994). Bycatch can be divided into two components: incidental catch and discarded catch. Incidental catch refers to retained or marketable catch of non-targeted species, while discarded catch is that portion of the catch returned to the sea as a result of regulatory, economic, or personal considerations.

While it is becoming increasingly apparent to scientists, natural resource managers, and much of the general public that bycatch is an important issue that must be addressed, characterizing the nature and extent of bycatch has proven extremely difficult. These difficulties are generally attributed to inadequate monitoring of many pertinent characteristics including actual bycatch levels, effort of the directed fishery, distribution of the bycatch species, and the mortality rate of the discarded species. The problem is exacerbated by the patchy distribution of effort and finfish in both time and space. The amount of bycatch in a particular trip is usually skewed, with many tows having some bycatch and very few tows with high bycatch. Additionally, available effort data are often inadequate. Although research indicates that tow duration is often a significant factor when estimating bycatch losses, the NCDMF and most other agencies typically record effort data by trip without any accompanying information on tow duration or the number of tows made during a trip. Mortality of bycatch captured in commercial gear varies by species, in addition to tow time, water temperature, fishing location, and gear configuration.

The lack of reliable discard estimates has not stopped researchers from investigating impacts on fish stocks, but it has prevented increases in precision. Most assessments address the range of bycatch estimates through sensitivity analyses by comparing basic assessment results over the range of bycatch estimates and assumptions. If none of the results seems plausible, the assessment may proceed without the bycatch estimates included but with the caveat that results may be biased or contain additional uncertainties due to unknown levels of missing catch. The following discussion will explore the issue of bycatch from the major commercial fisheries that land kingfishes.

6.3.2 Description of Fisheries Landing Kingfish

6.3.2.1 Shrimp trawl fishery

The gear and effort used to catch shrimp depends on the target species and area fished. Conventional two-seam otter trawls are used for pink and brown shrimp. White shrimp are harvested with a four seam and tongue trawls. Large Pamlico Sound vessels stay out four or five days and tow from one to three hours, often working day and night. Smaller vessels make daily trips and employ shorter tow times. In the Core Sound area, the fishery occurs mainly at night, with trips lasting one night. In the southern area, fishing is conducted in the ocean and estuarine waters on a day-trip basis, mostly during daylight hours.

6.3.2.2 Crab trawl fishery

The crab trawl fishery has received a large amount of attention due to the bycatch of finfish (mainly southern flounder) and sub legal crabs. There are few (less than 25) trawlers that exclusively harvest blue crabs in North Carolina's internal coastal waters. The number of vessels that reported crab trawls as at least one of the fishing gears used has ranged from 179 to 418 vessels since 1994, and averaged 290 vessels (NCTTP) per year. The majority (60%) of the effort in the crab trawl fishery, based on number of trips, occurs between March and June.

Crab trawl headrope lengths for double-rigged vessels ranged from 30 to 45 ft, while twin-rigged vessels pulled four nets in the 30-ft range. Crab trawlers working in the western portion of Pamlico Sound and the rivers (Pamlico, Pungo, and Neuse) are required to use 4" tailbag, while crab trawlers working in the eastern side of the sound must use at least a 3" tailbag (15A NCAC 3L.0202(a)). Tow times generally decrease as biomass and/or temperature increases.

6.3.2.3 Hard crab, peeler and ghost crab pots

The two management issues relating to finfish bycatch in crab pots are: 1) the composition, quantity, and fate of the marketable, and unmarketable discarded bycatch in actively fished pots; and 2) the composition, quantity, and fate of finfish bycatch in "Ghost pots". The NCTTP was used to determine marketable bycatch in crab pots and various North Carolina Fishery Resource Grant (FRG) studies were used to assess the unmarketable bycatch of kingfishes.

Ghost crab pots are defined as those pots that, either through abandonment or loss (float lines cut by boats, storm events, etc.) continue to catch crabs and finfish. Concern stemmed from the significant increase in the numbers of crab pots, the long life of vinyl coated pots, and the pot's ability to continue to trap crabs and finfish.

While data exist on the fate and quantity of blue crabs in ghost pots, little information is available on finfish bycatch since dead fish are quickly consumed by blue crabs, leaving only bones and fins (Guillory 1993, NCDMF unpublished data 1993). Due to this lack of finfish bycatch data from ghost pots, the NCDMF initiated studies in 2002 to address this. Analysis of these studies is not complete; therefore, no bycatch or discard data are available for kingfishes.

6.3.2.4 Long haul seine fishery

The North Carolina long haul seine fishery operates primarily in Core and Pamlico Sounds with most of the activity occurring in northern, and southern Pamlico Sound. The fishery is prosecuted using a long haul seine (usually between 1,000 and 1500 yards) that is stretched and pulled between two boats for a distance before the boats come together and close a circle with the net. As the net is hauled, the fish are forced into the bunt section where they are removed (Guthrie et al. 1973).

The long haul seine fishery harvests fish between April and November. It is a multi-species fishery with target species consisting of Atlantic croaker, spot and weakfish and occasionally bluefish and spotted seatrout. The long haul seine fishery in Pamlico Sound has two major areas of activity, one in northern Pamlico Sound and the other in southern Pamlico

Sound. These areas are divided geographically by Bluff Shoal, an 8.9–11.1 ft deep shoal bisecting the sound north to south and surrounded by deeper water (17.1-21.0 ft deep) on both sides. The deeper waters on either side of Bluff Shoal have been documented to have differences in species composition and abundance (Ross and Moye 1989).

Participation in the long haul seine fishery has been declining. Recently, there are only seven traditional long haul seine and swipe net crews working. Three crews work northern Pamlico Sound, behind the Outer Banks from Hatteras Island to Oregon Inlet and Roanoke Sound. A second center of activity, worked by only one crew, is located in southern Pamlico Sound and Core Sound. The other three crews located in Core Sound work the areas of Atlantic, Davis and Sea Level (Potthoff 2004).

6.3.2.5 Gill net fishery

Most kingfishes are captured in the small mesh (<5 inches) ocean gill net fishery but a few are taken incidentally in the large mesh (>5 inches) estuarine flounder fishery. Primary species harvested in the ocean with small mesh gear include Atlantic croaker, bluefish, kingfishes, spot and weakfish. The majority (62.4%) of kingfishes commercially harvested in North Carolina from 1994 to 2004 were captured with this gear. The type of small mesh gill nets targeting kingfishes is referred to as a sink or drop net. Most of the fish are captured with stretched mesh sizes between 2 ½ and 3 inches. Kingfishes are targeted in southern areas of the state, mostly in the ocean, but they represent only a portion of a multispecies ocean catch in other areas. Gill nets may be set overnight or opportunistically on suspected fish aggregations. The harvest of kingfishes is concentrated in the central and southern ocean waters of the state and to a lesser extent, the northern waters. Recent years have seen the percent of landings from small mesh gill nets rising while the landings from fish trawls, primarily flynets, has drastically decreased (see commercial section) due to restrictions on harvest areas.

6.3.2.6 Winter trawl (flynet) fishery

The flynet fishery is prosecuted in the ocean by North Carolina trawlers that fish for weakfish, Atlantic croaker, bluefish, butterfish, kingfishes and scrap (bait) fish. The fishery generally takes place October through April in waters less than 36 meters from Oregon Inlet to Cape Hatteras. Flynets are high profile trawls that fish just off the bottom. The nets range from 80 to 120 ft across with wing mesh sizes from 16 to 64 inches. The tailbags of these trawls are 3.5 inches square or 3.75 inches diamond hung. Concern over the over exploitation of weakfish led to the regulation (15A NCAC 3J .0202 (4) which prohibited flynets from fishing south of Cape Hatteras. This rule, which became permanent March 1, 1996 significantly reduced landings of kingfishes from flynets (see commercial section). Flynet landings prior to 1998 were a major contributor to kingfish landings but since 1998, landings have averaged only 2% of the total catch (NCTTP 1994-2004).

6.3.2.7 Beach seine fishery

The beach seine fishery involves setting and hauling a seine from the beach (Atlantic Ocean) to target nearshore migrating fish populations. Beach seines are set using dories launched from the beach, and retrieved back to the beach with 4-wheel drive trucks. The fishery presently occurs primarily along the northeastern NC coast, from the NC/VA border to Cape Hatteras.

The beach seine may consist of a wash net, bunt and wing. The most common beach seine is a “hybrid net” constructed of monofilament-nylon net (wash net, wings) and a multifilament-nylon bunt, but some beach seiners use nets that are constructed of monofilament-nylon throughout (wash net, wing and bunt). Small mesh beach seines range in length from 600-1,500 ft, but are restricted to a total length of 1,000 ft from May 1-October 31, NC/VA border to Cape Lookout, NC (BNDTRP, Final Rule, April 26, 2006, FR, Vol 71, No. 80). The fishery is currently listed under the Mid-Atlantic haul/beach seine fishery as a Category II fishery under the Marine Mammal Protection Act’s (MMPA’s) List of Fisheries (LOF).

The small mesh beach seine fishery operates predominantly during the spring (April-May) and fall (September-October). Small mesh beach seines typically consist of 2 ⅞ to 3 ¼ inches stretched mesh. There also is a large mesh (7 to 9 inches stretched mesh) beach seine fishery that targets striped bass. The striped bass beach seine fishery is limited to a seasonal quota, and opens by the proclamation authority of the NCDMF Director, typically during the winter (December-February). The large mesh beach seine fishery rarely captures kingfish and is not included herein.

6.3.3 Bycatch Results in Fisheries Landing Kingfishes

6.3.3.1 Shrimp trawl

Marketable bycatch

An average of 428,173 lb of finfish are landed annually by shrimp trawls (NCTTP 1994-2004). Kingfishes are the most common finfish species landed accounting for 34% of the total. Although most kingfishes captured are incidental to shrimp trawling, a directed fishery using shrimp trawls occurred in the Atlantic Ocean in 1996 and 1997. In 1996, 34% of the kingfishes landed by shrimp trawls were from trips that had no shrimp landings. This number increased to 54% in 1997 (Table 6.8). Annual shrimp trawl landings of these species were 143,863 lb. Seventy-one percent of the landings were from the Atlantic Ocean and 27% from Pamlico Sound (Table 6.9). The majority (40%) of the kingfishes landed from the ocean were caught from 0-3 miles south of Cape Hatteras. Eighty-eight percent of the ocean landings occurred from October through March, while 92% of the inside landings occurred July through November (Table 6.10).

Table 6.8 Comparison of kingfish landings from shrimp trawls with and without shrimp landings (NCTTP).

Year	Total reported kingfish landings from shrimp trawls	Kingfish landings from shrimp trawls with no reported shrimp landings	Percent difference
1994	94,477	1,233	1.31%
1995	243,100	9,194	3.78%
1996	202,326	69,373	34.29%
1997	229,079	123,930	54.10%
1998	80,470	1,627	2.02%
1999	237,427	6,352	2.68%
2000	156,870	2,170	1.38%
2001	47,542	128	0.27%
2002	114,285	711	0.62%
2003	68,088	229	0.34%
2004	108,825	1,296	1.19%
Total	1,582,492	216,243	13.66%
Average	143,863	19,658	

Table 6.9 Yearly landings (lb.) of kingfishes from shrimp trawls, by waterbody, for North Carolina (1994-2004). CH= Cape Hatteras and IWW=Inland Waterway

	Year													Percent
Waterbody	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total	Average	of total
Ocean 0-3 mi, S of CH	0	18,708	82,727	68,265	37,365	159,425	99,405	16,438	50,469	32,767	65,171	630,739	57,339.92	39.86%
Pamlico Sound	50,426	67,122	39,821	36,577	13,911	46,943	46,902	25,931	41,949	24,647	39,057	433,285	39,389.57	27.38%
Ocean less than 3 miles[ϑ]	35,200	79,605	34,031	17,081	2,654	14,284	0	0	0	0	0	182,855	16,623.14	11.55%
Ocean >3 mi, S of CH	0	9,274	11,371	63,797	24,234	8,807	7,117	4,421	18,093	9,333	3,743	160,189	14,562.62	10.12%
Ocean more than 3 miles[ϑ]	7,768	56,295	19,579	38,844	1,733	192	0	0	0	0	0	124,411	11,310.05	7.86%
Ocean >3 mi, N of CH	0	0	12,370	2,213	*	2,646	12	0	157	*	*	17,606	1,600.55	1.11%
Ocean 0-3 mi, N of CH	0	9,652	171	379	50	1,703	1,785	0	1,177	2	11	14,930	1,357.27	0.94%
Core Sound	549	1,411	42	1,149	132	805	514	389	303	817	466	6,575	597.68	0.42%
Neuse River	74	182	1,835	374	16	1,134	24	0	581	*	*	4,519	410.82	0.29%
New River	23	151	59	82	25	31	808	82	711	48	59	2,078	188.91	0.13%
Cape Fear River	158	40	83	58	68	280	145	60	638	193	65	1,788	162.50	0.11%
Pamlico River	48	616	98	216	93	115	18	206	192	49	0	1,651	150.05	0.10%
Bogue Sound	*	0	16	*	0	*	13	*	0	0	91	1,187	107.91	0.08%
Bay River	150	*	0	26	*	*	14	0	0	*	0	221	20.09	0.01%
IWW	*	7	0	*	10	0	68	*	9	23	0	127	11.53	0.01%
White Oak River	0	0	*	0	0	0	0	0	0	0	0	123	11.18	0.01%
North River/Back Sound	46	14	*	0	0	0	0	0	0	0	0	61	5.55	0.00%
Croatan Sound	0	4	0	5	0	6	28	7	3	0	0	53	4.82	0.00%
Newport River	0	*	0	0	0	0	*	0	0	0	0	25	2.27	0.00%
Roanoke Sound	7	6	0	3	0	*	0	0	5	0	0	23	2.12	0.00%
Stump Sound	*	*	0	0	0	0	0	0	0	0	0	18	1.64	0.00%
Masonboro Sound	0	0	0	0	*	0	*	*	0	*	0	9	0.82	0.00%
IWW (Onslow Co.)	0	0	0	0	0	0	0	0	0	*	7	8	0.73	0.00%
Topsail Sound	*	0	0	0	0	0	0	0	0	0	0	7	0.64	0.00%
IWW (Brunswick Co.)	0	0	0	0	0	0	0	0	0	5	*	6	0.55	0.00%
Total	94,477	243,100	202,326	229,079	80,470	237,427	156,870	47,542	114,285	68,088	108,825	1,582,492	143,862.90	100.00%

*Confidential data

[ϑ] Only available from NCTTP 1994 to 1999.

Table 6.10 Percent monthly contribution of kingfishes landings from shrimp trawls, by waterbody, for North Carolina (1994-2004). CH= Cape Hatteras and IWW=Inland Waterway

	Month											
Waterbody	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ocean 0-3 mi, S of CH	3.39%	0.58%	6.23%	2.05%	1.63%	1.86%	1.90%	1.98%	1.99%	19.23%	43.30%	15.87%
Pamlico Sound	0.03%	0.08%	0.03%	0.21%	1.08%	4.35%	18.28%	28.34%	12.77%	17.95%	14.89%	1.97%
Ocean less than 3 miles	5.19%	17.61%	14.80%	5.88%	2.51%	2.23%	4.15%	1.73%	1.86%	6.66%	28.45%	8.94%
Ocean >3 mi, S of CH	7.29%	27.28%	6.73%	1.25%	3.28%	3.43%	2.02%	0.85%	1.56%	13.82%	28.96%	3.53%
Ocean more than 3 miles	13.68%	20.09%	21.02%	1.76%	0.80%	0.78%	2.99%	1.62%	0.89%	2.79%	7.86%	25.70%
Ocean >3 mi, N of CH	0.00%	12.39%	69.09%	0.00%	0.34%	0.15%	0.15%	0.47%	1.66%	4.15%	11.59%	0.00%
Ocean 0-3 mi, N of CH	4.66%	0.00%	0.00%	0.36%	0.00%	0.76%	0.28%	0.77%	0.67%	6.99%	26.81%	58.71%
Core Sound	0.24%	15.36%	0.67%	8.60%	6.28%	7.61%	30.92%	11.01%	2.54%	4.84%	11.90%	0.02%
Neuse River	0.00%	0.00%	0.00%	0.00%	0.00%	6.17%	32.27%	21.44%	5.28%	2.15%	32.00%	0.69%
New River	0.00%	0.00%	1.06%	3.95%	3.34%	0.46%	1.97%	0.70%	10.73%	45.64%	29.36%	2.79%
Cape Fear River	2.97%	0.00%	16.22%	6.32%	0.06%	0.17%	3.13%	3.47%	13.20%	12.56%	30.88%	11.02%
Pamlico River	0.00%	0.00%	0.00%	0.00%	6.06%	10.18%	28.05%	19.27%	10.48%	9.30%	16.48%	0.18%
Bogue Sound	0.00%	0.00%	0.00%	1.94%	0.34%	0.42%	7.41%	0.00%	0.25%	0.34%	89.30%	0.00%
Bay River	0.00%	0.00%	0.00%	5.43%	13.12%	6.33%	67.19%	1.36%	4.07%	2.49%	0.00%	0.00%
IWW	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	61.12%	2.37%	22.08%	6.55%	7.89%	0.00%
White Oak River	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
North River/Back Sound	0.00%	0.00%	0.00%	3.28%	1.64%	0.00%	0.00%	47.54%	31.15%	0.00%	16.39%	0.00%
Croatan Sound	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.66%	43.40%	47.17%	3.77%	0.00%	0.00%
Newport River	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%
Roanoke Sound	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.28%	40.02%	51.41%	4.28%	0.00%	0.00%
Stump Sound	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Masonboro Sound	0.00%	0.00%	0.00%	55.56%	0.00%	11.11%	0.00%	0.00%	0.00%	33.33%	0.00%	0.00%
IWW (Onslow)	0.00%	0.00%	0.00%	25.00%	25.00%	0.00%	0.00%	12.50%	37.50%	0.00%	0.00%	0.00%
Topsail Sound	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
IWW (Brunswick)	0.00%	0.00%	0.00%	0.00%	16.67%	0.00%	66.67%	0.00%	0.00%	16.67%	0.00%	0.00%
Ocean total	5.33%	9.44%	10.21%	2.47%	1.87%	1.98%	2.35%	1.70%	1.77%	14.23%	34.25%	14.40%
Inside total	0.04%	0.30%	0.11%	0.38%	1.18%	4.42%	18.51%	27.66%	12.50%	17.61%	15.34%	1.95%
Monthly total	3.82%	6.83%	7.33%	1.87%	1.67%	2.68%	6.96%	9.11%	4.83%	15.19%	28.85%	10.85%

$^{\vartheta}$Only available from NCTTP 1994 to 1999.

Unmarketable bycatch

Although a long-term characterization study of bycatch in the shrimp trawl fishery has not been conducted for North Carolina waters, preliminary investigations were conducted in 1995 (Diamond-Tissue 1999) and 1999 (Johnson 2003). Additionally, two FRGs were funded by North Carolina Sea Grant to compare bycatch rates between day and night in the southern portion of the state (Taylor and Donello 2000; and Ingraham 2003).

Diamond-Tissue's (1999) 1995 characterization study examined 52 tows conducted over 15 trips. Sampled boats had one or two nets, and all nets contained the required TED and BRD. Ninety-two different species, including 66 species of finfish, 10 species of crabs, and 13 other invertebrates were identified. Data was provided for the top ten species by number and weight for each waterbody. These top ten species accounted for between 85 and 95% of the total catch by number and weight in each waterbody. Kingfishes were not part of the top ten species in any waterbody.

Johnson (2003) quantified the catch of shrimp trawlers working in Core Sound (n=46 tows) and the Neuse River (n=8 tows) during the summers of 1999 and 2000. Spot (48%), Atlantic croaker (13%), and pinfish (12%) accounted for 73% of the finfish bycatch from Core Sound. In the Neuse River, Atlantic croaker (44%), and spot (33%) accounted for 77% of the finfish bycatch. No kingfishes were observed in either area.

Taylor and Donello (2000) examined shrimp trawl catches from estuarine waters in the southern portion of the state (New River to Ocean Isle Beach bridge) from May through November (no tows in July). Catches from 54, 45-minute tows were examined. Data was only provided for species whose combined catch weight exceeded four kilograms. No data was reported for kingfishes, so if captured, the combined total weight was less than four kilograms.

Ingraham (2003) examined ocean (0-3 miles) shrimp trawl catches from Topsail Inlet to the Little River Inlet. Catches from 40 tows (20 daytime, and 20 nighttime) collected during May-June, and September-December were analyzed. Kingfishes were the 8th most abundant category, accounting for 1.2 percent of the total catch weight. Kingfish catches were significantly higher in December than any other month, and nighttime catch rates were significantly higher than daytime catch rates (0.14 lb/minute night, and 0.04 lb/minute daytime).

Bycatch reduction in the shrimp trawl fishery

The NMFS, along with the Gulf and South Atlantic Fisheries Development Foundation (GSAFDF), began a cooperative bycatch research program. Beginning in February 1992 and continuing until December 1996, observers were placed aboard cooperating vessels to characterize bycatch and to test BRDs during normal commercial shrimp trawling. More than 150 taxa have been identified from shrimp trawl catches in the South Atlantic, and the average overall catch rate was 57.33 lb per hour (Nance 1998). Finfish comprised 54% of the catch by weight, shrimp 18%, other invertebrates 18%, and the remaining 13% were crustaceans. Seasonal distribution of finfish bycatch in the South Atlantic indicates that the highest percentage by weight occurred in the summer but by number, the highest was in the spring. The top ten species by weight were: cannonball jelly (14%); white shrimp, spot, and Atlantic menhaden (9%); brown shrimp, other jellyfish and Atlantic croaker (6%); and southern kingfish, blue crab (4%), and star drum (3%).

Numerous gear evaluation studies have been conducted in North Carolina waters

(McKenna and Monaghan 1993; Coale et al. 1994; Murray et al. 1995; and McKenna et al. 1996). However, these data should not be used for characterization analysis since these studies were often conducted during times of low shrimp catch rates. Therefore, the bycatch data are not representative of times when shrimp catch rates are higher. For example, the fish to shrimp ratio for gear studies conducted in 1994 (McKenna et al. 1996) was 5.5 to 1, while characterization studies conducted in 1995 by Diamond-Tissue (1999) calculated the fish to shrimp ratio to be 1.6 to 1. Although these data should not be used for characterization analysis, catches provide information on presence or absence and size of species.

Gear testing was conducted on a commercial trawler in Pamlico Sound in 1991. Data was collected from 41, 90-minute tows during May (n=6), August (n=18), and September (n=17). Kingfishes comprised 1.5% of the total finfish catch, and averaged 3.4 lb per tow. May catches accounted for the highest average catch per tow (4.6 lb) and represented 4.5% of the total finfish catch. August and September had the same percent contribution of kingfishes to total finfish (1.3%). On average, 3.6 lb of kingfishes were captured per tow in August, and 2.8 lb in September.

Gear testing in 1994 was conducted in Pamlico, Croatan and Core sounds, and the Newport, New, and Cape Fear rivers. Work in the Pamlico Sound complex (Pamlico and Croatan sounds) was performed aboard commercial and state vessels. All work in the other areas was conducted aboard commercial trawlers. New River had the highest overall catch-per-unit-effort (CPUE) of kingfishes (1.39 lb/tow), followed by, the Cape Fear River (0.60 lb/tow), and Pamlico Sound [0.55 lb/tow (Table 6.11)]. Overall, kingfishes were observed in 24% of the sampled catches. The Cape Fear River had the highest percentage (62%) of the tows with kingfishes, while Core Sound and the Newport River had the lowest [2% (Table 6.11)].

Table 6.11 Kingfish data for control nets from gear testing conducted in North Carolina in 1994.

		Weight (lb)				Percentage of tows	
Area	Number of tows	Finfish	Kingfish	Percent kingfish	Kingfish CPUE (lb/tow)	without kingfish	with kingfish
Cape Fear River	32	2,033	19	0.95%	0.6	38.33%	61.67%
New River	115	8,551	160	1.87%	1.4	51.40%	48.60%
Core Sound	165	3,772	0	0.01%	0	98.33%	1.67%
Newport River	60	137	0	0.02%	0	98.33%	1.67%
Pamlico Sound	129	16,690	71	0.42%	0.6	68.63%	31.37%
Croatan Sound	43	2,576	1	0.05%	0.03	90.38%	9.62%
Total	544	33,759	252	0.75%	0.46	76.14%	23.86%

The length frequency of kingfishes captured during gear testing in 1994 is shown in Figure 6.52 and is overlapped with the length frequency of kingfishes captured during the PSS from 1987 through 2005. The PSS is a fishery independent survey conducted in June and September of each year. This survey uses two 30-foot mongoose trawls with a 1 ½ inch stretched mesh tailbag, which is the minimum required mesh size for shrimp trawls. The distribution of lengths in both studies was similar even though sample sizes were much higher in the PSS. The similarity of the lengths reflects the selectivity to the gears and abundance of kingfishes.

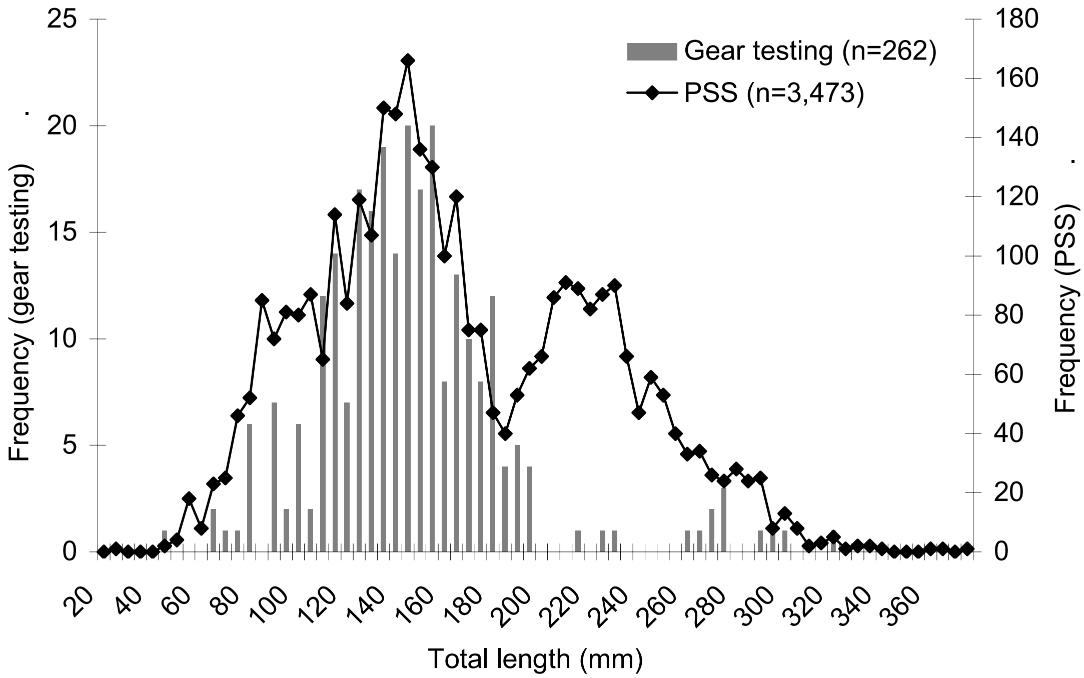

Figure 6.52 Length (mm) frequency distribution of kingfishes captured during gear testing in Pamlico Sound (1994) and the PSS, 1987 - 2005.

While the effect shrimp trawl bycatch has on kingfish stocks is unknown, the reduction of fishing mortality on unmarketable juvenile finfish stocks might result in more individuals recruiting into the spawning stock, recreational and other commercial fisheries. Methods and management options to reduce kingfish bycatch in the shrimp trawl fishery are addressed in the management strategies issue paper.

6.3.3.2 Crab trawl results

Marketable bycatch

Finfish landings from crab trawls averaged 80,620 lb per year (NCTTP 1994-2004). The main species landed was southern flounder accounting for 81% of the total. Kingfish landings accounted for 2% of total finfish landings from this gear and averaged 1,324 lb per year. April (42%), March (18%), November (12%) and December (15%) accounted for 87% of the kingfish landings. Pamlico Sound accounted for 93% of the kingfish landings from crab trawls.

Unmarketable bycatch

McKenna and Camp (1992) assessed the finfish bycatch of the crab trawl fishery in the Pamlico River. During this study, 15 trips were made March through June aboard commercial crab trawlers. The mean number of tows made during a trip was 3.3, and ranged from 1 to 5. Tow times ranged from 1 to 4 hours and averaged 2.87 hours. An average trip consisted of 9.46 hours of towing. No kingfishes were captured in 50 tows.

Bycatch reduction in the crab trawl fishery

Two gear studies conducted to determine the feasibility of reducing crab trawl bycatch through the alteration of the tailbag mesh size provided some limited data on kingfishes bycatch. McKenna and Clark (1993) tested the effects of different tailbag mesh sizes on reducing bycatch in the crab trawl fishery. This study was performed by the NCDMF between November 1991 and November 1992. The testing was conducted in the Pamlico, Pungo, and Neuse rivers during the fall and winter and in Adam's Creek during the summer using 3, 4, and 4½ inch (stretched mesh) tailbags. Seventy-one tows were conducted aboard a research vessel towing two nets at a time, the control net with the 3 inch tailbag and the test net with either the 4 inch tailbag (31 tows) or 4½ inch tailbag (40 tows). Tow times were one hour at night during the winter and spring and 30 minutes during the day in the summer. During this study, 587 lb of finfish were captured of which 0.5 lb (0.1%) were kingfishes.

Another study on different tailbag mesh sizes for crab trawls was examined by Lupton (1996) between June 1995 and May 1996. Two hundred twenty tows were conducted during the day in Bay River aboard a research vessel towing two 30-foot nets, the control net with the 3 inch tailbag and the test net with either the 4 inch tailbag (110 tows) or 4½ inch (110 tows) tailbag. Tow times were one hour during the winter, and spring and 30 minutes in the summer. Only nine lb of kingfishes were capture in 868 lb of finfish. Kingfishes comprised 1% of the finfish catch and averaged 0.04 lb per tow.

6.3.3.3 Hard crab and peeler pot results

Marketable bycatch

Annual landings of the marketable portion of the incidental finfish bycatch from hard crab pots averaged 59,208 lb (NCTTP 1994-2004). Kingfishes are the 18th most common finfish species landed from this gear. Annual landings of kingfishes from hard crab pots averaged 254 lb (NCTTP, single gear trips only). Eighty-nine percent of the landed kingfishes were captured April through July. Kingfishes landed from hard crab pots have been reported from 12 waterbodies. Pamlico Sound accounted for the majority (78%) of the landings, followed by Roanoke Sound (8%), Albemarle Sound (4%), and Croatan Sound (4%). Single gear trips reported an average annual finfish landings from peeler pots are 855 lb (NCTTP 1994-2004). Peeler pots landed a total of 5 lb of kingfishes from 1994 through 2004.

Discarded unmarketable bycatch

Four crab pot fishermen kept records of bycatch in their hard and peeler pots from March through October 1999 (Doxey 2000). Hard crab pot data were collected from 283 trips during which 149,649 hard crab pots were fished. Peeler pot data were collected from 11 trips taken in May during which 1,950 peeler pots were fished. Seventeen finfish species were observed in hard crab pots and nine in peeler pots. No kingfishes were observed in any of the pots examined.

Thorpe et al. (2004) reported hard crab pot bycatch data (May – December 2003) from Core Sound [CS (28 trips)] and Brunswick County [BC (28 trips)]. The number of pots fished per trip ranged from 68-84, with average soak times of 2 ½ (BC) and 2 ¾ days (CS). A total of 19 finfish species were observed. No kingfishes were captured.

6.3.3.4 Long haul seine results

Incidental marketable bycatch

The long haul seine fishery harvests fish between April and November. This is a minor fishery for kingfishes representing a 3.3% average of total landings from 1994 to 2004. Target species are Atlantic croaker, spot and weakfish and occasionally bluefish and spotted seatrout. Kingfishes are incidental with some trips landing between 100 and 150 lb of kingfishes, primarily on the south side of Bluff Shoals. Fish house sampling from 1994 to 2003 indicated that kingfishes represented less than 1% by number and weight of all catches. Species compositions for 42 trips sampled in 2003 are shown in Table 6.12 (Potthoff 2004). Species composition has changed little since 1982.

Scrapfish

A significant portion of long haul seine catches is sold as scrapfish (bait). Annual mean scrapfish percentages by weight have ranged between 30 and 45% of the total catch (Potthoff 2004). The dominant species in the scrapfish each year was Atlantic croaker, spot, Atlantic menhaden and pinfish, accounting for nearly 90% of the scrapfish by weight and number (Table 6.13). Kingfishes constituted only a trace amount of the long haul seine scrap fishery ranging from 0.04% in 2004 to 0.3% in 2002. NCDMF sampled the scrapfish component of 42 long haul seine catches in 2003 and the mean weight of kingfishes per catch was 0.89 lb.

Table 6.12 Species composition of long haul seine catches, Pamlico Sound area, April October, 2003, N=42.

	Weight (lb)		Number			
Species	Mean	Percent	Mean	Percent	Mean fish weight (lb)	Percent occurrence
Spot	3,321.40	39.80	11,464	34.40	0.10	100.00
Atlantic croaker	1,466.50	17.60	7,777	23.30	0.10	88.10
Weakfish	1,191.80	14.30	2,105	6.30	0.30	97.60
Pinfish	937.60	11.20	8,275	24.80	0.10	100.00
Atlantic menhaden	463.00	5.50	1,453	4.40	0.10	45.20
Pigfish	329.60	3.90	1,352	4.10	0.10	88.10
Bluefish	188.30	2.30	272	0.80	0.30	90.50
Black drum	161.60	1.90	47	0.10	1.60	40.50
Spotted seatrout	66.40	0.80	46	0.10	0.60	76.20
Southern kingfish	**53.80**	**0.60**	**107**	**0.30**	**0.20**	**54.80**
Sheepshead	31.30	0.40	12	0.00	1.20	64.30
Houndfish	24.00	0.30	9	0.00	1.20	19.00
Silver perch	21.20	0.30	139	0.40	0.10	47.60
Harvestfish	15.40	0.20	39	0.10	0.20	21.40
Spadefish	12.80	0.20	28	0.10	0.20	23.80
Unknown fishes	9.50	0.10	54	0.20	0.10	2.40
Florida pompano	6.60	0.10	8	0.00	0.40	42.90
Cownose ray	5.50	0.10	1	0.00	1.70	7.10
Striped mullet	4.90	0.10	7	0.00	0.30	4.80
Atlantic thread herring	4.40	0.10	36	0.10	0.10	7.10
Southern flounder	4.20	0.10	3	0.00	0.70	14.30
Butterfish	4.00	0.00	30	0.10	0.10	31.00
Red drum	3.70	0.00	1	0.00	1.70	19.00
Flounder species	2.90	0.00	2	0.00	0.70	16.70
Kingfish species	**2.40**	**0.00**	**5**	**0.00**	**0.20**	**9.50**
Spanish mackerel	2.20	0.00	2	0.00	0.40	26.20
Lookdown	2.20	0.00	32	0.10	0.00	11.90
Northern puffer	1.80	0.00	3	0.00	0.30	14.30
Blue crab	1.80	0.00	10	0.00	0.10	11.90
Striped burrfish	1.50	0.00	2	0.00	0.40	14.30
Crevalle jack	1.30	0.00	7	0.00	0.10	7.10
Atlantic stingray	1.30	0.00	.	0.00	.	4.80
Bighead sea robin	1.30	0.00	17	0.10	0.00	2.40
Summer flounder	0.70	0.00	3	0.00	0.10	7.10
Mullet species	0.70	0.00	1	0.00	0.30	7.10
Striped Sea robin	0.40	0.00	3	0.00	0.10	4.80

Table 6.13 Species composition of scrapfish in Pamlico Sound area long haul seine catches, April– October, 2003, n=42.

	Weight (lb)		Number		
Species	Mean	Percent	Mean	Percent	Mean fish weight (lb)
Atlantic croaker	1231.90	33.00	7,594	31.70	0.20
Pinfish	906.70	24.30	8,361	34.80	0.20
Spot	820.80	22.00	5,057	21.10	0.20
Atlantic menhaden	474.20	12.70	1,489	6.20	0.20
Pigfish	190.90	5.10	982	4.10	0.20
Bluefish	43.90	1.20	130	0.50	0.40
Silver perch	21.80	0.60	142	0.60	0.20
Weakfish	7.30	0.20	51	0.20	0.20
Harvestfish	6.40	0.20	11	0.00	0.70
Cownose ray	5.70	0.20	2	0.00	3.70
Atlantic spadefish	5.10	0.10	21	0.10	0.20
Atlantic thread herring	4.40	0.10	37	0.20	0.20
Butterfish	3.10	0.10	28	0.10	0.20
Lookdown	2.20	0.10	33	0.10	0.20
Blue crab	1.80	0.00	11	0.00	0.20
Northern puffer	1.50	0.00	3	0.00	0.70
Striped burrfish	1.50	0.00	2	0.00	0.90
Crevalle jack	1.30	0.00	7	0.00	0.20
Striped searobin	1.30	0.00	18	0.10	0.00
Southern kingfish	**0.90**	**0.00**	**4**	**0.00**	**0.20**
Summer flounder	0.70	0.00	3	0.00	0.20
Bighead searobin	0.40	0.00	3	0.00	0.20
Black drum	0.20	0.00	1	0.00	0.20
Longspine porgy	0.00	0.00	<1	0.00	0.20
Leopard searobin	0.00	0.00	2	0.00	<0.1
Planehead filefish	0.00	0.00	<1	0.00	<0.1

6.3.3.5 Gill net results

Ocean Fishery Bycatch

Kingfishes harvested in gill nets were primarily (89%) captured in the ocean from 1994 to 2004. The remaining 11% of the gill net harvest occurred in estuarine waters. For this gill net bycatch analysis, a kingfish trip was defined as any gill net trip landing at least one pound of kingfishes. These kingfish trips are the data source for the subsequent analysis. The gill net fishery in the ocean averaged 2,481,153 lb of marketable catch per year with at least one pound of kingfish landed in each of these trips (NCTTP 1994-2004). Weakfish landings in the ocean waters were the highest landings associated with kingfishes (29.1%) followed by spot (14.7%), kingfishes (14.3%) and croaker (13.2%). Most of the trips in the ocean gill net fishery that harvested kingfishes were multispecies trips while others targeted kingfishes. The target species that were sought varied depending on the region (Figure 6.53). Regions along the coast were designated by district as northern, central and southern and the differences in species composition were examined (Table 6.14). Kingfishes were bycatch in the Atlantic croaker, bluefish, spot and weakfish fisheries in the Northern and Central districts but were targeted along with spot in the southern district. Kingfishes ranked first in the southern district in the total lb by species, just ahead of spot but ranked sixth in the northern district and fourth in the central district.

Landings were separated for the top five species by the weight of kingfishes harvested on each trip and then summed to derive total landings by bin size and district (Table 6.15). These data further illustrated that kingfishes were part of a multispecies fishery in the Northern and Central districts. These districts harvested weakfish, spot, Atlantic croaker, Spanish mackerel and bluefish in varying amounts across all bin sizes. It was impossible to determine a clear point where fishermen began targeting kingfishes in the northern and central districts. Landings of kingfishes did not surpass landings of weakfish until greater than 600 lb of kingfishes were caught in the Northern District and 500 lb in the Central District.

There is a clear point when fishermen targeted kingfishes in the Southern District ocean waters. Kingfish trips greater than 100 lb in the Southern District were designated as targeted trips since no other species had higher landings than kingfishes in any of the bin sizes greater than 100 lb. The species composition of targeted kingfish trips (bin sizes 100 lb and greater) is represented in Figure 6.54. Landings from the Southern District accounted for 48% of the total kingfish landings in the state. Spot ranked second in the district and accounted for 35% of the total landings (only trips with kingfishes in the catch) of which 79% came from trips with less than 100 lb of kingfishes. Kingfishes did not appear to be the targeted species on these trips. Weakfish in the Southern District comprised only 8% of the gill net landings in trips that landed kingfishes. Other marketable bycatch in the kingfish trips included spot, weakfish, bluefish and Atlantic croaker.

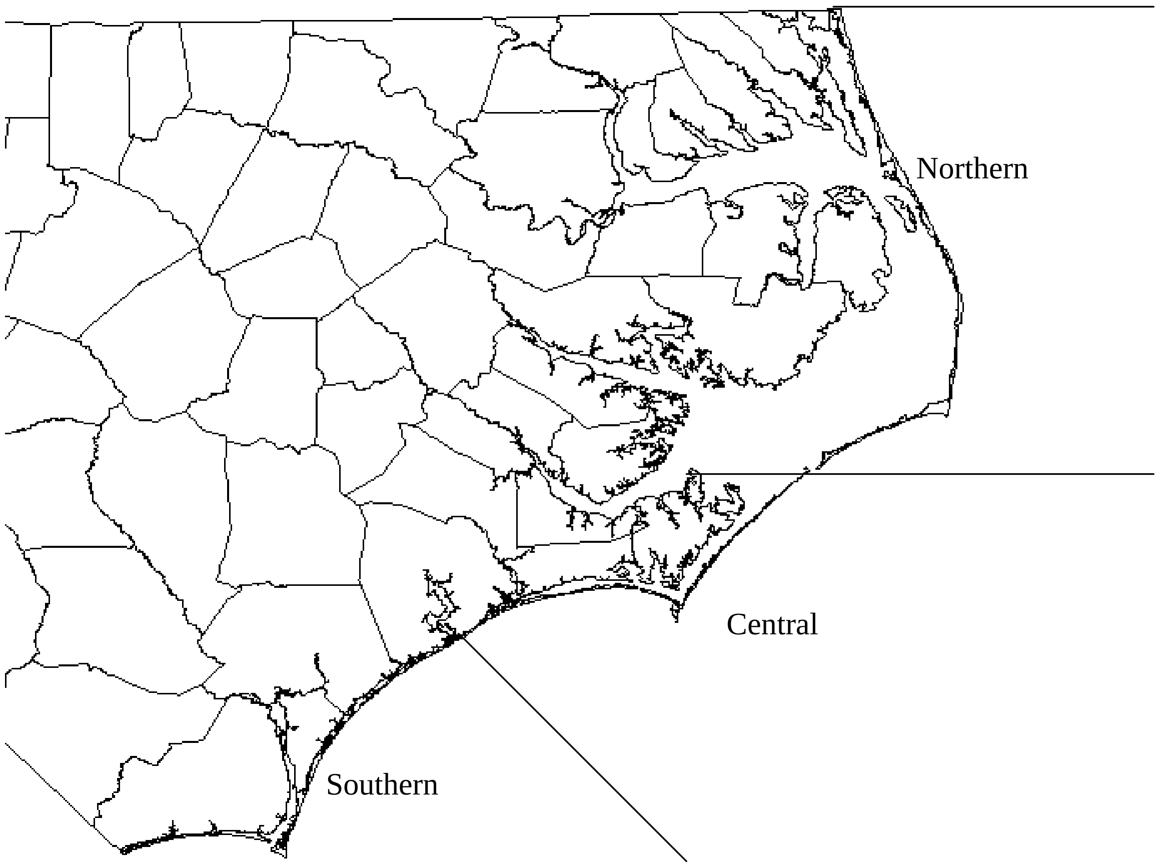

Figure 6.53 Regions used to describe the species captured in the gill net fisheries.

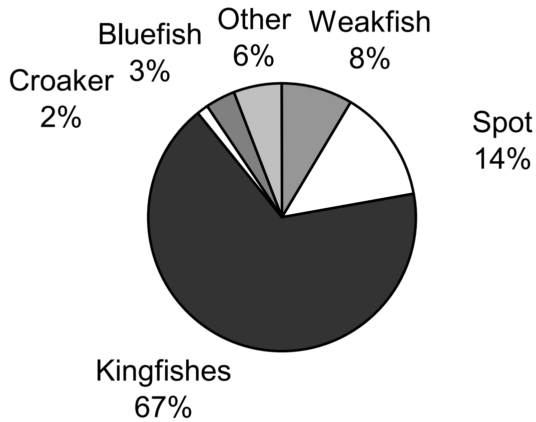

Figure 6.54 Species composition of targeted gillnet kingfish trips (> 100 lb kingfish) in the Southern District, NCTTP, 1994 - 2004.

6.3.3.6 Estuarine Gill net Fishery Bycatch

The combined estuarine landings of all marketable species in trips landing at least one pound of kingfishes averaged 729,409 lb from 1994 to 2004. Bluefish landings were the highest marketable landings associated with kingfishes (20.4%), followed by weakfish (19.7%), flounder (17.4%) and spot (16.8%). Kingfishes ranked 6th among all market categories (5.6%). Kingfishes were marketable bycatch in fisheries that targeted bluefish, weakfish, flounder and spot (Table 6.14).

Estuarine landings from 1994 to 2004 were separated for the top five species by the weight of kingfishes harvested on each trip and then summed to derive total landings by bin size and district (Table 6.15). These data indicated that 70.7% of kingfishes landed were associated with a multi-species fishery that included spot, weakfish and bluefish. Most kingfish were landed in trips in the first three bin sizes (0-99, 100-199, and 200-299 lb). Also there was a small, directed fishery in the estuarine waters that captured the remaining (29.3%) landings of kingfishes. NCDMF dependent and independent sampling indicated minimal bait or reported discards of kingfishes from the estuarine gill net fishery.

Table 6.14 Landings (lb), rank and percent of species captured in the gill net fishery with at least one pound of kingfish by district, 1994 - 2004.

Market Category	Estuarine Waters	Estuarine % of Total	Ocean Northern District (ND)	Ocean ND % of Total	Ocean Central District (CD)	Ocean CD % of Total	Ocean Southern District (SD)	Ocean SD % of Total	Total	Ocean Total	% of all Ocean Species	% of all Estuarine Species
Weakfish	1,581,348(**2**)	16.6%	5,328,621(**1**)	55.9%	2,212,481(**1**)	23.2%	412,714(**3**)	4.3%	9,535,164	83.4%	29.1%	19.7%
Spot	1,344,687(**4**)	25.2%	686,724	12.8%	1,506,556(**2**)	28.2%	1,807,669(**2**)	33.8%	5,345,636	74.8%	14.7%	16.8%
Kingfishes	452,525(**6**)	10.4%	702,362(**6**)	16.2%	1,098,470(**4**)	25.3%	2,091,533(**1**)	48.1%	4,344,890	89.6%	14.3%	5.6%
Croaker	213,949	5.6%	2,295,617(**2**)	60.4%	1,218,035(**3**)	32.0%	74,533	2.0%	3,802,134	94.4%	13.1%	2.7%
Bluefish	1,636,214(**1**)	47.6%	1,265,202(**4**)	36.8%	265,366(**5**)	7.7%	268,106(**4**)	7.8%	3,434,887	52.4%	6.6%	20.4%
Spanish mackerel	493,983(**5**)	19.9%	1,694,521(**3**)	68.3%	115,908	4.7%	177,354(**5**)	7.1%	2,481,766	80.1%	7.3%	6.2%
Flounders	1,395,706(**3**)	99.0%	11,453	0.8%	1,250	0.1%	1,640	0.1%	1,410,048	1.0%	0.1%	17.4%
Spiny Dogfish	3,523	0.3%	786,549(**5**)	74.5%	261,274	24.7%	4,808	0.5%	1,056,154	99.7%	3.9%	0.0%
Butterfish	46,275	7.9%	293,039	49.8%	231,885	39.4%	17,223	2.9%	588,421	92.1%	2.0%	0.6%
Jumping Mullets	196,822	44.7%	7,556	1.7%	202,295	45.9%	33,620	7.6%	440,294	55.3%	0.9%	2.5%
Smooth Dogfish	5,322	1.4%	342,877	90.4%	24,022	6.3%	6,955	1.8%	379,176	98.6%	1.4%	0.1%
Sharks	9,466	2.9%	125,784	38.9%	15,221	4.7%	172,494	53.4%	322,965	97.1%	1.1%	0.1%
Unclassified Dogfish	4,682	1.5%	296,135	97.2%	554	0.2%	3,304	1.1%	304,675	98.5%	1.1%	0.1%
Little tunny	6,175	2.4%	208,807	82.7%	21,937	8.7%	15,442	6.1%	252,361	97.6%	0.9%	0.1%
Spotted seatrout	141,428	76.7%	21,489	11.7%	13,822	7.5%	7,561	4.1%	184,299	23.3%	0.2%	1.8%
King mackerel	5,416	3.1%	169,143	95.7%	748	0.4%	1,438	0.8%	176,745	96.9%	0.6%	0.1%
Amercian shad	8,378	7.4%	22,556	19.9%	108	0.1%	82,277	72.6%	113,319	92.6%	0.4%	0.1%
Hard Crabs (lb)	84,243	98.3%	15	0.0%	8	0.0%	1,427	1.7%	85,693	1.7%	0.0%	1.0%
Bonita	1,730	2.0%	24,100	28.3%	22,269	26.2%	36,981	43.5%	85,080	98.0%	0.3%	0.0%
Harvestfish	16,336	19.6%	50,897	61.2%	14,414	17.3%	1,521	1.8%	83,167	80.4%	0.2%	0.2%
Black Drum	55,395	69.2%	14,935	18.7%	7,861	9.8%	1,868	2.3%	80,059	30.8%	0.1%	0.7%
Other	319,901	39.5%	399,262	49.3%	36,275	4.5%	53,812	6.6%	809,250	60.5%	1.8%	4.0%
Total	8,023,502		14,747,642		7,270,759		5,274,280		35,316,182		100%	100%

Table 6.15 Landings by market category in the gill net fishery separated by the landings of kingfishes associated with each trip by district, 1994 - 2004.

	Pounds										
Area/Species	0-99	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	> 1000
Ocean Northern District											
Weakfish	4,199,779	515,743	273,443	129,956	54,712	51,512	33,173	23,747	18,544	11,061	16,951
Spot	590,441	40,584	21,248	14,870	7,443	3,580	3,036	1,403	1,658	853	1,608
Kingfishes	150,009	108,205	88,869	68,369	53,704	48,346	35,889	33,781	19,490	15,941	79,759
Atlantic croaker	2,117,979	134,201	17,798	4,408	3,448	4,808	2,022	3,134	2,830	570	4,419
Other	5,279,432	230,008	103,685	40,054	24,678	16,119	11,401	7,797	6,567	3,077	11,500
Northern Total	12,337,639	1,028,741	505,043	257,657	143,985	124,365	85,521	69,862	49,089	31,502	114,237
Ocean Central District											
Weakfish	1,408,921	271,619	153,847	81,104	69,283	56,643	31,601	21,706	30,646	11,619	75,492
Spot	1,253,900	115,254	44,754	22,409	10,812	9,660	9,277	6,669	6,092	2,117	25,613
Kingfishes	96,051	97,096	91,236	80,355	64,973	66,240	53,274	43,848	52,786	37,518	415,093
Atlantic croaker	915,907	83,255	78,205	25,511	32,419	18,729	6,110	10,025	5,901	3,540	38,433
Other	821,286	186,809	58,013	41,463	27,271	16,152	15,096	11,642	9,287	4,062	44,137
Central Total	4,496,064	754,033	426,055	250,842	204,758	167,424	115,358	93,890	104,712	58,856	598,768
Ocean Southern District											
Weakfish	172,726	77,276	41,931	30,838	18,135	16,362	11,181	9,924	7,197	6,153	20,993
Spot	1,417,276	154,502	59,386	46,907	26,245	20,067	25,337	18,515	9,515	6,731	23,189
Kingfishes	202,174	272,677	246,990	209,917	166,586	157,396	130,001	114,483	113,032	79,053	399,224
Atlantic croaker	28,904	15,993	11,610	4,824	4,171	1,504	1,104	1,963	1,602	249	2,610
Other	623,532	125,497	50,260	27,378	13,660	11,540	8,581	7,195	3,815	2,871	13,501
Southern Total	2,444,611	645,945	410,177	319,864	228,796	206,868	176,204	152,080	135,161	95,057	459,517
Estuarine Waters											
Weakfish	1,342,244	118,268	51,310	29,050	13,224	11,528	4,048	1,432	1,626	996	7,622
Spot	1,262,720	58,427	13,709	2,359	599	2,419	323	748	1,777	211	1,396
Kingfishes	206,908	67,995	44,946	32,141	16,302	19,507	14,125	8,834	5,038	6,715	30,015
Atlantic croaker	192,052	10,026	2,479	1,404	3,444	1,358	572	86	40	34	2,455
Other	4,323,510	70,927	20,805	6,182	2,890	2,068	1,780	705	113	594	1,419
Estuarine Total	7,327,434	325,642	133,249	71,135	36,459	36,880	20,848	11,805	8,594	8,550	42,907

6.3.3.7 Flynet results

Flynet Marketable Bycatch

Atlantic croaker and weakfish are the two top species harvested when kingfishes were also captured in flynets. These two species accounted for 94% of the marketable catch when kingfishes were landed in the Northern District and 88% in the Central District. Kingfishes accounted for less than 1% of the harvest in the Northern District and 9% in the Central district. Both the effort and species composition of trips that captured kingfishes changed dramatically in the period 1994 to 1997 and 1998 to 2004. This change is attributed to the regulatory change that eliminated flynets fishing south of Cape Hatteras. Average landings of croaker from 1998 to 2004 decreased 81% with a corresponding 86% decrease in the average number of trips in the Central District relative to averages from 1994 to 1997. Other species indicated similar trends in effort and catch rates. The average number of trips that caught kingfishes dropped from 83 trips to 46 trips per year in the Northern District and dropped from 45 to 4 trips per year in the Central District (Table 6.16). It is important to realize that due to the regulatory changes trips landing catches in the Central District were fishing in ocean waters north of Cape Hatteras.

Flynet Unmarketable bycatch

All estimations of scrapfish landings were based on fish house sampling of the catches and have changed little since 1997. The flynet fishery has a scrapfish component that accounted from between 4% to 7.7% of the total flynet landings between 2000-2004. The scrap fish is dominated by Atlantic croaker, weakfish, Atlantic menhaden and spot. Kingfishes represented from 0.1% to 0.7% of the scrap fish during 2000-2004. These ranges were derived from 114 flynet catches that were sampled by NCDMF staff (Burns 2004). Estimates for the scrap fish for the 2003 – 2004 season (6.2%) were similar with bait estimates from 1997 (4.0%) and 1998 [7.7% (Monaghan 2001)]. Species composition of scrapfish was dominated by Atlantic croaker, which represented 84% of all the scrap fish during the 2003 – 2004 season. Kingfishes represented less than 1% of the retained scrapfish since 1998 (NCDMF unpublished data 2005).

Table 6.16 Average landings and number of trips of the top seven market categories from 1994 to 1997 and 1998 to 2004 for the flynet fishery in the Northern and Central districts.

Area/Market Category	Average pounds 1994-1997	Average No. of trips 1994-1997	Average pounds 1998-2004	Average No. of trips 1998-2004
Northern				
Atlantic croaker	1,925,876	81	1,824,793	44
Weakfish	193,352	79	79,379	37
Bluefish	93,514	53	42,184	25
Kingfishes	13,037	83	3,307	46
Butterfish	21,288	68	7,358	35
Flounders	5,757	35	12,501	33
Spot	5,533	6	3,914	8
Other	34,050	83	24,292	46
Northern Avg	2,292,406		1,997,728	
Central				
Atlantic croaker	466,898	29	89,175	4
Weakfish	174,493	38	9,373	3
Bluefish	5,830	9	223	1
Kingfishes	80,858	45	220	4
Butterfish	12,868	30	286	2
Flounders	3,915	12	463	2
Spot	331	*	*	*
Other	5,669	37	769	4
Central Avg	750,862		100,639	

*****denotes confidential data

6.3.3.8 Beach seine fishery results

The dominant species taken in the small mesh beach seine fishery included Atlantic croaker, bluefish, harvestfish, kingfishes, spot, spotted seatrout, striped mullet and weakfish. The type of species caught is opportunistic and depends on the seasonal presence of the migratory fish (Bowman and Tork 1998). The beach seine fishery is a minor fishery for kingfishes representing 3.4% of the total NC kingfishes landings from 1994 to 2004. Fish house sampling from 1997 to 2004 indicated that kingfishes were represented in the top ten species by weight (1.2-11.4%) and number (0.6-21.6%) each year (Table 6.17). Species composition changed little each year, but the dominant species varied depending on the season and catches sampled.

Scrapfish/discards

The amount of scrapfish (bait) in the beach seine fishery is minimal, with most or all of the unmarketable catch discarded while on the beach. When bait was encountered, it was primarily composed of Atlantic menhaden, but sometimes included small bluefish, spot, and/or striped mullet. Species discarded on the beach were most often skates and rays, along with some regulatory discards including small weakfish, spotted seatrout, and/or red drum, or hickory shad that cannot be landed out of season (January 1-April 15th). Of all the beach seine catches sampled from 1994-2004 (n=58), only one unmarketable kingfish was encountered. NCDMF sampled the scrapfish component of 20 beach seine catches, with the mean weight of kingfish only 0.1 % of the total catch weight.

Table 6.17 Species compositions of beach seine catches sampled, 1997 - 2004.

Year	Species	% weight	% number	N samples	Year	Species	% weight	% number	N samples
1997	Weakfish	49.1	46.5	10	**2001**	Striped mullet	86.7	77.3	5
	Bluefish	28	28.4	10		Kingfishes	11.3	21.6	5
	Kingfishes	11.5	13.9	10		Weakfish	0.7	0.7	5
	Spotted seatrout	6	3.7	10		Bluefish	0.7	0.2	5
	Harvestfish	1.8	1.6	10		Spotted seatrout	0.1	0.1	5
	Spot	1.5	3.5	10		Butterfish	0.1	<0.1	5
	Hickory shad	0.5	0.6	10		Spot	0.1	<0.1	5
	A. Menhaden	0.4	0.8	10		Red drum	<0.1	<0.1	5
	Red drum	0.4	0.1	10					
1998	Weakfish	79.5	71.2	10	**2002**	Striped mullet	92.9	85.4	7
	Spot	10.1	20.6	10		Spot	4.4	12.5	7
	Kingfishes	5.3	4.9	10		Black drum	0.9	0.5	7
	Bluefish	3.4	1.6	10		Spotted seatrout	0.8	0.6	7
	Spotted seatrout	1	0.4	10		Bluefish	0.6	0.5	7
	Butterfish	0.4	1.1	10		Kingfishes	0.2	0.4	7
	Spanish mackerel	0.1	<0.1	10		Red drum	<0.1	< 0.1	7
	King mackerel	0.1	<0.1	10		Florida pompano	<0.1	< 0.1	7
1999	Spot	51.6	70.3	18	**2003**	Striped mullet	54.2	33.2	5
	Weakfish	18.1	14.1	18		Spot	37.4	64.9	5
	Spotted seatrout	8.2	2.7	18		Bluefish	3.3		5
	Striped mullet	7.3	5.2	18		Spotted seatrout	2.7	0.2	5
	Kingfishes	4.8	3.3	18		Kingfishes	1.4	1.3	5
	Bluefish	4.4	2.3	18		Weakfish	0.6		5
	Red drum	1.5	0.1	18		Red drum	0.3	0.5	5
	Spanish mackerel	1.4	1	18					
	Black drum	1.2	0.2	18					
2000	Striped Mullet	63.6	52.2	20	**2004**	Spot	42.4	68.2	24
	Spot	11.8	24.4	20		Striped mullet	40.1	25.2	24
	Spotted seatrout	6	3	20		Striped bass	8	0.5	24
	Weakfish	5.4	6.3	20		Bluefish	3.4	1.3	24
	Kingfishes	2.7	3.6	20		Spotted seatrout	1.8	0.8	24
	Bluefish	2.6	2.2	20		Kingfishes	1.5	1.9	24
	Hickory shad	2.5	1.2	20		Black drum	0.9	0.4	24
	Harvestfish	1.8	6.3	20		Weakfish	0.8	0.8	24
	Red drum	1.1	0.2	20		Hickory shad	0.7	0.4	24
						Red drum	0.3	<0.1	24

6.3.4 Implications of Bycatch in Kingfish Fisheries

6.3.4.1 Shrimp and crab trawl fisheries

Kingfishes are the most common finfish species landed by shrimp trawls with average annual landings of 143,863 lb. However, in observer studies in the field, they represented a much lower percent captured in the observed trips. Most of the kingfishes observed would be marketable bycatch based on the observed lengths and conversations with fish house dealers. The contradiction between documented trip ticket landings and observer studies limits conclusions but is most likely due to small sample sizes of observed data exacerbated by the limited spatial and temporal coverage. The limited data available on discarded bycatch indicates that the bycatch of these species is highly variable. Various management measures have been implemented by the NCMFC to address bycatch in the shrimp trawl fishery including: trip limits to address the targeting of kingfishes by shrimp trawls, bycatch has been reduced with BRD's, area closures, time restrictions, and phasing out of otter trawls in the New River. Fishery dependent information on the number and size of kingfishes in this fishery needs to be collected across a broad range of waterbodies and seasons.

NCTTP data and studies assessing kingfishes bycatch (incidental and discarded) in the crab trawl fishery revealed minimal and insignificant catches of kingfishes [i.e., 14,574 lb kingfishes out of 886,787 lb total finfish bycatch (1994-2004 totals)]. Considering these data, the bycatch of kingfishes, both marketable and unmarketable, does not appear to be a significant problem in the crab trawl fishery.

6.3.4.2 Crab pot fisheries

Crab pots (hard and peeler) did not appear to be a source of significant bycatch for kingfishes. Through the NCTTP and various studies assessing the bycatch in hard crab and peeler pot fisheries, very few kingfishes were observed. Specifically, kingfishes represented only 0.41% of the total finfish bycatch in hard crab pots, and only 5 lb of kingfishes were observed out of 9,404 lb of finfish bycatch from peeler pots. Overall, kingfish bycatch does not appear to be a significant problem in the crab pot fisheries.

6.3.4.3 Long haul seine fishery

Although the long haul seine fishery averaged of 3.3% of the annual landings of kingfishes, these fish were not targeted and were part of the incidental bycatch. Most of the sciaenids landed as scrapfish are spot and Atlantic croaker. Scrapfish landings of kingfishes were negligible with the majority of the fish landed sold as food fish. Anytime a fishery lands a large percentage scrapfish relative to the total catch there is a reason for fishery managers to be concerned. However, in regard to kingfishes, the amount of small unmarketable fish was so few that it would have little impact on the health of these stocks.

6.3.4.4 Gill net fishery

Currently, the dominant commercial gear capturing kingfishes is small mesh gill nets. Kingfishes were not the sole targeted species in most trips but rather one of the targeted species in a multispecies fishery. Landings associated with kingfishes were most often Atlantic croaker, bluefish, spot and weakfish. Management measures directed towards any one of these species in the gill net fishery would certainly impact kingfishes. Most kingfishes landed in the gill net fishery were sold. NCDMF data indicated insignificant amounts of kingfishes were discarded in the gill net fishery. This was because the fishers generally utilized nets that selected for marketable fish. Size selectivity relative to kingfishes and gill nets is discussed in the Kingfishes Management Measures issue paper (Section 12.3).

6.3.4.5 Winter trawl (flynet fishery)

The contribution of flynets to kingfish landings has decreased to the point where this gear only contributed 0.8% to total landings in 2004 and landed catches of marketable fish and scrap fish are small. Contrast this 0.8% to the 33% flynets contributed in 1994 and the effect of the flynet ban south of Cape Hatteras is apparent. This decrease in effort and landings certainly had a positive impact on kingfish populations; although the impact may have been mitigated by the increased catches in the gill net fisheries.

6.3.4.6 Beach seine fishery

Although the beach seine fishery accounts for an average of 3.6% of the annual landings of kingfishes, these fish are not typically targeted by beach seines but rather a part of the incidental bycatch. Scrapfish landings of kingfish are negligible with most of the fish landed sold as marketable food fish.

7. ECONOMIC STATUS

7.1 COMMERCIAL FISHERY ECONOMICS

7.1.1 Ex-vessel value and price

Kingfishes have maintained an economically important fishery in North Carolina since the earliest records were kept. However, the economic value of kingfishes has historically lagged behind that of several other finfish species such as bluefish, Atlantic croaker striped mullet (*Mugil cephalus*), spot, and weakfish (Chestnut and Davis 1975). Figure 7.1 shows the “inflated” ex-vessel value (the actual amount paid dockside to the fisherman) and the ex-vessel value of landings “deflated” (normalized) for all years to the value of a dollar in 1972. The year 1972 was chosen for the deflation year because it is the year for which we begin to have data that cover all species managed by the NCDMF. Deflated values are calculated to provide a dollar value that is comparable across all years. There are no comparable deflated values prior to 1918 because the US government did not begin calculating the Consumer Price Index (CPI) as a measure of inflation until that year.

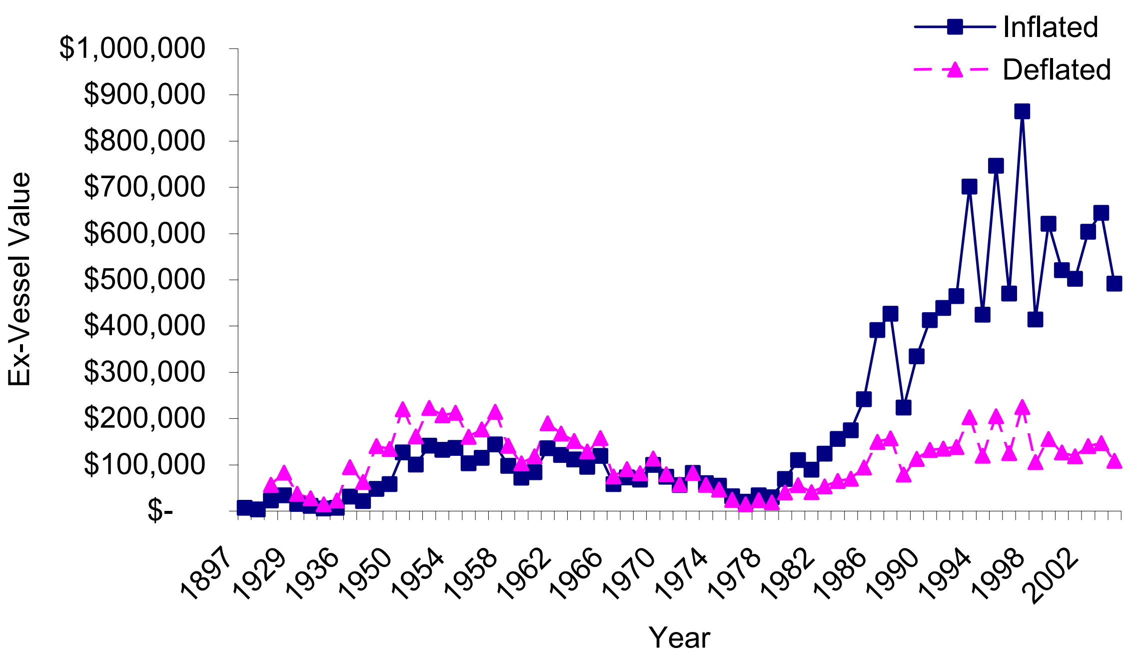

Figure 7.1 Commercial ex-vessel landings value of kingfishes, North Carolina, 1897 - 2004 (Chestnut and Davis 1975; From NCTTP).

The landings values viewed from a historical perspective indicate there have been two major peaks in ex-vessel value of kingfishes. The first peak occurred in the 1950’s where the deflated value of kingfishes was around $200,000 annually. The deflated ex-vessel value then declined from the 1960’s through the late 1970’s. However, the ex-vessel value began to rebound in the 1980’s. In some years the deflated value was near the $200,000 highs of the 1950’s. But in most years since the 1980’s the annual deflated value remained above $100,000 (Table 7.1).

Table 7.1 Inflated and deflated ex-vessel landings value and price per pound of kingfishes, North Carolina, 1897 - 2004 (Chestnut and Davis 1975, and NCTTP).

Year	Inflated Value	Deflated Value	Inflated Price/Lb.	Deflated Price/Lb.
1897	$ 7,150		$ 0.02	
1902	$ 3,395		$ 0.03	
1923	$ 23,196	$ 56,701	$ 0.04	$ 0.10
1928	$ 34,053	$ 83,241	$ 0.04	$ 0.11
1929	$ 15,191	$ 37,134	$ 0.04	$ 0.10
1930	$ 11,165	$ 27,946	$ 0.04	$ 0.10
1931	$ 5,396	$ 14,839	$ 0.03	$ 0.08
1934	$ 7,240	$ 22,584	$ 0.02	$ 0.07
1936	$ 31,493	$ 94,706	$ 0.03	$ 0.08
1937	$ 21,596	$ 62,688	$ 0.03	$ 0.09
1938	$ 47,464	$ 140,709	$ 0.03	$ 0.09
1945	$ 57,925	$ 134,515	$ 0.05	$ 0.12
1950	$ 126,800	$ 219,927	$ 0.09	$ 0.16
1951	$ 100,373	$ 161,369	$ 0.09	$ 0.14
1952	$ 141,167	$ 222,671	$ 0.10	$ 0.15
1953	$ 132,416	$ 207,303	$ 0.09	$ 0.14
1954	$ 136,770	$ 212,527	$ 0.07	$ 0.11
1955	$ 103,194	$ 160,952	$ 0.08	$ 0.13
1956	$ 114,704	$ 176,273	$ 0.08	$ 0.12
1957	$ 144,308	$ 214,665	$ 0.09	$ 0.13
1958	$ 97,699	$ 141,309	$ 0.09	$ 0.13
1959	$ 71,866	$ 103,230	$ 0.09	$ 0.13
1960	$ 84,026	$ 118,658	$ 0.09	$ 0.13
1961	$ 135,919	$ 190,014	$ 0.09	$ 0.13
1962	$ 120,871	$ 167,298	$ 0.10	$ 0.13
1963	$ 111,307	$ 151,650	$ 0.10	$ 0.14
1964	$ 95,669	$ 128,999	$ 0.08	$ 0.11
1965	$ 118,982	$ 157,887	$ 0.09	$ 0.12
1966	$ 58,119	$ 74,981	$ 0.08	$ 0.10
1967	$ 72,664	$ 90,939	$ 0.09	$ 0.11
1968	$ 67,841	$ 81,487	$ 0.11	$ 0.13
1969	$ 99,878	$ 113,758	$ 0.12	$ 0.13
1970	$ 74,217	$ 79,955	$ 0.13	$ 0.14
1971	$ 55,785	$ 57,576	$ 0.12	$ 0.12
1972	$ 82,740	$ 82,740	$ 0.12	$ 0.12
1973	$ 60,556	$ 57,010	$ 0.14	$ 0.13
1974	$ 54,445	$ 46,162	$ 0.17	$ 0.15
1975	$ 31,635	$ 24,579	$ 0.15	$ 0.12
1976	$ 20,173	$ 14,820	$ 0.16	$ 0.12
1977	$ 33,926	$ 23,401	$ 0.17	$ 0.11
1978	$ 29,534	$ 18,934	$ 0.19	$ 0.12
1979	$ 69,580	$ 40,061	$ 0.22	$ 0.13
1980	$ 110,436	$ 56,022	$ 0.32	$ 0.16
1981	$ 89,396	$ 41,108	$ 0.35	$ 0.16
1982	$ 123,817	$ 53,633	$ 0.34	$ 0.15
1983	$ 155,857	$ 65,410	$ 0.35	$ 0.15
1984	$ 174,597	$ 70,242	$ 0.38	$ 0.15
1985	$ 241,653	$ 93,876	$ 0.38	$ 0.15
1986	$ 391,492	$ 149,310	$ 0.39	$ 0.15
1987	$ 426,366	$ 156,885	$ 0.44	$ 0.16
1988	$ 223,357	$ 78,921	$ 0.44	$ 0.16
1989	$ 334,358	$ 112,711	$ 0.59	$ 0.20
1990	$ 412,824	$ 132,028	$ 0.56	$ 0.18
1991	$ 439,283	$ 134,817	$ 0.51	$ 0.16
1992	$ 464,525	$ 138,397	$ 0.55	$ 0.16
1993	$ 701,314	$ 202,871	$ 0.59	$ 0.17
1994	$ 424,344	$ 119,687	$ 0.68	$ 0.19
1995	$ 746,603	$ 204,777	$ 0.71	$ 0.19
1996	$ 470,545	$ 125,359	$ 0.89	$ 0.24
1997	$ 864,030	$ 225,025	$ 0.99	$ 0.26
1998	$ 414,315	$ 106,248	$ 1.04	$ 0.27
1999	$ 621,078	$ 155,829	$ 1.02	$ 0.26
2000	$ 520,965	$ 126,460	$ 0.94	$ 0.23
2001	$ 501,999	$ 118,484	$ 1.03	$ 0.24
2002	$ 603,854	$ 140,306	$ 0.97	$ 0.23
2003	$ 644,920	$ 146,509	$ 0.99	$ 0.22
2004	$ 491,584	$ 108,778	$ 0.87	$ 0.19

The inflated ex-vessel values show the same fluctuating trend. However, the trends are much higher and the differences between years are larger in the years since 1993.

NCDMF has conducted a survey since 1995 to obtain price estimates from dealers for seafood purchased from fishermen. The data from the survey are used to determine an average annual price per unit for each market grade of each species commercially landed.

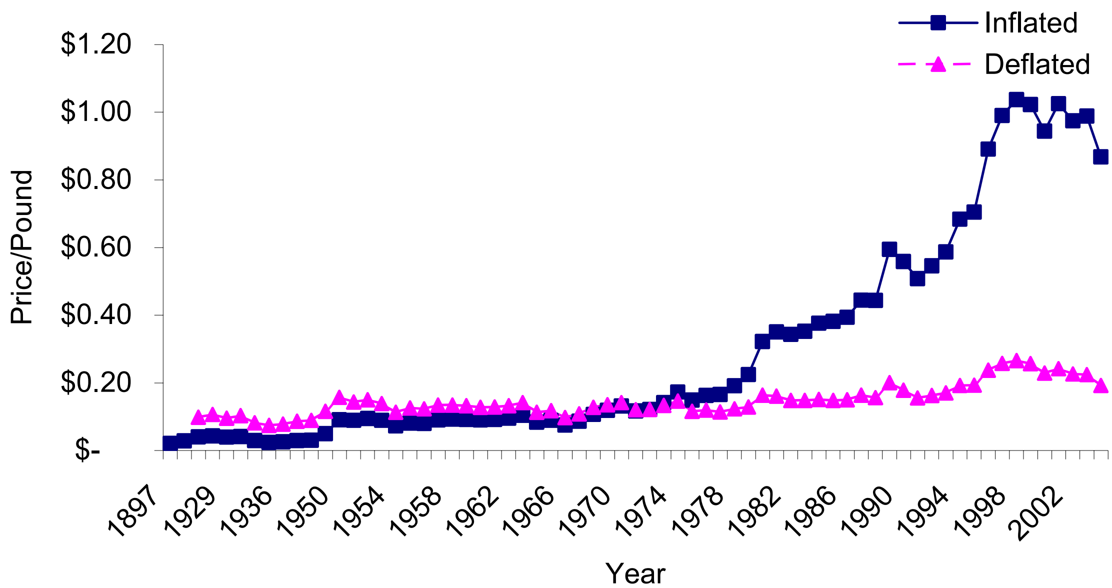

Figure 7.2 Commercial ex-vessel price per pound for kingfishes, North Carolina, 1887 - 2004 (Chestnut and Davis 1975; From NCTTP).

Price per pound of kingfishes has shown an overall slight, steady increase over the years, regardless of the number of fish landed. However, since the late 1990’s there has been a slight downward trend. Fishermen attribute this trend to competition from a developing Florida fishery. The lowest inflated price per pound for kingfishes was $.02 in 1897 and 1934 with the highest being $1.04 per pound in 1998. When inflation is taken into account, 1934 had the lowest price per pound at $.07. The highest deflated price per pound for kingfishes was $.27, also occurring in 1998 (Figure 7.2).

7.1.2 Gear

The advent of the NCTTP in 1994 allowed the NCDMF to track landings by individual trips taken by fishermen. Kingfishes are primarily harvested by gill nets and caught as bycatch in other fisheries, most notably, the shrimp trawl fishery.

Table 7.2 shows the number of trips taken, ex-vessel value (unadjusted for inflation), and average price per pound paid to fishermen who landed kingfishes by gear type. In every year since trip level information became available in 1994, more kingfishes were landed using gill nets than any other gear.

The average ex-vessel value per trip (unadjusted for inflation) for kingfishes caught in a gill net ranged from a low of $34 in 1994 to a high of $122 in 2002. For kingfishes harvested by trawl, the lowest was $38 in 2001 and the highest was $114 in 1997.

Table 7.2 Trips, ex-vessel value, and average price per pound for harvesting by gill nets, trawls, and other methods for kingfishes, North Carolina, 1994 - 2004 (NCTTP).

Year	Gear	Trips	Value	Average value/ trip	Price/ pound
1994	Gill nets	5,889	$199,867	$34	$0.75
1995		7,168	$449,398	$63	$0.70
1996		5,210	$212,090	$41	$0.97
1997		6,859	$489,936	$71	$1.01
1998		5,408	$275,771	$51	$1.05
1999		5,128	$347,236	$68	$1.02
2000		4,968	$317,127	$64	$0.95
2001		4,606	$391,051	$85	$1.02
2002		3,734	$455,789	$122	$0.97
2003		4,383	$526,194	$120	$0.99
2004		4,120	$354,176	$86	$0.87
1994	Shrimp Trawls	3,667	$182,370	$50	$0.61
1995		3,909	$249,363	$64	$0.72
1996		2,287	$201,459	$88	$0.80
1997		2,850	$325,429	$114	$0.96
1998		2,283	$100,774	$44	$1.01
1999		3,349	$250,262	$75	$1.02
2000		2,668	$158,471	$59	$0.94
2001		1,904	$71,441	$38	$1.08
2002		2,274	$122,363	$54	$0.98
2003		1,952	$75,571	$39	$0.99
2004		2,131	$99,057	$46	$0.86
1994	Other gear	1,532	$42,106	$27	$0.77
1995		1,418	$47,843	$34	$0.70
1996		1,410	$56,996	$40	$0.97
1997		1,312	$48,666	$37	$1.02
1998		1,077	$37,770	$35	$1.04
1999		951	$23,580	$25	$1.03
2000		1,021	$45,367	$44	$0.95
2001		712	$39,506	$55	$1.02
2002		465	$25,702	$55	$0.97
2003		415	$43,155	$104	$0.99
2004		529	$38,352	$72	$0.87

7.1.3 Waterbodies

More kingfishes were caught in state waters from 0-3 miles from the shore in all years since the beginning of the trip ticket program. The year 1994 saw the lowest ex-vessel value at approximately $200,000 and 1997 had the highest annual ex-vessel value at nearly $600,000. The value of landings from the ocean 0-3 miles fluctuate the most from year to year when compared to other waterbodies. The landings value in most years from all other water bodies was less than $100,000. With the exception of 1996, the years of 1994 to 1997 saw relatively greater ex-vessel value from the ocean beyond three miles when compared to the Pamlico Sound and other non-ocean landings. However in years subsequent to 1997, landings in the ocean beyond three miles were slightly lower than those of the Pamlico Sound and all other inshore water bodies combined (Figure 7.3).

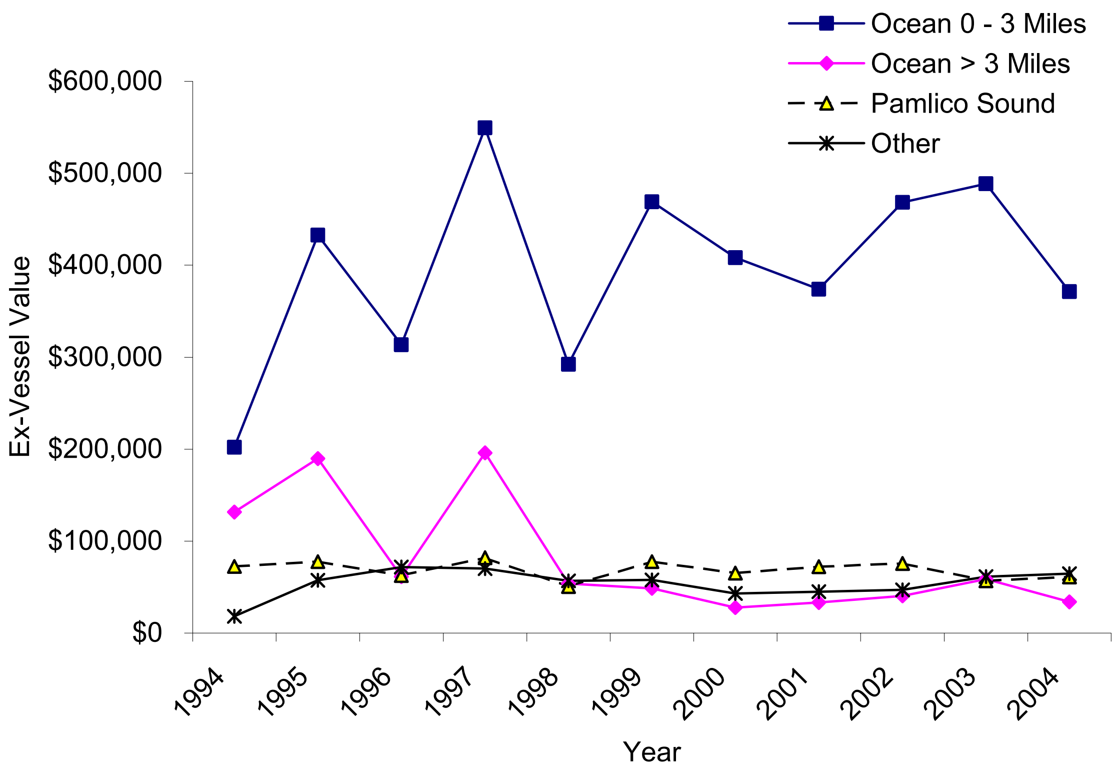

Figure 7.3 Annual ex-vessel value (inflated) for kingfishes from selected water bodies, North Carolina, 1994 - 2004 (From NCTTP).

7.1.4 Participants

The NCTTP enables managers to monitor fishing activity at the trip level, and gives an indication of how many people participate in a fishery. The number of participants in the fishery for kingfishes has shown an overall decline from 1994 to 2004. North Carolina fishermen are noted for being opportunistic, switching between fisheries based on their understanding of which fishery will provide them the greatest return for their efforts. Since the trip ticket program began in 1994, participants ranged from a high of 937 in 1995 to 620 participants in 2003. Included in the participants in the fishery are those who did not target kingfishes, but caught them as bycatch in other fisheries (Table 7.3).

Table 7.3 Number of participants and annual ex-vessel landings value for kingfishes, North Carolina, 1994 - 2004 (From NCTTP).

	Year										
Annual Ex-vessel Value	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<= $100	508	538	503	504	449	458	451	385	371	345	405
$100.01 - $500	170	168	165	166	166	140	138	136	135	137	120
$500.01 - $1,000	69	83	58	63	47	49	46	40	48	50	53
$1,000.01 - $5,000	72	113	89	100	66	106	89	79	78	59	60
$5,000.01 - $10,000	8	23	8	23	9	21	19	13	17	16	12
> $10,000	3	12	7	15	8	10	8	9	13	13	14
Total Participants	830	937	830	871	745	784	751	662	662	620	664

Approximately 60% of the fishermen who land kingfishes make less than $100 per year from the species, while 10 – 15% of the participants make more than $1,000 from the fishery. Only since 2002 have at least 2% of the fishermen made more than $10,000 from the fishery for kingfishes (Table 7.3).

Table 7.4 shows the percent of the market value comprised by kingfishes on trips where kingfishes were caught. The overall small percentage indicates that a lot of kingfishes are caught as bycatch, but are targeted by a small group of fishermen. In roughly two thirds of all trips across all years, kingfishes made up 5% or less of the total value of the sellable catch. Prior to 1998, kingfishes were at least 50% of the sellable catch in 7 – 10% of the trips. Since 1998, kingfishes were at least 50% of the total value in 11 – 19% of the trips.

Table 7.4 Percent of total market value of kingfishes compared to the total value for trips in which kingfishes were landed, North Carolina, 1994 - 2004 (From NCTTP).

	Year										
Percent Kingfishes	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<1 - 5%	7,316	8,345	5,843	6,595	5,528	6,072	5,528	4,074	3,680	3,792	4,271
5.1 - 10%	1,151	1,172	955	1,211	989	926	924	685	553	603	561
10.1 - 25%	1,195	1,128	853	1,231	939	827	889	741	595	751	606
25.1 - 50%	622	670	559	830	478	531	445	527	418	477	425
50.1 - 90%	599	903	558	791	553	717	441	727	728	595	556
90.1 - 99.9%	140	223	85	277	207	286	338	390	408	472	315
>= 100%	65	54	54	86	74	87	148	116	129	104	116
Total Trips	11,088	12,495	8,907	11,021	8,768	9,446	8,713	7,260	6,511	6,794	6,850

Table 7.5 shows the number of dealers statewide who reported landings of kingfishes on trip tickets between 1994 and 2004. The number of dealers purchasing kingfishes from NC fishermen has remained relatively constant over the years. The number of dealers purchasing has ranged from a low of 143 in 2002 to a high of 176 in 1997. Depending on the year, 31 – 45% of dealers purchased $100 or less of kingfishes from fishermen. Approximately 7 – 13% of dealers purchased at least $10,000 of kingfishes in a given year.

Table 7.5 Number of dealers and annual ex-vessel landings value for kingfishes, North Carolina, 1994 - 2004 (From NCTTP).

	Year										
Ex-vessel Value	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
< $100	47	65	78	73	62	61	58	64	52	55	54
$100.01 - $500	30	27	33	29	28	25	20	19	23	32	38
$500.01 - $1,000	11	15	6	12	16	11	17	7	6	13	12
$1,000.01 - $5,000	38	32	31	25	26	31	29	32	36	25	23
$5,000.01 - $10,000	14	7	11	15	8	17	15	13	11	14	13
> $10,000	10	22	15	22	17	22	13	13	15	12	16
Total Dealers	150	168	174	176	157	167	152	148	143	151	156

Kingfishes sold in North Carolina are primarily sold to dealers in Dare and Brunswick counties. Table 7.6 shows the counties and the numbers of dealers in each county who purchased kingfishes from 1994 to 2004. Counties that did not have at least $1,000 in landings value were included in the category “Other Counties”.

Table 7.6 Number of dealers reporting landings of kingfishes by county, North Carolina, 1994 - 2004 (From NCTTP).

	Year										
County	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Dare	32	35	38	31	27	25	24	22	21	22	19
Hyde	11	14	16	15	15	19	14	16	13	15	13
Pamlico	10	14	12	9	8	10	8	8	10	7	12
Onslow	11	12	11	11	11	10	10	12	14	12	18
Pender	6	3	7	8	6	4	3	7	4	8	10
New Hanover	15	15	16	17	15	16	14	17	16	19	16
Brunswick	25	29	29	34	29	31	33	24	24	29	30
Other Counties	40	46	45	51	46	52	46	42	41	39	38
Total	150	168	174	176	157	167	152	148	143	151	156

7.1.5 Processing

Kingfishes are generally sold whole and packed in 50 lb cartons. Some fish houses will pack them in smaller boxes later in the year if they are planning to freeze them for later resale.

7.1.6 Economic Impact of Commercial Fishing

Burgess and Bianchi (2004) estimated the total economic impact of the kingfishes harvesting sector to be roughly $961,725 in 2002. As was shown in Table 7.3, harvest sector employment in 2002 was $662. The overall average earnings per worker in that fishery for the year were $681 based on a total landings value of approximately $603,845. The additional $35,880 that went into the economy as a result of the fishery for kingfishes went to wages, and non-wage expenditures such as loan payments, fuel and oil, gear, repairs, and maintenance, etc. The kingfishes economic impact in 2002 also funded the equivalent of four additional full time jobs in the overall economy of North Carolina.

7.2 RECREATIONAL FISHERY ECONOMICS

Currently, there are no data to indicate the economic impact of recreational harvest in North Carolina.

8. SOCIAL IMPORTANCE OF THE FISHERY

8.1 COMMERCIAL FISHERY

There are insufficient data available to indicate the current social importance of the commercial fishery.

8.2 RECREATIONAL FISHERY

There are insufficient data available to indicate the current social importance of the recreational fishery.

8.3 DEMOGRAPHIC CHARACTERISTICS

The NCDMF license database collects limited demographic information from commercial fishermen at the time of license sale. Table 7.7 shows the gender and racial composition of 593 fishermen who bought commercial licenses in 2004 and who had reported landings of kingfishes. The majority of the fishermen are male (95%) and nearly all are Caucasian (99%). The average age of these fishermen was 48 with the youngest being 18 and the oldest was 90 years of age.

Table 8.1 Demographics of commercial fishermen who harvest kingfishes, North Carolina, 2004 (From NCTTP).

Variable	Categories	Number	Percent.
Gender			
	Male	566	95%
	Female	27	5%
	Total	593	100%
Race			
	African-American	3	1%
	American-Indian	2	0%
	Asian	1	0%
	Caucasian	587	99%
	Total	593	100%

There are no comparable data available for determining the demographic characteristics of the participants in the recreational fishery.

8.4 RESEARCH RECOMMENDATIONS

Socioeconomic surveys of commercial participants in the fishery for kingfishes need to be performed to determine specific business characteristics and the economics of working in the fishery, which issues are important to these businesses, attitudes towards management of the fishery, as well as general demographic information. NCDMF has conducted many surveys of this type in the past, however, none of the surveys has targeted participants in a specific state-managed fishery. Designing and executing a study of this nature targeting kingfishes fishermen while using the same parameters as other NCDMF socioeconomic surveys, could be completed for approximately $12,000.

9. ENVIRONMENTAL FACTORS

9.1 HABITAT

Kingfishes have diverse habitat preferences that shift due to season and ontogenetic stage (Life History Section). Kingfishes are found in most habitats defined by the North Carolina CHPP including: water column, submerged aquatic vegetation, soft bottom, and hard bottom (Street et al. 2005). Wetlands and shell bottom habitat, although not directly connected to habitats of kingfishes, are critical to the kingfishes because they provide nursery areas for prey items and are important to the health of aquatic ecosystems. Protection of each habitat type is vital to maintaining a productive coastal ecosystem, which in turn is essential for a sustainable stock of kingfishes. Much of the information below was taken from the CHPP (Street et al. 2005).

9.1.1 Water Column

The water column habitat is defined as “the water covering a submerged surface and its physical, chemical, and biological characteristics” (Street et al. 2005). Kingfishes make use of the water column throughout each life stage. The water column is a transport mechanism for the kingfishes eggs, which are buoyant due to oil globules [1-18 (Welsh and Breder 1923)]. As described in the life history section, spawning occurs in near shore ocean or possibly inshore waters. Eggs are transported to the surf zone and into estuaries by prevailing wind driven currents (Welsh and Breder 1923; Hoese 1965; Irwin 1970; Bourne and Govoni 1988). Additionally, larval behavioral responses such as directional swimming or movement in the water column further increase the chance of recruitment into estuaries, entrainment in an estuary, or recruitment to the surf zone (Boehlert and Mundy 1988; Churchill et al. 1999). Alterations of a natural system due to inlet stabilization or dredging of navigational channels will affect egg and larvae transport into estuaries (Epifanio 1988). Jetties have been shown to limit the scope of flood tide prisms [focusing flood waters to between jetties (Seabergh 1988; Blanton et al. 1999)], which may reduce the numbers of eggs and larvae transported into the system, particularly for ocean-spawned fishes (Lawler et al. 1988; Epifanio 1988; Hare et al. 1999).

The water column provides an important source of food items for juvenile kingfishes. Juvenile kingfishes feed primarily on epibenthic or planktonic prey such as copepods (Bearden 1963; Irwin 1970; Delancey 1984; McMichael and Ross 1987). The resuspension and retention of inorganic nutrients in the surf zone, an important nursery area for kingfishes, creates a food rich environment for larval and juvenile kingfishes and supports large concentrations of fishes that utilize this area seasonally (Hackney et al. 1996).

Adult kingfishes are most common in waters defined as high-salinity by the CHPP [>18 ppt (Bearden 1963; Irwin 1970; Street et al. 2005)]. Salinity, which is an important factor in determining species distribution, is affected by rainfall, season, estuarine morphology, wind, lunar tides, and freshwater discharge (Street et al. 2005). Other important water quality factors determining species distribution include: water temperature, dissolved oxygen (DO), flow, and pH. Kingfishes tolerate a wide range of temperatures but are generally regarded as spring and summer residents of North Carolina (Ross and Lancaster 2002). Kingfishes have been reported to migrate southward in the near shore ocean during the fall and winter when the temperature decreases (Smith and Wenner 1985).

Refer to water quality section for information on monitoring efforts in estuarine and ocean waters.

9.1.2 Wetlands

Wetlands are defined as "… areas that are inundated or saturated by an accumulation of 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 saturated soil conditions" (Street et al. 2005). Wetlands are one of the most biologically productive ecosystems (Teal 1962). The productivity is transported into the estuarine system as decayed plant matter (detritus) and microalgae growing on or between marsh plants (Peterson and Howarth 1987). While kingfishes are rarely found in shallow wetlands, common prey items such as shrimp and crabs rely on wetlands as nursery areas and foraging habitat. Wetlands also provide many ecosystem functions that benefit the waters and habitats that kingfishes utilize. Wetlands are crucial to the stability of the coastal ecosystem. Riparian wetlands trap and filter toxins and sediments from stormwater runoff, stabilize the shoreline by slowing wave energy, and reduce flooding effects by storing and slowly dispersing stormwater runoff (Mitsch and Gosselink 1993).

In 1993, it was estimated that approximately 66% (4.7 million acres) of North Carolina's original wetlands remain (DWQ 2000a). Human activities that result in wetland habitat loss include ditching, channelization, filling for agriculture and development, and shoreline stabilization (DWQ 2000b). Prior to the 1990's, the major impact on the wetlands was agriculture and forestry. After 1990, the threats to wetlands have shifted to dredging, filling, water control projects and shoreline stabilization associated with development. Reducing wetland losses is critical to long-term protection of the coastal ecosystem.

9.1.3 Submerged Aquatic Vegetation (SAV)

SAV habitat is defined as "…bottom that is recurrently vegetated by submerged, rooted vascular plants (roots, rhizomes, leaves, stems, or propagules), as well as temporarily unvegetated areas between vegetated patches" (Street et al. 2005). Submerged aquatic vegetation occurs in both subtidal and intertidal zones and may be colonized by estuarine species, such as eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*), or widgeon grass (*Ruppia maritima*) or freshwater species, such as wild celery (*Vallisneria americana*) and sago pondweed (*Potamogeton pectinatus*). Under NCMFC rules, SAV is included as a Critical Habitat Area [NCMFC rule 15A NCAC 03I .0100 (b)(20)].

High salinity SAV beds are present primarily in Pamlico, Core, and Bogue sounds (Ferguson and Wood 1994). Smaller patches of seagrass occur from New River through northern New Hanover County (Street et al. 2005). Kingfishes primarily utilize estuarine SAV because of salinity preferences. Seagrasses provide habitat for an array of species including kingfishes and prey of kingfishes (Ross and Noble 1990). Sampling by NCDMF in grass beds behind the Outer Banks documented southern and northern kingfish in low densities (NCDMF 1990). Over 150 other species of fish and invertebrates were found in seagrass beds in eastern Pamlico and Core sounds.

SAV enhances the ecosystem by stabilizing and trapping sediment, reducing wave energy, and cycling nutrients within the system (Thayer et al. 1984). The three dimensional structure provides a surface for small plants and animals to attach to and provides a safe refuge and foraging area for a large number of juvenile fish and invertebrates (SAFMC 1998). Beds of SAV also produce large quantities of organic matter, which supports a complex food base for numerous fish and other organisms (Thayer et al. 1984). SAV provides a structure that enhances safe corridor between habitats, reducing predation and providing food for kingfishes and other species (Micheli and Peterson 1999).

The amount of SAV in North Carolina was estimated in 1990 to be between 134,000 and 200,000 acres (Orth et al. 1990; cited in Ferguson and Wood 1994). Low salinity SAV in North Carolina experienced large-scale losses. The high salinity SAV distribution appears to be stable (Ferguson and Wood 1994). However comprehensive re-mapping is needed to quantify change in high salinity SAV abundance since last mapped in 1990. In addition, high salinity grass beds south of Bogue Sound and low salinity grass beds have never been mapped adequately.

Decreases in abundance of SAV are attributed to nutrient enrichment and sediment loading (Twilley et al. 1985; Durako 1994). Nutrient enrichment and sediment loading increase the turbidity in the water column, decreasing the photosynthetic capability of SAVs (Kenworthy and Haunert 1991). Increased sediment and nutrient loading in the water column can enter coastal waters from point source discharges, nonpoint source stormwater runoff, or resuspension of bottom sediments. Specific sources that contribute to increased sediment loading include: construction activities, unpaved roads, road construction, golf courses, uncontrolled urban runoff, mining, silviculture, row crop agriculture, and livestock operations (DWQ 2000a). Specific sources that contribute to increased nutrient loading include: agricultural and urban runoff, wastewater treatment plants, forestry activities, and atmospheric deposition. Nutrients in point source discharges are from human waste, food residues, cleaning agents, and industrial processes. The primary contributors of nutrients from nonpoint sources are fertilizer and animal wastes (DWQ 2000b).

Dredging, shading by docks, and trawling can also decrease SAV abundance. Dredging for navigational channels, marinas, or other infrastructure can physically damage or remove SAV, while shade from docks over grass beds can lead to gradual loss of SAV beneath the structures. Use of bottom disturbing gear, (e.g. crab and oyster dredges, shrimp trawls) can also damage SAV beds, but NCDMF regulations restrict such gears over most SAV habitat. Protection of the SAV grass beds is critical. If a grass bed is lost, chance of recolonization to the area is difficult due to increased turbidity and destabilized sediment.

9.1.4 Soft Bottom

The soft bottom habitat is defined as “ unconsolidated, unvegetated sediment that occurs in freshwater, estuarine, and marine environments” (Street et al. 2005). The soft bottom habitat is separated into freshwater, estuarine, and marine habitats due to differing geomorphology, salinity regime, sediment type, hydrography, and/or water depth (Street et al. 2005). Estuarine sediment types include sand, peat, inorganic mud, and organic rich mud. Courser sandy sediments are concentrated along eroding or high-energy shorelines and shallower perimeter of water bodies, while finer mud sediments are in the deeper center of water bodies (Wells 1989; Riggs 1996). Intertidal flats, ocean beaches, and inlets are dynamic soft bottom features, comprised of shifting sands. Soft bottom habitat in the estuary and ocean is highly valuable as a foraging area for kingfishes and other organisms.

All three kingfish species appear to be associated with soft bottom more than other benthic habitat types. Southern and northern kingfishes occur over sand and mud bottoms of estuarine and marine habitats (Hildebrand and Cable 1934; Bearden, 1963; Irwin, 1970; Dahlberg, 1972; Ralph, 1982; Crowe, 1984; Harding and Chittenden 1987). Southern kingfish inhabit deep channels with mud bottoms (Viosca 1959) and mud bottoms in the ocean (Irwin 1970) and Pamlico Sound (J. Schoolfield, NCDMF, pers. com.). Northern kingfish are common in shallow bays as juveniles, and the adults are associated with mud bottom in the ocean as well as with hard substrate in the ocean (Irwin 1970; Miller et al. 2002). Juvenile and adult Gulf kingfish are most common in the near shore marine habitat over a sandy bottom (Irwin 1970; Dahlberg 1972; Modde and Ross 1981). The use of distinct topographical features such as shoals, sandbars, and sloughs, by kingfishes has not been described. More research is needed to confirm spawning and nursery use of soft bottom habitat by these species.

Soft bottom habitat plays a key role as a foraging area for herbivores, detrivores, invertebrate, feeding fish (including kingfishes), and larger predators because of the high concentrations of organic matter and infauna that occurs there (Peterson and Peterson 1979). The sediment type and energy regime will affect the primary and secondary productivity of the bottom, and therefore the benthic microalgae (benthic diatoms and blue-green algae), demersal zooplankton, and invertebrate prey available for kingfishes and other organisms (Peterson and Peterson 1979). Primary production in bottom sediments is also derived from deposition of detrital matter from marsh vegetation, submerged grasses, and macroalgae that settles on soft bottoms (Currin et al. 1995). The soft bottom environment of the estuary supports a high diversity of benthic fauna [300 spp. (Hackney et al. 1996)]. Two important prey taxa for the kingfishes, polychaete worms and pelecypods, inhabit the soft bottom in the estuary (Irwin 1970; McMicheal and Ross 1987; Miller et al. 1996). The kingfishes will nip off pelecypod siphons and also prey on mobile invertebrates that utilize the soft bottom such as penaeid shrimp (*Penaeus* spp.), and hermit crabs [*Pagurus* spp., *Petrochirus* spp., and *Clibanarius vittatus* (Irwin 1970; McMicheal and Ross 1987; Miller et al. 1996)].

The marine soft bottom habitat includes two distinct areas: surf zone (intertidal) and subtidal bottom (Street et al. 2005). Juvenile kingfishes of all three species utilize the surf zone as a nursery area. Kingfishes are summer residents of the surf zone, with Gulf kingfish generally ranking in the top five in number of individuals collected in surf zone studies (Ross and Lancaster 2002; Tagatz and Dudley 1961; Cupka 1972). Although species diversity is reduced in the marine intertidal bottom compared to the estuary and subtidal marine bottom, the habitat includes two of the more common prey species for kingfishes; the mole crab (*Emerita talpoida*) and coquina clams [*Donax variables*, *D. parvula* (McMicheal and Ross 1987; Hackney et al. 1996)].

The offshore sand bottom along coastal North Carolina is a diverse habitat comprised of polychaete worms, crustaceans, mollusks, and fishes (Posey and Ambrose 1994; Van Dolah et al. 1994). The infaunal species such as tube dwelling worms and permanent burrow dwelling worms are most impacted by beach renourishment and sand mining (Hackney et al. 1996). These soft bottom species tend to be opportunistic and recovery relatively quickly after disturbances, depending on time of year, sediment compatibility, and other factors (Posey and Alphin 2001).

Kingfishes can utilize shallow unvegetated estuarine shoreline as a corridor to migrate within the estuary with reduced risk of predation (Peterson and Peterson 1979). Although there is little benthic structure associated with soft bottom, kingfishes can find refuge from predators by remaining on very shallow flats that are inaccessible to predators. Kingfishes are also somewhat camouflaged against the sand substrate. Adult kingfishes migrating in fall will feed on intertidal flats (Peterson and Peterson 1979).

Soft bottom also plays a very important role in the ecology of estuarine ecosystems as a storage reservoir of nutrients, chemicals and microbes. Intense biogeochemical processing and recycling establishes a filter to trap and reprocess natural and human-induced nutrients and toxic substances. These materials may pass through an estuary (Matoura and Woodward 1983), become trapped in the organic rich low salinity zone (Sigels et al. 1982; Imberger et al. 1983), or migrate within the estuary over seasonal cycles (Uncles et al. 1988).

Estuarine soft bottom habitat may be affected by marina and dock facilities through alteration of the shoreline configuration, circulation patterns, and changes in bottom sediment characteristics (Wendt et al. 1990). Because benthic microalgae, an important component of primary production in soft bottom habitat, are light dependent, bottom sediments in dredged marinas will have reduced light availability due to the deeper water depth and shading from docking structures. A study in Long Island Sound found that microalgae production on soft bottom declined by 48% due to marina construction and macroalgae production declined by 17%, although some loss would be offset by productivity on hard structures in the marina (Ianuzzi et al. 1996). Operation of a marina can also affect productivity of the soft bottom community due to introduction of heavy metals, hydrocarbons, and bacteria (Chmura and Ross 1978; Marcus and Stokes 1985; Voudrias and Smith 1986). Heavy metals and hydrocarbons are toxic to many soft bottom dwelling invertebrates and benthic feeding fish (Weis and Weis 1989). Additionally, dissolved oxygen may become depleted or below biotic thresholds in dredged marina basins and channels. A North Carolina marina study found significantly lower DO concentrations (less than 5.0 mg/l) inside some marinas compared to outside marinas (DEHNR 1990).

Fishing related impacts to soft bottom and other habitats have been reviewed and compiled in federal fishery management plans for managed species and have been summarized in fishery management plans by the South Atlantic Fishery Management Council (SAFMC) and the Mid-Atlantic Fishery Management Council (MAFMC), as well as by the Moratorium Steering Committee (MSC 1996, Auster and Langton 1999, NCDMF 1999, and Collie et al. 2000). A legislative report to the MSC (1996) compiled a list of the gears used in North Carolina waters and their probable impacts. The gears with the greatest potential for damage to soft bottom or other habitats include dredges and trawls. The extent of habitat damage from fishing gear varies greatly with the gear type, habitat complexity, and amount of gear contact. While NCMFC rules are designed to minimize commercial fishing gear impacts to fisheries habitat, these restrictions primarily focus on restricting the use of highly destructive bottom disturbing gear from most structural habitats such as oyster or SAV beds. Soft bottom habitat, because of its low structure and dynamic nature, has historically been considered the most appropriate location to use bottom-disturbing gear.

Crab and oyster dredges have long teeth that dig deep into the sediment and cause extensive sediment disturbance. Hydraulic clam dredging and clam kicking also cause extensive sediment disturbance, creating trenches over one foot deep and mounds of discarded material in soft bottom habitat, redistributing and resuspending sediment, and uprooting any biotic structure present such as worm tubes, algae, or shell hash (Godcharles 1971; Adkins et al. 1983). Because of the severe impacts to habitats, hydraulic clam dredging and clam kicking are restricted to open sand and mud bottoms, including areas frequently dredged as navigational channels. Similar to effects from navigational dredging, these gears can elevate turbidity, clogging fish gills and smothering benthic prey of kingfishes (SAFMC 1998).

Bottom trawling is used more extensively than dredges on soft bottom habitat in both estuarine and coastal ocean waters. Trawling impacts fish habitat by directly removing or damaging epifauna, removing burrow or pit-forming invertebrates, reducing diversity and abundance of benthic community, smoothing sediment features, and increasing exposure to predators (Auster and Langton 1999; Collie et al. 1997). Sediment resuspension can increase turbidity, reducing light dependent benthic productivity, which in turn affects the benthic food web. While several studies have shown negative effects of trawling, other studies have found no negative impacts (Van Dolah et al 1991; Currie and Parry 1996; Cahoon et al. 2002). No studies have looked at the effect of trawling on the bottom habitat of Pamlico or other sounds in North Carolina, or the effect on the species that utilize the trawled bottom habitat. Further research should be conducted to identify the location and duration of trawling in North Carolina waters, and assess the long-term effect on the fish community.

Beach nourishment can threaten the quality of intertidal and shallow subtidal ocean bottom habitat, which is important nursery and foraging grounds for kingfishes. When sand is put on the intertidal beach, the existing benthos is buried, killing the prey available for kingfishes (Hackney et al. 1996). The reported recovery time of the benthic community generally ranges from one month to one year, although longer in some cases (Reilly and Bellis 1983; Van Dolah et al. 1992; Rackocinski et al. 1993; Donoghue 1999; Jutte et al. 1999; Peterson et al. 2000; Lindquist and Manning 2001; COE 2001). Factors that affect the recover time include compatibility of deposited material with native sand, volume, depth, and length of filler area, time of year, frequency of renourishment events, and specific site conditions. In addition to reduction in available food, beach renourishment can affect kingfishes and other fish species by altering preferred topographic features such as ebb tide deltas and near shore muddy sloughs or reducing visibility (Street et al. 2005). Demersal feeding fish that spend more time in the surf zone, such as kingfishes and Florida pompano (*Trachinotus carolinus*) would be most vulnerable. Since Gulf kingfish exhibit strong site fidelity, localized disturbances may negatively impact abundance of Gulf kingfish (Ross and Lancaster 2002). Northern kingfish also exhibit strong site fidelity (Miller et al. 2002)

In North Carolina, the effects of a Brunswick County beach nourishment project on surf fish, benthic invertebrates, and water quality, were evaluated from March 2001 to May 2002 (COE 2003). Sand from the lower Cape Fear River dredging project was placed on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach. Sampling conducted before and after the project found no significant differences in fish abundance or diversity among disturbed, undisturbed, and reference sites during any season. Although statistically not significant, Gulf kingfish were less abundant at the disturbed sites than the undisturbed sites. The decline was thought to be at least partially due to the reduced availability of benthic invertebrates preferred by Gulf kingfish (COE 2003). However, the high mobility and schooling behavior of the dominant fish species (anchovies and drum family) and insufficient and uneven sampling size made statistical detection difficult.

In a beach nourishment study conducted in New Jersey, abundance of bluefish, a visual feeder, decreased while northern kingfish, a benthic feeder, appeared to increase (COE 2001). However, no long-term trends were detected in distribution or abundance. This study concluded that the inter-annual fluctuations in surf zone fish populations were too large to accurately detect change from such a project, unless the change was completely catastrophic (COE 2001). In addition, the cumulative impacts when beach renourishment is conducted over a wide area may have a greater impact on kingfishes since kingfishes exhibit little movement along the intertidal zone as juveniles (Ross and Lancaster 2002; Miller et al. 2002). Adequate monitoring of the effects of beach nourishment on the soft bottom community and associated surf fish populations is increasingly important as the number of beach nourishment projects increase and should be required for all large-scale or long-term nourishment projects. Currently, a study is being conducted on the surf zone assemblage of Wrightsville Beach by University of North Carolina Wilmington (UNCW) to track trends in several intertidal species such as bluefish, kingfishes, pompano, and invertebrates, and assess if there is an effect of beach nourishment events (T.

Lankford, Jr., UNCW, pers. Com., 2006).

The frequency and magnitude of beach nourishment on developed beaches have increased over time. From the 1960s to 2000, only nine miles of beach (3% of the ocean shoreline) had ongoing storm damage reduction projects: Wrightsville Beach, Carolina Beach, and Kure Beach. With the exception of Currituck County where there have been no nourishment projects, Onslow County has had the least beach renourishment, with only one small project in the 1990s. In 2005, there were 16 mi (5%) of beach along North Carolina's coast that had authorized and funded storm damage reduction projects ongoing. An additional 35 mi (11%) of beaches had authorization to conduct projects, and 104 mi of additional beaches (33%) were at some stage of requesting long-term beach nourishment (storm damage reduction projects). This included all of Hatteras and Ocracoke islands because of the Department of Transportation (DOT NC Highway 12 study, but it is likely that only a small part of these islands would actually be nourished (J. Sutherland, WRC, pers. com., 2004). Beach renourishment of federally authorized storm reduction projects generally occurs on three or four year intervals. Potentially, 155 mi or 48% of North Carolina's beaches could be renourished regularly if resources existed, and these beaches could be impacted by such activities. This does not include approximately 16 mi of beach renourished periodically by disposal from channel, inlet, and port dredging. There are approximately 160 mi of federally or state owned barrier islands along the 320 mi of ocean shoreline where storm damage reduction projects would be unlikely.

Given the increasing numbers of existing and requested nourishment projects over time, the cumulative impacts of activities on the intertidal and subtidal communities are also expected to increase. To adequately and correctly assess the direct and cumulative impacts of beach nourishment activities on fish, their habitat, and biological recovery rates, thorough monitoring must be conducted. Increasing use of beach nourishment may have a cumulative impact on fish productivity of nearshore waters through impacts on the benthic community and alteration of natural barrier island processes. The NCMFC adopted a beach nourishment policy in 2000 to guide the permitting process to more fully consider fish habitat impacts (See Appendix 1). All beach nourishment projects should adhere to the guidelines provided in that policy. The policy is a tool for the NCMFC to use, should they decide to comment on a project. In addition, preparation of a coastwide comprehensive sand management plan by DENR or DCM could provide guidelines to minimize long-term impacts, benefiting kingfishes and other surf zone species.

9.1.5 Hard Bottom

Hard bottom as defined by the CHPP is an "exposed area of rock or unconsolidated sediments, distinguished from surrounding unconsolidated sediments, which may or may not be characterized by live or dead biota, generally located in the ocean rather than in the estuary" (Street et al. 2005). Hard bottom provides habitat for kingfishes on reefs in waters less than 30 m (Street et al. 2005). Anecdotal evidence supports the claim that kingfishes utilize hard bottom areas. Northern kingfish's Latin name, *saxatilis,* means "among the rocks" (FishBase 2005) and fishermen suggest an increase in northern kingfish catch near rocky bottom habitat. More information is needed on the use of hard bottom habitat by kingfishes.

Shallow hard bottom habitats in North Carolina state waters are threatened in some areas by beach nourishment, since the added sand can be transported seaward with cross shelf currents over time, covering hard bottom structures (Thieler et al. 1995; Thieler et al. 1998; Reed and Wells 2000). As the hard bottom area decreases, the number of species and abundance decrease (Lindeman and Snyder 1999; Ojeda et al. 2001).

Other impacts to hard bottom habitats include commercial fishing, infrastructure, and water quality degradation (Street et al. 2005). Commercial fishing gear, mainly trawls, impacts the hard bottom habitat by breaking or detaching organisms (Street et al. 2005), and causes reductions in the abundance of benthic invertebrates often consumed as prey (Watling and Norse 1998). Infrastructure for pipelines, fiber optic cable, and sonar testing (Navy) impacts hard bottom habitats by cable movement, repairs to broken cables, directional drilling, sedimentation, or a physical barrier to movement (Street et al. 2005).

The water quality of the offshore habitat is critical to the survival of the hard bottom species since most fishery species are sensitive to degraded water quality during the first months of life (Street et al. 2005). Primary sources of pollutants in the hard bottom habitats of kingfishes are discharge of contaminants from estuaries and stormwater runoff. Additional sources of pollution include oil and gas development, and offshore municipal wastewater discharge but at this time are not permitted in North Carolina (Street et al. 2005).

9.2 WATER QUALITY DEGRADATION

Adequate water quality is necessary to maintain the chemical properties of the water column that are needed by kingfishes, as well as sustain the other habitats that kingfishes rely on. Human activities can alter the chemistry and flow characteristics of the water column in ways that are not optimal for growth or survival of kingfishes. For example if salinity or dissolved oxygen concentrations are altered beyond the known preferences of kingfishes, their distribution or growth rates may be affected. The most common causes of water quality impairment in North Carolina’s coastal river basins are excessive sediment loading and low DO (DWQ 2000a). Since kingfishes are demersal bottom feeders, low DO and toxin bioaccumualtion are probably the greatest water quality concerns for these species. Because southern kingfish spend more time in North Carolina’s estuarine waters than northern or Gulf kingfish, it is more vulnerable to estuarine water quality degradation.

There have been significant population increases over the past 20 years in coastal river basins. This increase in population has resulted in increased stormwater runoff, the addition of new septic tanks, and the need for additional wastewater treatment capacity, water supply sources, and marinas (DWQ 2000a). Water quality impacts associated with increasing population density are affected by development locations, land use and topography of the river basin (Street et al. 2005).

Water pollution sources are classified into two categories: point and nonpoint source pollution. Point source pollution is defined as pollution from a defined point such as a pipe while nonpoint source pollution is pollution from a non-defined point of entry such as stormwater run off. Both source types contribute to oxygen consuming wastes, excessive nutrients, increased sediment, as well as toxins, pesticides, and heavy metals. Point source dischargers (municipal and industrial wastewater treatment plants, small domestic wastewater treatment system for schools, commercial offices, residential subdivisions and individual homes) in North Carolina must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the Division of Water Quality (DWQ 2000a).

Sediment and nutrients are the major pollution substances associated with nonpoint source pollution but fecal coliform bacteria, heavy metals, oil and grease as well as any substance that may be washed from the ground or removed from the atmosphere also result from nonpoint sources. There are several activities that are associated with nonpoint source pollution. These include land clearing, plowing, drainage ditch construction, pesticide and fertilizer use, as well as concentrated livestock operations (DWQ 2000a).

Ambient water quality monitoring data are available for some estuarine waters from DWQ and is summarized in the appropriate river basin plans (Lumber, Cape Fear, White Oak, Neuse, Tar-Pamlico, and Pasquotank). DWQ does not monitor benthic community or sediments in estuarine areas. There is negligible sampling by DWQ in the larger sounds. However, the FerryMon program collects water quality information in three transects along Ferry routes. The routes are located in southeast Pamlico Sound (Cedar Island to Ocracoke), across central Pamlico Sound, and across the Neuse River. Information collected includes temperature, salinity, dissolved oxygen, pH, turbidity, and chlorophyll a. More recently, data from FerryMon has been coupled with remote sensing efforts by EPA to determine suspended phytoplankton composition and concentration in the sound. An additional source of data to determine water quality in North Carolina is the National Coastal Assessment Program conducted by the EPA. Approximately 33 stations have been sampled in every summer since 2002. Information is collected on the quality of the water, as well as the sediment, benthos, and fish. Some stations are located in areas where kingfishes more typically occur and that lacked state monitoring (Albemarle, Roanoke, Pamlico, Core, Bogue sounds and estuarine waters). The 2005 assessment rated the water quality index for the Carolinian province as ”fair to good” (EPA 2005).

Information is sparse or lacking for water quality trends in ocean waters where kingfishes most commonly occur. DWQ does not monitor ambient water quality in nearshore ocean waters. However, since 1997, the Shellfish Sanitation Office, Division of Environmental Health, has been recording *Enterococcus* bacteria levels for safe swimming along ocean beaches and some estuarine areas. Since 2002, a public advisory or alert has been issued for the ocean for 288 days in 38 sampling areas (0 in 2002, 12 in 2003, 19 in 2004, 7 in 2005). Dare County had the most with 22 areas with advisories and alerts followed by Carteret County with 14. New Hanover and Beaufort counties each had one advisory or alert. Although these bacteria will not hurt kingfishes, it is an indicator that other pollutants associated with upland activity, such as nutrients or toxins, are present. In addition some university based monitoring is occurring from ocean fishing piers and nearshore waters. UNCW’s Coastal Ocean Research and Monitoring Program (CORMP) collects information on water temperature, wave height, water depth, and wind conditions on a regular basis from fixed moorings and additional parameters from cruises in southeast North Carolina.

9.2.1 Nutrients

Nitrogen and phosphorus, components of fertilizers and animal and human wastes, are common nutrients that, in small quantities, are beneficial to aquatic life, but can be detrimental in large quantities. In excessive amounts, nutrient loading leads to habitat degradation, toxicity, hypoxia, anoxia, algal blooms, fish kills, and loss of biodiversity (Paerl 2002). These are all signs of cultural eutrophication and water quality degradation (Paerl 2002, DWQ 2000a). Cultural eutrophication is the rapid process of the accumulation of nutrients and sediments caused by man (DWQ 2000a). Urban runoff, crop agriculture, animal operations, erosion, and industrial expansion in the coastal regions have lead to the rise of nitrogen loading in our estuaries.

Recent research has shown atmospheric depositions of nitrogen (AD-N), previously considered a minor source of nitrogen input, to be a highly significant source of externally supplied nitrogen entering the estuaries (Paerl 2002). There also may be a link between acidic deposition (acid rain) and eutrophication of estuaries (Driscoll et al. 2003). Sources of both AD-N and acid rain are mostly from burning fossil fuels and by agricultural activities (Driscoll et al. 2003; Pearl 2002).

9.2.2 Oxygen Depletion

Survival of kingfishes and other organisms depends on an adequate supply of dissolved oxygen. Anoxia (no oxygen), and hypoxia (low oxygen) occur naturally but can increase in frequency due to anthropogenic causes. Stratification of the water column, particularly in summer, due to wind, temperature and salinity conditions prevents mixing of bottom waters with more oxygenated surface waters. Algal blooms can result in lower dissolved oxygen (DO) levels in the water, especially at night, due to excessive plant respiration. When these blooms die, bacteria decomposing the dead plant material remove oxygen (DWQ 2000b). Shallow water estuaries with less frequent flushing often develop persistent stratification and bottom-water hypoxia that can last for weeks to months (Tenore 1972). Low oxygen levels can, in turn, lead to fish kills. Anthropogenic causes of oxygen depletion are often attributed to excessive loading of nutrients from stormwater runoff, heavy rainfall, and air deposition. Low oxygen events in coastal waters of the US are becoming larger and longer lasting due to increasing eutrophication (Breitberg 1992; Cooper and Brush 1991; Lenihan and Peterson 1998).

Most demersal fishes experience mortality in waters having 1-2 mg/l O_2, altered metabolism where oxygen levels are < 4 mg/l, and impaired larval growth where oxygen levels are < 4.7 mg/l(Miller et al. 1995; Gray et al. 2002). Some estuarine species are capable of detecting and avoiding low oxygen waters, but there are species-specific differences in tolerance thresholds (Wannamaker et al. 2000). There are no reported oxygen tolerances for kingfishes. Of the species studied, Atlantic croaker (*Micropogonias undulatus*), which is similar to kingfishes in habitat and diet preferences, are more sensitive to moderate hypoxia than other species, and would move to waters with slightly greater oxygen levels (2 mg/l vs. 1 mg/l), suggesting they would be capable of avoiding hypoxia-related mortality. The migration of benthic organisms from hypoxic or anoxic waters can result in high densities of organisms in oxygenated areas, increased competition, and increased predation by opportunistic predators (Eby and Crowder 1998).

Although mortality due to oxygen depletion does not appear to be a significant factor for kingfishes, prolonged periods of hypoxia could stress and alter the ecological successional patterns if the benthos are altered (Luettich et al. 1999). The various successional stages may impact or benefit different benthic feeders to various extents, with disturbed early successional benthic communities favoring small and juvenile benthic feeders and recovered benthic communities favoring larger adult species (Luettich et al. 1999). Research is needed on kingfishes' tolerance levels of and behavioral responses to hypoxia, and the effect of current conditions on populations.

The number of fish kill events has declined from a peak in 2001 (77) to a low in 2004 (18). Although the number of kills has decreased, the intensity has been variable with 2003 having the highest number of mortalities. Areas having the largest number of fish kills from 1996-2001 include the Neuse, Tar-Pamlico and Cape Fear river basins (DWQ 2001), with low DO being a common cause. Low oxygen is considered the leading cause of fish kill events in 22 coastal states (Lowe et al 1991). Kingfishes have not been reported in fish kill investigations. However, the lack of a swimbladder and demersal nature of kingfishes may hinder ability of investigators to spot dead or dying kingfishes. All reported fish kills prior to

2005 occurred in estuarine and freshwaters. A series of menhaden kills In December 2005 and January 2006 were reported in ocean and estuarine waters of New Hanover and Pender counties. However, the fish kills were attributed to a localized reduction in dissolved oxygen due to dense schooling of fish, and was not associated with any water quality problems (Smith 1999; Rich Carpenter, pers. com., 2006).

Low DO was a major source of impairment in the Cape Fear (5,000 acres) and the Pasquotank river basins (1,125 acres). Eby and Crowder (1998) estimated that up to 30-50% of the Neuse River estuary was unsuitable bottom habitat during summer due to hypoxia. Since kingfishes occur on the bottom in estuaries where hypoxia and anoxia have been reported to occur, the species may be negatively affected by low oxygen events. Several studies have indicated that the frequency, duration, and spatial extent of low oxygen events have increased over the years due to increasing eutrophication of coastal waters from human and animal waste discharges, greater fertilizer use, loss of wetlands, and increased atmospheric nitrogen deposition (Cooper and Brush 1991; Dyer and Orth 1994; Paerl et al. 1995; Buzelli et al. 2002). More information is needed to understand the consequences on the estuarine food web and to what extent anoxia is impacting the soft bottom community. Efforts are needed to reduce anthropogenic nutrient loading, particularly in systems that have a history of hypoxia and anoxia.

Several hurricanes occurring in September and October of 1999 significantly impacted water quality in North Carolina. Because of the heavy rainfall in short time periods during these storms, record flooding caused an input of at least half of the typical nitrogen load, as well as twice the amount of carbon input into Pamlico Sound through the Neuse River. This heavy pulse of nutrients and freshwater runoff caused bottom water hypoxia, an increase in algal biomass for a long period of time, and the displacement of many marine organisms as well as an increase in the occurrence of fish disease (Paerl et al. 2001).

9.2.3 Sedimentation and Turbidity

Sediment impacts on fish depend on the concentration of suspended sediment, type of sediment, and the duration of the sedimentation. These impacts can plug gills and reduce respiratory abilities. This can lead to a reduced tolerance to disease, toxins and turbidity as well as affect spawning and rearing habitat (DWQ 2000a).

Sediment loading usually results from nonpoint sources such as building and road construction. Stormwater runoff from urban areas, agriculture, silviculture, animal operations, as well as mining and removal of vegetated buffers accelerates sediment loading as well as increases turbidity in the water column (DWQ 2000a). Water activities such as dredging, boating and fishing with bottom disturbing gears also adds to an increase in turbidity. Of all of these sources, agriculture is one of the largest contributors of sedimentation in the southeastern US (SAFMC 1998).

Another natural process that occurs in our estuaries is erosion, which increases turbidity and sedimentation. Both processes occur when waves and currents erode shorelines and transport sediment into the waters, causing short and long-term changes along the coast. However, this process, like eutrophication has been accelerated because of man’s activities.

9.2.4 Toxic Chemicals

Toxic chemicals that are found in the water column include heavy metals, polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, polychlorinated biphenyls (PCBs), dioxins, antifoulants, chlorine, ammonia and pesticides. Most of these chemicals come from localized point and nonpoint sources while activities contributing to heavy metal contamination include urban sprawl, dock and marina development, boating activity, dredge spoil disposal, automotive transportation, industrial shipping and industrial emissions (Wilbur and Pentony 1999). Studies have shown that fine-grained sediments act as a reservoir for heavy metals and are readily adsorbed on tiny sediment particles, particularly organic rich muds (Riggs et al. 1991). Chemicals such as DDT, Diedrin and TBT continue to contaminate sediments, even though they have been banned since 1977.

While toxins can fluctuate between the sediment and water column, concentrations of toxic chemicals tend to accumulate in sediments to several orders of greater magnitude than overlying waters (Kwon and Lee 2001). The bioavailability and transport of a toxin is affected by the physical and chemical conditions of the environment and the feeding habits and condition of aquatic organisms. Toxic chemicals can become active in soft bottom sediment or overlying waters through resuspension from natural weather events or human activities such as dredging and trawling. Resuspension of sediments with heavy metal contamination can be a problem in fine-grained areas such as sheltered creeks. Because low concentrations of heavy metals in the water column can be easily incorporated into fine-grained sediment, such as organic rich mud, toxicants levels can accumulate in the sediment and be resuspended into the water column (Riggs et al. 1991). This is of particular concern as the majority of NC's soft bottom is composed of fine-grained organic sediments.

Toxins in sediments or the water column can affect benthic invertebrates by inhibiting or altering reproduction or growth or in some situations causing mortality (Weis and Weis 1989). Early life stages are most vulnerable to toxins (Funderburk et al. 1991). Food resources for benthic feeders, like kingfishes, may be limited in highly contaminated areas because macroinvertebrate diversity significantly declines with increasing sediment contamination (Weis et al. 1998; Brown et al. 2000; Dauer et al. 2000). While the survival of some aquatic organisms is affected by toxins, other organisms survive and bioaccumulate the chemicals to toxic levels, passing them along in the food chain. Multiple studies have shown clear connections between concentrations of toxins in sediments and those in benthic feeding fish and invertebrates (Kirby et al. 2001; Marburger et al. 2002). Heavy metal contamination of sediments has been documented to result in elevated trace metal concentrations in shrimp, striped mullet, oysters, and flounder (Kirby et al. 2001; Livingstone 2001). Fish can uptake metals in different ways, through the skin and gills and the wall of the digestive tract. Mzimela et al. (2003) found that the groovy mullet, *Liza dumerelii,* accumulated elevated levels of iron, aluminum, zinc, manganese, chromium, copper, and lead (in that order) from discharges into Richards Bay, South Africa. Sources of contamination were industrial discharges from fertilizer, paper pulp and aluminum smelter production (Mzimela et al. 2003).

Toxic chemicals come from localized point sources as well as diffuse nonpoint sources. Industrial and municipal waste discharges are point sources. Nonpoint sources of toxins include: urban runoff containing household and yard chemicals, roadways, marinas and docks, boating activity, runoff from agriculture and forestry, industrial emissions, spills from industrial shipping, and dredge spoil disposal (Wilbur and Pentony 1999).

The extent of sediment contamination in North Carolina coastal waters is not well known. Sediment sampling is not conducted by DWQ since there are no sediment standards in the state. Studies examining sediment contamination at sites in North Carolina soft bottom have found various levels of contamination. The EPA Environmental Monitoring and Assessment Program surveyed 165 sites within North Carolina's sounds and rivers during 1994-1997 to evaluate condition of bottom sediments (Hackney et al. 1998). Highest contamination levels occurred in low salinity areas with low flushing and high river discharge. Benthic populations were dominated by tolerant opportunistic species and benthic communities had low species richness. Laboratory bioassays showed that sediments from many sites were toxic to biological organisms. However, because of the low sample size, frequency of sampling, and the confounding effects of hypoxia in areas sampled, results from this study may not accurately assess the condition of North Carolina sediments (C. Currin, NOAA, pers. com., 2003). Some additional information regarding the condition of estuarine benthic sediments has been collected since 2002. DWQ samples 33 stations primarily in the sounds during the summer for the EPA-funded National Coastal Assessment Program. Information is collected to determine sediment, benthic, and habitat indices, as well as fish tissue condition. In 2005, the assessment indices for sediment quality, sediment contamination, and sediment toxicity in the Carolinian province were rated as "good" (EPA 2005).

To better determine if contaminated sediment is a significant threat to coastal fish habitat, the distribution and concentration of heavy metals and other toxins in estuarine sediments need to be adequately assessed, as well as the condition of the benthic community, and the areas of greatest concern need to be identified. Continued minimization of point and nonpoint sources of toxic contaminants is vital for protecting not only soft bottom but also the other fish habitats.

9.3 HABITAT AND WATER QUALITY PROTECTION

9.3.1 NCMFC Authority

Presently, the NCMFC has authority for the following actions with regard to marine and estuarine resources: manage, restore, develop, cultivate, conserve, protect, and regulate. Marine and estuarine resources are "All fish [including marine mammals, shellfish, and crustaceans], except inland game fish, found in the Atlantic Ocean and in coastal fishing waters; all fisheries based upon such fish; all uncultivated or undomesticated plant and animal life, other than wildlife resources, inhabiting or dependent upon coastal fishing waters; and the entire ecology supporting such fish, fisheries, and plant and animal life." (G.S. 113-129).

Although the NCMFC's primary responsibilities are management of fisheries (season, size and bag limits, licensing, etc.), the NCMFC has the authority to comment on state permit applications that may have an effect on marine and estuarine resources or water quality, regulator placement of fishing gear, develop and improve mariculture, and regulate location and utilization of artificial reefs. Authority for the NCMFC is found at G.S. 143B-289.51 and 52.

9.3.2 Authority of Other Agencies

The NCDENR have several divisions responsible for providing technical and financial assistance, planning, permitting, certification, monitoring, and regulatory activities, which impact the coastal water quality or habitat. The North Carolina Division of Coastal Management (DCM) is responsible for development permits along the estuarine shoreline in 20 coastal counties. Wetland development activity throughout North Carolina is permitted through the US Army Corps of Engineers (COE) and the North Carolina Division of Water Quality (DWQ) (DWQ; 401-certification program). The DWQ has established a water quality classification and standards program for "best usage" to promote protection of unique and special pristine waters with outstanding resource values. The High Quality Waters (HQW), Outstanding Resource Waters (ORW), Nutrient Sensitive Waters (NSW), and Water Supply (WS) classifications have outlined management strategies to control point and nonpoint source pollution. Various federal and state environmental and resource agencies, including NCDMF, evaluate projects proposed for permitting and provide comments and recommendations to the DCM, DWQ, and COE on potential habitat and resource impacts. Habitat protection relies on enforcement, the efforts of commenting agencies to evaluate impacts, and the incorporation of recommendations into permitting decisions. Habitats are also protected through the acquisition and management of natural areas as parks, refuges, reserves, or protected lands by public agencies and/or private groups.

9.3.3 Coastal Habitat Protection Plan

The FRA of 1997 mandated the NCDENR to prepare CHPPs (CHPPs -- G. S. 143B-279.8). The legislative goal for the CHPPs is long-term enhancement of the coastal fisheries associated with coastal habitats and provides a framework for management actions to protect and restore habitats critical to North Carolina’s coastal fishery resources. There are three commissions that have regulatory jurisdiction over the coastal resources, water, and marine fishery resources including: NCMFC, Coastal Resources Commission (NCCRC), and the Environmental Management Commission (NCEMC). The CHPP was completed in December 2004 and implementation plans for each Division and the Department were approved in July 2005. The plan is to be reviewed every five years. Actions taken by all three commissions pertaining to the coastal area, including rule making, are to comply, “to the maximum extent practicable” with the plans. The CHPP helps to ensure consistent actions among these three commissions as well as their supporting NCDENR agencies.

The CHPP describes and documents the use of habitats by species supporting coastal fisheries, status of these habitats, and the impacts of human activities and natural events on those habitats. Fish Habitat is defined as freshwater, estuarine, and marine areas that support juvenile and adult populations of economically important fish, shellfish, and crustacean species (commercial and recreational), as well as forage species important in the food chain (Street et al. 2005). Fish Habitat also includes land areas that are adjacent to, and periodically flooded by riverine and coastal waters. Six FH are discussed and designated based on distinctive physical properties, ecological functions, and habitat requirements for living components of the habitat: wetlands, SAV, soft bottom, shell bottom, ocean hard bottom, and water column.

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

The CHPP focuses on the fish habitat and threats to the habitat. This FMP describes habitat conditions or needs for the various life stages of the kingfishes. The FRA gives precedent to the CHPP and stipulates habitat and water quality considerations in the FMP be consistent with CHPP. Any recommendations will be considered and acted upon through the CHPP implementation process.

10. PRINCIPAL ISSUES AND MANAGEMENT OPTIONS

A summary of the major issues and management options identified during the development of the FMP are contained in this section. Each issue is briefly described along with potential management options, recommended strategies, and actions to be taken by the NCMFC, NCDMF, and others. An in-depth discussion of habitat and water quality is in Section 9 (Environmental Factors) while the remaining issues are discussed in Section 12 (Appendices).

10.1 ISSUES

10.1.1 Habitat

10.1.1.1 Issue/ Purpose: Protect, enhance, and restore habitats utilized by southern, Gulf, and northern kingfishes.

Suitable and adequate habitat is a critical element in the ecology and productivity of estuarine and marine systems. Degradation or improvement in one aspect of habitat may have a corresponding impact on water quality. Maintenance and improvement of suitable estuarine and marine habitat and water quality are important factors in maintaining sustainable stocks of kingfishes.

10.1.1.2 Management Options

1. No regulatory action.
2. NCMFC should approve rule changes to protect additional critical habitats for kingfishes as recommended in the actions in 10.1.1.4.
3. MFC should work with other agencies (NCCRC, NCEMC, and others) to modify their rules in ways that would better protect critical habitats and water quality for kingfishes, as recommended in the actions in 10.1.2.4.

Option two would require rule changes by the NCMFC.

10.1.1.3 Recommended Management Strategy

The AC and PDT recommended options 2 and 3. Habitat protection, conservation, and restoration are essential to accomplish the goal and objectives of this plan. The NCMFC, NCCRC, and NCEMC should adopt rules to protect critical habitats for kingfishes as outlined in the CHPP. The NCDENR should develop a strategy to fully support the CHPP process with additional staff and funding. The NCMFC and NCDMF should continue to comment on activities that may impact aquatic habitats and work with permitting agencies to minimize impacts and promote restoration and research. Research must be conducted to investigate the impacts of trawling on various habitats.

A strategy should be developed and adopted by the NCMFC and DENR to accomplish the actions outlined in Section 10.1.1.4. These strategies would address objectives 4 and 6 of this plan.

10.1.1.4 Actions

Actions 2 - 7, 10, and 12 - 14 would need to be implemented through the cooperative efforts of the NC General Assembly and/or several divisions within the NCDENR. The involvement of federal agencies and increased funding (state and federal) may be necessary to accomplish these actions. Actions 1, 8, 9, 11, and 15 could be implemented by NCDMF/NCMFC.

STRATEGIC HABITAT AREAS

Action 1: Identify and delineate Strategic Habitat Areas that will enhance protection of southern, Gulf, and northern kingfishes.

SOFT BOTTOM

Action 2: Minimize contamination of bottom sediments through protection and enhancement of wetlands utilizing regulatory and non-regulatory measures, such as land use planning, land acquisition, vegetated buffers, and permitting regulations.
Action 3: Implement a comprehensive beach and inlet management plan that minimizes impacts to the habitat of kingfishes.
Action 4: Implement and enforce sediment compatibility criteria for beach nourishment projects.
Action 5: Require adequate and robust pre- and post- monitoring/research of the biological effect of large-scale beach nourishment on the benthic invertebrate and surf fish communities, and recovery of the system.
Action 6: Require that all large-scale beach nourishment projects adhere to the NCMFC beach nourishment policy.
Action 7: Assess the distribution, concentration, and threat of heavy metals and other toxic contaminants in freshwater and estuarine sediments and identify the areas of greatest concern to focus water quality improvement efforts (research).
Action 8: More research is needed to confirm spawning and nursery use of soft bottom habitat by southern, Gulf, and northern kingfishes (research).
Action 9: Evaluate the effects of bottom disturbing gear on soft bottom habitat and kingfishes (research).

SUBMERGED AQUATIC VEGETATION (SAV)

Action 10: Completely map all SAV in North Carolina (research).
Action 11: Expand nursery sampling to include high salinity SAV beds to adequately evaluate their use by kingfishes and other species, and trends in those species.
Action 12: Reduce nutrient and sediment loading in the Albemarle-Pamlico system, particularly the Neuse and Tar-Pamlico rivers, to levels that will support SAV, using regulatory and non-regulatory actions.
Action 13: Evaluate dock criteria to determine if existing requirements are adequate for SAV survival and growth and modify accordingly (research).
Action 14: Develop and implement a comprehensive coastal marina and dock management plan and policy to minimize impacts to SAV, shell bottom, soft bottom, and water quality.
Action 15: Expand areas where dredging and trawling is not allowed to protect existing SAV and allow some recovery of SAV where it historically occurred.

10.1.2 Water Quality

10.1.2.1 Issue/ Purpose: Protect, enhance, and restore estuarine water quality.

Suitable water quality is a critical element in the ecology and productivity of estuarine systems. Degradation or improvement in one aspect of water quality may have a corresponding impact on habitat. Maintenance and improvement of suitable estuarine water quality and habitat are probably the most important factors in providing a sustainable stock of kingfishes.

10.1.2.2 Management Options

The NCMFC has no regulatory authority over water quality impacts. The NCMFC and NCDMF should highlight problem areas and advise other regulatory agencies (NCEMC, NCDWQ, Division of Environmental Health – Shellfish Sanitation, Division of Land Resources, US Army Corps of Engineers, and local governments) on preferred options and potential solutions.

10.1.2.3 Recommended Management Strategy

The NCMFC and NCDMF should continue to comment on activities (state, federal, and local permits) that may impact estuarine water quality and work with permitting agencies to minimize impacts. Additionally, the NCMFC and NCDMF should solicit and support FRG projects that may provide information necessary for protection, management, and restoration of water quality. Water quality standards should be based on the assimilative capacity of, and impacts to, the entire system. Several plans for water quality management have recommended strategies that need to be implemented to improve water quality. A strategy should be developed and adopted by the NCMFC and NCDENR to accomplish the actions outlined in Section 10.1.2.4, and to assure that recommendations of existing and future water quality plans are addressed in a timely manner. The NCDENR should develop a strategy to fully support the CHPP process with additional staff and funding. Water quality protection and restoration are essential to accomplish the goal and objectives of this plan.

This strategy would address objectives 4 and 6 of this plan.

10.1.2.4 Actions

The actions below would need to be implemented through the cooperative efforts of the NC General Assembly and several divisions within the Department of Environment and Natural Resources. The involvement of federal agencies and funding (state and federal) will be necessary to accomplish these actions.

Action 1: Improve methods to reduce sediment and nutrient pollution from construction sites, agriculture, and forestry.
Action 2: Increase on-site infiltration of stormwater through voluntary or regulatory measures.
Action 3: Provide more incentives for low-impact development.
Action 4: Modify stormwater rules to more effectively reduce the volume and pollutant loading of stormwater runoff entering coastal waters.
Action 5: Reduce point source pollution from wastewater through improved inspections of wastewater treatment facilities, improved maintenance of collection infrastructure, and establishment of additional incentives to local governments for wastewater treatment plant upgrading.

Action 6: Prohibit new or expanded stormwater outfalls to beaches and phase out existing outfalls.
Action 7: Research is needed on kingfishes' tolerance levels of and behavioral responses to hypoxia, and the effect of current conditions on kingfishes (research).

10.1.3 Protected Species

10.1.3.1 Issue/Purpose: Incidental capture of species of concern that may be affected by North Carolina fisheries for kingfishes

10.1.3.2 Management Options

1. Status quo; The NCDMF will continue working with federal agencies and stakeholder groups to address interactions and management between category I & II commercial fisheries and high profile species.
2. Determine what new federal rules will be and react accordingly.

10.1.3.3 Recommended Management Strategy

The PDT and AC recommended that NCDMF continue to work with federal agencies and stakeholders to address interactions and management between category I & II commercial fisheries and high profile species (Option 1).

10.1.4 Management Measures of Kingfishes

10.1.4.1 Issue/Purpose: The implications of different management strategies to ensure a sustainable harvest of kingfishes

10.1.4.2 Management Options

1. Status Quo
2. Management Triggers
3. Recommend ASMFC or SAFMC conduct a stock assessment for kingfishes
4. "Consensus Based" Approach

10.1.4.3 Recommended Management Strategy

The recommended management strategies for kingfishes were similar between the NCMFC, PDT and AC. All groups recommended that management triggers be implemented for kingfishes instead of other "Consensus Based" approaches since most trends from the Trend Analysis were neutral to positive. If a trigger is met, the director will have proclamation authority to protect the population of kingfish so as to obtain and maintain sustainable harvest. The Kingfish AC originally recommended that the draft proclamation and all relevant supporting information be released to the public for their review and comment to the Director. This comment period need not exceed thirty days, and may be made available to the public by publication on the Division's web site without the need for public meetings. The AC further recommended that after the comment period, within 10 days, the AC would be reconvened to discuss potential management action and public comment, and recommend a course of action to the Director. After hearing recommendations from regional AC and PDT, the

AC rescinded their recommendation of a 30 day comment period. Neither the NCMFC nor PDT recommended the comment period.

The PDT also recommended that ASMFC or SAMFC manage kingfishes based on the concerns of reviewers in the stock assessment. The kingfishes likely migrate along the Atlantic Coast and until mixing rates have been determined to define stocks, the broadest scale for the stock should be used in a stock assessment. The NCMFC and Kingfish AC did not support this action based on past regulatory actions developed by ASMFC and SAMFC.

10.2 SUMMARY OF MANAGEMENT ACTIONS

10.2.1 Rules (new, modifications, or technical changes)

Proclamation Authority and Technical Amendment to Rule 03J .0202 (5) /Kingfish Rule Amendment (See Appendix 6).

10.2.2 Legislative Action

No legislative action is required.

10.2.3 Processes

1. Identify and delineate Strategic Habitat Areas that will enhance protection of southern, Gulf, and northern kingfishes.
2. Minimize contamination of bottom sediments through protection and enhancement of wetlands utilizing regulatory and non-regulatory measures, such as land use planning, land acquisition, vegetated buffers, and permitting regulations.
3. Implement a comprehensive beach and inlet management plan that minimizes impacts to the habitat of kingfishes.
4. Implement and enforce sediment compatibility criteria for beach nourishment projects.
5. Require adequate and robust pre- and post- monitoring/research of the biological effect of large-scale beach nourishment on the benthic invertebrate and surf fish communities, and recovery of the system.
6. Require that all large-scale beach nourishment projects adhere to the NCMFC beach nourishment policy.
7. Assess the distribution, concentration, and threat of heavy metals and other toxic contaminants in freshwater and estuarine sediments and identify the areas of greatest concern to focus water quality improvement efforts (research).
8. More research is needed to confirm spawning and nursery use of soft bottom habitat by southern, Gulf, and northern kingfishes (research).
9. Evaluate the effects of bottom disturbing gear on soft bottom habitat and kingfishes (research).
10. Completely map all SAV in North Carolina (research).
11. Expand nursery sampling to include high salinity SAV beds to adequately evaluate their use by kingfishes and other species, and trends in those species.
12. Reduce nutrient and sediment loading in the Albemarle-Pamlico system, particularly the Neuse and Tar-Pamlico rivers, to levels that will support SAV, using regulatory and non-regulatory actions.
13. Evaluate dock criteria to determine if existing requirements are adequate for SAV survival and growth and modify accordingly (research).
14. Develop and implement a comprehensive coastal marina and dock management plan

and policy to minimize impacts to SAV, shell bottom, soft bottom, and water quality.

15. Expand areas where dredging and trawling is not allowed to protect existing SAV and allow some recovery of SAV where it historically occurred.
16. Improve methods to reduce sediment and nutrient pollution from construction sites, agriculture, and forestry.
17. Increase on-site infiltration of stormwater through voluntary or regulatory measures.
18. Provide more incentives for low-impact development.
19. Modify stormwater rules to more effectively reduce the volume and pollutant loading of stormwater runoff entering coastal waters.
20. Reduce point source pollution from wastewater through improved inspections of wastewater treatment facilities, improved maintenance of collection infrastructure, and establishment of additional incentives to local governments for wastewater treatment plant upgrading.
21. Prohibit new or expanded stormwater outfalls to beaches and phase out existing outfalls.
22. Research is needed on kingfishes' tolerance levels of and behavioral responses to hypoxia, and the effect of current conditions on kingfishes (research).

10.2.4 Management Related Research (not ranked in order of priority)

1. Determine migration and mixing of kingfishes along North Carolina and the Atlantic Coast.
2. Validate YOY and adult indices used in trend analysis and expand current indices to include a seine survey in the ocean.
3. Determine selectivity patterns for a variety of fisheries along the North Carolina Coast used in YPR and other stock assessments.
4. Recommend a coastwide stock assessment be conducted by ASMFC or SAFMC.
5. Collect observer data from commercial fishing operations to estimate at sea species composition of the catch, discard rates, and lengths.
6. Improve data collection in MRFSS and commercial fish house sampling
7. Expand the NCDMF fishery independent gill net survey to provide data on species composition, abundance trends, and population age structure by including additional areas of North Carolina's estuarine and near-shore ocean waters.
8. Continue bycatch reduction device studies to decrease bycatch.

10.2.5 Biological Research Needs (not ranked in order of priority)

1. Continue with aging studies to provide future stock assessments with aging data for each species of kingfish.
2. Sample inlets and river plumes to determine the importance of these areas for kingfishes and other estuarine dependent species.
3. Improve reproductive related data including maturity schedule, fecundity, and spawning areas.
4. Determine the effects of beach renourishment on kingfishes and their prey.
5. Improve estimates of natural and fishing mortality rates.
6. Estimate biological reference points for a sustainable harvest of kingfishes.

10.2.6 Social and Economic Research Needs (ranked in order of priority)

1. Determine specific business characteristics and the economics of working in the fishery.
2. Collect information on the recreational fishermen to determine the fishery importance of kingfishes.

11. LITERATURE CITED

Able, K.W. and M.P. Fahay. 1998. The first year in the life of estuarine fishes in the Middle Atlantic Bight, Rutgers University Press, New Brunswick, NJ. 342 p.

Adkins, B.E., R.M. Harbo, and N. Bourne. 1983. An evaluation and management considerations of the use of a hydraulic clam harvester on intertidal clam populations in British Columbia. Canadian Manuscript Reports Fisheries Aquatic Science 1716: 38.

Anderson, W.W. 1968. Fishes taken during shrimp trawling along the South Atlantic Coast of the United States, 1931-1935. US Fish and Wildlife Service, Special Scientific Report, Fisheries. No. 570. 60 p.

ASMFC (Atlantic States Marine Fisheries Commission) 1994. Acronymns, Abbreviations and Technical Terms Used in ASMFC Fishery Management Programs. Special Report No. 33. October 1994.

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

Bearden, C.W. 1963. A contribution to the biology of the king whiting, genus *Menticirrhus* of South Carolina. Contributions of Bears Bluff Laboratory 38: 1.

Berkes, F., R. Mahon, P. McConney, R.C. Pollnac, and R.S. Pomeroy. 2001. Managing small-scale fisheries: alternative directions and methods. International Development Research Centre, Ottawa, Canada.

Beresoff, D. and J.H. Schoolfield. 2002. Movements of Kingfishes off North Carolina. NC Sea Grant 99-FEG-03. 16 p.

Blanton, J.O., F.E. Werner, A. Kapolnai, B.O. Blanton, D. Knott, and E.L. Wenner. 1999. Wind-generated transport of fictitious passive larvae into shallow tidal estuaries. Fisheries Oceanography 8(2): 210-223.

Boehlert, G.W. and B.C. Mundy. 1988. Roles of behavioral and physical factors in larval and juvenile fish recruitment to estuarine nursery areas. American Fisheries Symposium 3: 51-67.

Bourne, D.W. and J.J. Govoni 1988. Distribution of fish eggs and larvae and patterns of water circulation in Narragansett Bay, 1972-1973. American Fisheries Symposium 3: 132-148.

Bowman, R. and M. Tork. 1998. Summary report of the Outer Banks beach fishery of North Carolina, NMFS Northeast Fishery Science Center, Fisheries Sampling Branch, Internal Report. 10 pp.

Breitburg, D.L. 1992. Episodic hypoxia in Chesapeake Bay: interacting effects of recruitment behavior, and physical disturbance. Ecological Monographs 62(4): 525-546.

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

Burgess C. and A. Bianchi. 2004. An economic profile analysis of the commercial fishing industry of North Carolina including profiles for state-managed species. Hurricane Floyd Disaster Assistance for North Carolina, Project 6 –Impacts on Commercial Activities, NOAA Award No. NA16FW1543. 228 p.

Burns, B.L. 2004. Winter trawl fishery assessment *in* Assessment of North Carolina commercial finfisheries 2001-2003, Completion Report NA 06 FI 0321, North Carolina Department of Natural Resources and Community Development, Division of marine Fisheries, Morehead City, NC, USA, 27pp.

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

Cahoon, L.B., M.H. Posey, T.D. Alphin, D. Wells, S. Kissling, W.H. Daniels, and J. Hales. 2002. Shrimp and crab trawling impacts on estuarine soft-bottom organisms. UNC-Wilmington, Wilmington, NC, 17 p.

Carpenter, K.E. (ed.) 2002. The living marine resources of the Western Central Atlantic. Volume 2: Bony fishes part 1 (Acipenseridae to Grammatidae). FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologists and Herpetologists Special Publication No. 5. Rome, Italy, FAO. pp 601- 1374.

Chao, L.N. and J.A. Musick. 1977. Life history, feeding habits, and functional morphology of juvenile sciaenid fishes in the York River estuary, Virginia. Fishery Bulletin 75: 657-702.

Chestnut A. and H. Davis. 1975. Synopsis of Marine Fisheries of North Carolina. Part 1: Statistical Information, 1880-1973. North Carolina Sea Grant Award No. UNC-SG-75-12. 425 p.

Chmura, G.L. and N.W. Ross. 1978. Environmental impacts of marinas and their boats. Rhode Island Sea Grant, Narragansett, RI, P675; RIU-T-78-005.

Churchill, J.H., R.B. Forward, R.A. Luettich, J.J. Hench, W.F. Hettler, L.B. Crowder, and J.O. Blanton. 1999. Circulation and larval fish transport within a tidally dominated estuary. Fisheries Oceanography 8 (Suppl. 2): 173-189.

Coale, J.S., R.A. Rulifson, J.D. Murray, and R. Hines. 1994 Comparison of shrimp catch and bycatch between a skimmer trawl and an otter trawl in the North Carolina inshore shrimp fishery. North American Journal of Fisheries Management 14: 751-768.

COE (US Army Corps of Engineers). 2001. The New York District's biological monitoring program for the Atlantic coast of New Jersey, Asbury Park to Manasquan section beach erosion control project. USACOE, Vicksburg, MS, Final report, 103 p.

COE (US Army Corps of Engineers). 2003. Effects of dredged material beach disposal on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, North Carolina: Interim study findings. Versar, Inc., Columbia, Md.

Collie, J.S., S.J. Hall, M.J. Kaiser, and I.R. Poiners. 2000. A quantitative analysis of fishing impacts on shelf-sea benthos. Journal of Animal Ecology 69: 785-798.

Cooper, S.R. and G.S. Brush. 1991. A 2500 year history of anoxia and eutrophication in the Chesapeake Bay. Science 254: 992-1001.

Crowe, B.J. 1984. Distribution, length-frequency data of southern kingfish, *Menticirrhus americanus*, in Mississippi. Fishery Bulletin 82: 427-434.

Cupka, D.M. 1972. A survey of the ichthyofauna of the surf zone in South Carolina. South Carolina Wildlife and Marine Resource Department, Technical Report No. 4. 19 p.

Currie, D.R. and G.D. Parry. 1996. Effects of scallop dredging on a soft sediment community: a large-scale experimental study. Marine Ecological Progress Series 134: 131-150.

Currin, C.A., S.Y. Newell, and H.W. Paerl. 1995. The role of standing dead *Spartina alterniflora* and benthic microalgae in salt marsh food webs: considerations based on multiple stable isotope analysis. Marine Ecology Progress Series 121: 99-116.

Dahlberg, M.D. 1972. An ecological study of Georgia coastal fishes. Fishery Bulletin 70: 323-354.

Dauer. D.M., J.A. Ranasinghe, and S.B. Weisberg. 2000. Relationships between benthic community condition, water quality, sediment quality, nutrient loads, and land use patterns in Chesapeake Bay. Estuaries 23: 80-96.

Delancey, L.B. 1984. An ecological study of the surf zone at Folly Beach, South Carolina. Masters Thesis. The College of Charleston, Charleston, S. C. 113 p.

DEHNR (NC Department of Environment Health and Natural Resources). 1990. North Carolina coastal marinas: water quality assessment. DEHNR, Raleigh, NC, 90-01, 69p.

Diamond-Tissue, S.L. 1999. Characterization and estimation of shrimp trawl bycatch in North Carolina waters. Doctorate dissertation, North Carolina State University, Department of Zoology, Raleigh, NC 27695. 54 pp.

Ditty, J.G., T.W. Farooqi, and R.F. Shaw. 2006. Sciaenidae: Drums or croakers. *In*: Early Stages of Atlantic Fishes: An Identification Guide for the Western Central North Atlantic Volume II (W.J. Richards, ed.), 1669-1724. Taylor and Francis, Boca Raton, FL.

Donoghue, C.R. 1999. The influence of swash processes on *Donax variabilis* and *Emerita talpoida*. PhD Dissertation, University of Virginia, Charlottesville, Va, 197 p.

Doxey, R. 2000. Bycatch in the Crab Pot Fishery. NC 99FEG-45.

Driscoll, C.H., D. Whitall, J. Aber, E. Boyer, M. Castro, C. Cronan, C.L. Goodale, P. Groffman, C. Hopkinson, K. Lambert, G. Lawrence, and S. Ollinger. 2003. Nitrogen pollution in the Northeastern United States: sources, effects, and management. Bioscience 53: 357-374.

Durako, M.J. 1994. Seagrass die-off in Florida Bay (USA): changes in shoot demographic characteristics and population dynamics in *Thalassia testudinum*. Marine Ecology Progress Series 110: 59-66.

DWQ (North Carolina Division of Water Quality). 2000a. Water quality progress in North Carolina in 1998-1999, 305(b) report. DENR, Division of Water Quality, Raleigh, NC, 34 p.

DWQ (North Carolina Division of Water Quality). 2000b. A citizen's guide to water quality management in North Carolina. DENR, Div. Water Quality, Planning Branch, Raleigh, NC, 156 p.

Dyer, K.R. and R.J. Orth. 1994. Changes in fluxes in estuaries: implications from science to management. Olsen and Olsen, Fredenburg, Denmark.

Eby, L., L. Crowder, and C. McClellan. 2000. Neuse River estuary modeling and monitoring project Stage 1: effects of water quality on distribution and composition of the fish community. Water Resources Research Institute, Raleigh, NC, Report N. 325-C, 2 p.

Environmental Protection Agency (EPA). 2005. National Coastal Condition Report II. EPA-620/R-03/002.

Epifanio, C.E. 1988. Transport of invertebrate larvae between estuaries and the continental shelf. American Fisheries Symposium 3: 104-114.

Fahay, M. 1983. Journal of Northwest Atlantic Fishery Science. Volume 4. Guide to the early stages of marine fishes occurring in the western North Atlantic Ocean, Cape Hatteras to the southern Scotian Shelf. Dartmouth, Canada. Northwest Atlantic Fisheries Organization.

Fennessy, F.T. 1994. The impact of commercial prawn trawlers on lionfish off the north coast of Natal, South Africa. South African Journal of Marine Science 14, 263-279.

Ferguson, R.L. and L.L. Wood. 1994. Rooted vascular aquatic beds in the Albemarle-Pamlico estuarine system. NMFS, NOAA, Beaufort, NC, Project No. 94-02, 103 p.

Fischer, W. (ed.). 1978. FAO species identification sheets for fishery purposes. Western Central Atlantic (fishing area 31). Vol. 4 FAO. Rome.

FishBase 2005. FishBase. A global information system on fishes. http://www.fishbase.org/search.php, [Accessed on December 12, 2005].

Funderburk, S.L., J.A. Mihursky, S.J. Jordan, and D. Riley. 1991. Habitat requirements for Chesapeake Bay living resources. Habitat Objectives Workgroup, Living Resources Subcommittee and Chesapeake Research Consortium with assistance from Maryland Department of Natural Resources, Solomons, MD.

Gearhart J. 2001. Sea turtle bycatch monitoring of the 2000 fall flounder gillnet fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1259. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 26 p.

Gearhart J. 2002. Sea turtle bycatch monitoring of the 2001 fall flounder gillnet fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1348. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 44 p.

Gearhart J. 2003. Sea turtle bycatch monitoring of the 2002 fall flounder gillnet fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1398. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 39 p.

Godcharles, M.F. 1971. A study of the effects of a commercial hydraulic clam dredge on benthic communities in estuarine areas . Florida Department of Natural Resources , St. Petersburg, FL, 51 p.

Gray, C.A. 2002. Management implications of discarding in an estuarine multi-species gill net fishery. Fisheries Research 56 (2002): 177-192.

Gray, J.S., R.S. Wu, and Y.Y. Or. 2002. Effects of hypoxia and organic enrichment on the coastal marine environment. Marine Ecology Progress Series 238: 249-279.

Guillory, V. 1993. Ghost fishing by blue crab traps. North American Journal of Fisheries Management 13:459-466.

Guthrie, J.F., R.L. Kroger, H.R. Gordy and C.W. Lewis 1973. The long haul fishery of North Carolina. Marine Fisheries Review 35(12): 27-33.

Hackney, C.T., J. Grimley, M. Posey, T. Alphin, and J. Hyland. 1998. Sediment contamination in North Carolina's estuaries. Center for Marine Science Research, UNC-W, Wilmington, NC, Publication #198, 59 p.

Hackney, C.T., M.H. Posey, S.W. Ross, and A.R. Norris. 1996. A review and synthesis of data on surf zone fishes and invertebrates in the South Atlantic Bight and the potential impacts from beach renourishment. Prepared for Wilmington District, US Army Corps of Engineers. UNC-Wilmington, Wilmington, NC, 111 p.

Haddon, M. 2001. Modelling and Quantitative Methods in Fisheries. Chapman and Hall/CRC, Boca Raton, FL. Revised Printing.

Hall, S.J. 1999. The effects of fishing on marine ecosystems and communities. Fish Biology and Aquatic Resources Series 1. Blackwell Science, Oxford.

Harding, S.M., and M.E. Chittenden, Jr. 1987. Reproduction, movements, and population dynamics of the southern kingfish, *Menticirrhus americanus*, in the Northwestern Gulf of Mexico. NOAA Technical Report NMFS 49: 1-21.

Hare, J.O., J.A. Quinlan, F.E. Werner, B.O. Blanton, J.J. Govini, R.B. Forward, L.R. Settle, and D.E. Hoss. 1999. Larval transport during winter in the SABRE study area: results of a coupled vertical larval behavior-three-dimensional circulation model. Fisheries Oceanography 8(2): 57-76.

Hilborn, R. and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics, and Uncertainty. Chapman and Hall, London.

Hildebrand, S.F., and L.E. Cable. 1934. Reproduction and development of whiting or kingfishes, drums, spot, croaker, and weakfishes or seatrouts, family Sciaenidae, of the Atlantic coast of the United States. Bulletin of US Bureau of Fisheries 48: 41-117.

Hildebrand, S.F. and W.C. Schroeder. 1928. The fishes of the Chesapeake Bay. Bulletin of US Bureau of Fisheries 43: 1-388.

Hildebrand, S.F. and W.C. Schroeder. 1972. Fishes of the Chesapeake Bay. Smithsonian Institution Press, Washington, DC, 388 p.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate natural mortality rates. Fishery Bulletin. 82: 898-903.

Hoese, H.D. 1965. Spawning of marine fishes in the Port Aransas, Texas as determined by the distribution of young and larvae. Ph. D. Thesis, University of Texas, Austin. 144 p.

Iannuzzi, T.J., M.P. Weinstein, K.G. Sellner, and J.C. Barrett. 1996. Habitat disturbance and marina development: An assessment of ecological effects. I. Changes in primary production due to dredging and marina construction. Estuaries 19(2A): 257-271.

Imberger, R. 1983. The influence of water motion on the distribution and transport of materials in a salt marsh estuary. Limnology and Oceanography 28: 201-214.

Ingraham, B. 2003. Night Vs. Day Bycatch Comparison for Shrimp Trawling in the Southern District of North Carolina. North Carolina Fisheries Resource Grant. FRG-98-FEG-46 Final Report.

Irwin, R.J. 1970. Geographical variation, systematics, and general biology of shore fishes of the genus *Menticirrhus*, family Sciaenidae. Ph. D. Thesis. Tulane University. 295 p.

Jennings, S., M.J. Kaiser and J.D. Reynolds. 2002. Marine Fisheries Ecology. Oxford, Blackwell Science, 417 pp

Johnson, G.A.. 2003. The Role of Trawl Discards in Sustaining Blue Crab production. FRG 99-EP-07.

Jutte, P.C., R.F. Van Dolah, and M.V. Levison . 1999. An environmental monitoring study of the Myrtle Beach renourishing project: intertidal benthic community assessment. Phase II-Myrtle Beach. Final Report, prepared by Marine Resources Division; submitted to US Army Corps of Engineers. SC Department of Natural Resources, Charleston, SC, 34 p.

Kenworthy, W.J. and D.E. Haunert. 1991. The light requirements of seagrasses: proceedings of a workshop to examine the capability of water quality criteria, standards and monitoring progress to protect seagrasses. National Oceanic and Atmospheric Administration, Beaufort, NC, Tech. Memo. NMFS-SEFC-287 , 181p.

Kirby, J., W. Maher, and F. Krikowa. 2001. Selenium, cadmium, copper, and zinc concentrations in sediments and mullet (*Mugil cephalus*) from the southern basin of Lake Macquarie, NSW Australia. Archives of environmental contamination and toxicology 40(2): 246-256.

Kwon, Y. and C. Lee. 2001. Ecological risk assessment of sediment in wastewater discharging area by means of metal speciation. Microchemical Journal 70: 255-264.

Lawler, J.P., M.P. Weinstein, H.Y. Chang, and T.E. Englert. 1988. Modeling of physical and behavioral mechanisms influencing recruitment of spot and Atlantic croaker to the Cape Fear Estuary. American Fisheries Symposium 3: 115-131.

Lee, D.S. and M. Socci 1989. Potential Impact of Oil Spills on Seabirds and Selected Other Oceanic Vertebrates off the North Carolina Coast. Prepared by the North Carolina State Museum of Natural Science for the State of North Carolina, Department of Administration, Raleigh, NC. 85 p.

Lenihan, H.S. and C.H. Peterson. 1998. How habitat degradation through fishery disturbance enhances impacts of hypoxia on oyster reefs. Ecological Applications 8(1): 128-140.

Lindeman, K.C. and D.B. Snyder. 1999. Nearshore hardbottom fishes of southeast Florida and effects of habitat burial caused by dredging. Fisheries Bulletin 97: 508-525.

Lindquist, N. and L. Manning. 2001. Impacts of beach nourishment and beach scraping on critical habitat and productivity of surf fishes. NC Division of Marine Fisheries, Fisheries Resource Grant 98-EP-05: 41.

Lippson, A.J. and R.L. Moran. 1974. Manual for identification of early developmental stages of fishes of the Potomac River Estuary. Prepared for Maryland Department of Natural Resources, Power Plant Siting Program. PPSP-MP-13. 282 p.

Livingstone, D.R. 2001. Contaminant-stimulated reactive oxygen species production and oxidative damage in aquatic organisms. Marine Pollution Bulletin 42(8): 656-666.

Lowe, A.J., D.R.G. Farrow, A.S. Pait, S.J. Arenstam, and E.F. Lavan. 1991. Fish kills in coastal waters. National Oceanic and Atmospheric Administration, Rockville, MD, 190-1989 p.

Luettich, R.A., J.E. McNinch, J.L. Pinckney, M.J. Alperin, C.S. Martens, H.W. Paerl, C.H. Peterson, and J.T. Wells. 1999. Neuse River estuary modeling and monitoring project, final report: Monitoring phase. Water Resources Research Institute, Raleigh, NC, 190 p.

Lupton, B.Y. and P.S. Phalen. 1996. Designing and implementing a trip ticket program based on the North Carolina experience. NCDEHNR, Morehead City, NC 32p.

Lupton, O., Jr. 1996. Bycatch reduction in the estuarine crab trawl industry through manipulation of tailbag sizes. Pamlico Co. Schools, Bayboro, NC. N.C. FRG-94-11. Final report. 43p.

Marburger, J.E., W.E. Johnson, T.S. Gross, D.R. Douglas, and J. Di. 2002. Residual organochlorine pesticides in soils and fish from wetland restoration areas in central Florida. Wetlands 22(4): 705-711.

Marcus, J.M. and T.P. Stokes. 1985. Polynuclear aromatic hydrocarbons in oyster tissue around three coastal marinas. Bulletin of Environmental Contamination and Toxicology 35: 835-844.

Matoura, R.F.C. and E.M.C. Woodward. 1983. Conservative behavior of riverine dissolved organic carbon in the Severn estuary: chemical and geochemical implications. Geochimica Cosmochimica Acta 47: 1293-1309.

McKenna, S., and J.T. Camp. 1992. An examination of the blue crab fishery in the Pamlico River estuary. Albemarle-Pamlico Estuarine Study Rep. No. 92-08. 101p.

McKenna, S. and A.H. Clark. 1993. An examination of alternative fishing devices for the estuarine shrimp and crab trawl fisheries. Final Report to the Albemarle/Pamlico Estuarine Study, Project No. 93-11. 34 pp.

McKenna, S.A., G. Judy, C.P. Lewis and J. Schoolfield. 1996. Evaluation of trawl efficiency device/bycatch reduction device in estuarine and nearshore waters of North Carolian. Completion Report NOAA, No. NA 47FF0016, North Carolina Department of Environment, Health, and Natural Resources, Division of Marine Fisheries. 37 pp.

McKenna, S.A. and J.P. Monaghan, Jr. 1993. Gear development to reduce bycatch in the North Carolina trawl fisheries. Completion Report for Cooperative Agreement No. NA90AA-SK052 to Gulf and South Atlantic Fisheries Development Foundation, Contract No. 43-01, North Carolina Department of Environment, Health, and Natural Resources, Division of Marine Fisheries.

McMichael Jr., R.H., and S.T. Ross. 1987. The relative abundance and feeding habits of juvenile kingfish (Sciaenidae: *Menticirrhus*) in a Gulf of Mexico surf zone. Northeast Gulf Sciences 9: 109-123.

Micheli, F.M. and C.H. Peterson. 1999. Estuarine vegetated habitats as corridors for predator movement. Conservation Biology 13(4): 869-881.

Miller, D.C., R.J. Geider, and H.L. MacIntyre. 1996. Microphytobenthos: the ecological role of the "secret garden" of unvegetated, shallow-water marine habitats. II. Role in sediment stability and shallow-water food webs. Estuaries 19(2A): 202-212.

Miller, J.M., L.B. Crowder, and M.L. Moser. 1985. Migration and utilization of estuarine nurseries by juvenile fishes: an evolutionary perspective. p. 338-352 *in* M.A. Rankin (ed.). Migration: mechanisms and adaptive significance. Contributions to Marine Science (Supplement). 27.

Miller, M.J., P.M. Rowe, and K.W. Able. 2002. Occurrence and growth rates of young-of-year northern kingfish, *Menticirrhus saxatilis*, on ocean and estuarine beaches in southern New Jersey. Copeia 2002: 815-823.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands, Second Edition. Van Nostrand Reinhold, New York, NY, Second Edition, 772 p.

Modde, T. 1980. Growth and residency of juvenile fishes within a surf zone habitat in the Gulf of Mexico. Gulf Research Reports 6: 377-385.

Modde, T., and S.T. Ross. 1981. Seasonality of fishes occupying a surf zone habitat in the northern Gulf of Mexico. Fishery Bulletin 78: 911-922.

Monaghan, J.P., Jr. 2001. Winter trawl fishery assessment *in* Assessment of North Carolina commercial finfisheries 1997-2000, Completion Report for Project NA 76 FI 0286, North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC, USA, 25pp.

MSC (Moratorium Steering Committee). 1996. Final report of the Moratorium Steering Committee to the Joint Legislative Commission on Seafood and Aquaculture of the North

Carolina General Assembly. N.C. Sea Grant College Program, Raleigh, NC, NC-SG-96-11, 155 p.

Mzimela, H.M., V. Wepener, and D.P. Cyrus. 2003. Seasonal variation of selected metals in sediments, water and tissues of the groovy mullet, *Liza dumerelii* (Muglidae) from the Mhlathuze Estuary, South Africa. Marine Pollution Bulletin 46: 659-676.

Murray, J.D., J.L. Gearhart, R.A. Rulifson, and C.W. Wescott. 1995. Introduction of large mesh webbing in the belly and wings of traditional shrimp trawls to reduce bycatch in inshore waters. Saltonstall-Kennedy Final Report, Project NA 37FC008801, February 1995. 75 pp.

Nance, J.M. (Editor). 1998. Report to Congress. Southeastern United States Shrimp Trawl Bycatch Program, 154 p.

NCDMF (North Carolina Division of Marine Fisheries). 1990. Justification for submerged aquatic vegetation critical habitat designation. DMF , Unpub. rep., 15 p.

NCDMF (North Carolina Division of Marine Fisheries). 1999. Shrimp and crab trawling in North Carolina's estuarine waters. DENR, Morehead City, NC Report to NC Marine Fisheries Commission, 121 p.

NCDMF (North Carolina Division of Marine Fisheries). 2005. North Carolina License and Statistics Section summary of statistics of License and Permit Program, Commercial Trip Ticket Program, Marine Recreational Fishery Statistics Survey, Recreational Commercial Gear Survey, and Striped Bass Creel Survey in the Central and Southern Management Area. DENR, Morehead City, NC.

NC Marine Fisheries Commission, Sea Turtle Advisory Committee, 2006. Sea Turtle Interactions With North Carolina Commercial Fisheries Review and Recommendations.

NMFS, USFWS (1992) Recovery plan for leatherback turtles in the US Caribbean Sea, Atlantic Ocean and Gulf of Mexico. National Marine Fisheries Service and US Fish and Wildlife Service.

Ojeda, G.Y., P.T.Gayes, A.L. Sapp, P.C. Jutte, and R.F. Van Dolah. 2001. Habitat mapping and sea bottom change detection on the shoreface and inner shelf adjacent to the Grand Strand beach nourishment project. Coastal Carolina University and SC DNR, Charleston, SC, 48 p.

Ortega, S., J.P. Sutherland, and C.H. Peterson. 1990. Environmental determination of oyster success in the Pamlico Sound. Albemarle-Pamlico Study, North Carolina Department of Environment, Health, and Natural Resources and United States Environmental Protection Agency, Report 90-08, 29 p.

Paerl, H. 2002. Connecting atmospheric nitrogen deposition to coastal eutrophication. Environmental Science & Technology 36: 323A-326A.

Paerl, H.W., J.D. Bales, L.W. Ausley, C.P. Buzzelli, L.B. Crowder, L.A. Eby, J.M. Fear, M. Go, B.L. Peierls, T.L. Richardson, and J.S. Ramus. 2001. Ecosystem impacts of three sequential hurricanes (Dennis, Floyd, and Irene) on the United States' largest lagoonal estuary, Pamlico Sound, NC. Proceedings of the National Academy of Sciences, USA 98(10): 5655-5660.

Paerl, H.W., M.M. Mallin, C.A. Donahue, M. Go, and B.L. Peierls. 1995. Nitrogen loading sources and eutrophication of the Neuse River, North Carolina: direct and indirect roles of atmospheric deposition. UNC - Chapel Hill, Water Resources Research Institute, Chapel Hill, NC, Publication, 291 p.

Peterson, B.J. and R.W. Howarth. 1987. Sulfur, carbon, and nitrogen isotopes used in trace organic matter flow in the salt-marsh estuaries of Sapelo Island, Georgia. Limnology and Oceanography 32: 1195-1213.

Peterson, C.H., H.C. Summerson, E. Thompson, H.S. Lenihan, J. Grabowski, L. Manning, F. Micheli, and G. Johnson. 2000. Synthesis of linkages between benthic and fish communities as a key to protecting essential fish habitat . Bulletin of Marine Science 66(3): 759-774.

Peterson, C.H. and N.M. Peterson. 1979. The ecology of intertidal flats of North Carolina: A community profile. US Fish and Wildlife Service, OBS-79/39 , 73 p.

Posey, M.H. and T.D. Alphin. 2001. Monitoring of benthic faunal responses to sediment removal associated with the Carolina Beach and vicinity - area south project. UNC-Wilmington, Wilmington, NC, Final Report to the US Army Corps of Engineers, 18 p.

Posey, M.H. and W.G. Ambrose Jr. 1994. Effects of proximity to an offshore hard-bottom reef on infaunal abundances. Marine Biology 118(4): 745-753.

Potthoff, M.T. 2004. Long haul seine fishery assessment *in* Assessment of North Carolina commercial finfisheries 2003-2004, Completion Report for Project NA 03 NMF 4070160, North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC, USA, 18pp.

Rakocinski, C., S.E. LeCroy, J.A. McLelland, and R.W. Heard. 1993. Responses by macroinvertebrate communities to beach renourishment at Perdido Key, Florida: benthic recovery. US Dept. of the Interior, National Park Service.

Ralph, D.E. 1982. Biological and fisheries data on the northern kingfish, *Menticirrhus saxatilis*. NOAA Technical Series Report. No. 27. 45 p.

Rebel, T.P. 1974. Sea turtles and the turtle industry of the West Indies, Florida, and the Gulf of Mexico. University of Miami Press, Coral Gables, FL, 250 p.

Reed, A.J. and J.T. Wells. 2000. Sediment distribution patterns offshore of a renourished beach: Atlantic Beach and Fort Macon, North Carolina. Journal of Coastal Research 16(1): 88-98.

Reilly, F.J., Jr. and B.J. Bellis. 1983. The ecological impact of beach nourishment with dredged materials on the intertidal zone at Bogue Banks, North Carolina. US Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.

Riggs, S.R. 1996. Sediment evolution and habitat function of organic-rich muds within the Albemarle estuarine system, North Carolina. Estuaries 19(2A): 169-185.

Riggs, S.R., J.T. Bray, E.R. Powers, C. Hamilton, D. Ames, D. Yeates, K. Owens, S. Lucas, J. Watson, and M. Williamson. 1991. Heavy metal pollutants in organic-rich muds of the Neuse River Estuary: their concentration and distribution. Albemarle-Pamlico Estuarine Study Report. Project no. 90-07. DENR, Raleigh, 168 p.

Ross, J. and L. Noble. 1990. Justification for submerged aquatic vegetation critical habitat designation. Report to the NC Marine Fisheries Commision 1992. 17p.

Ross, J.L. and D.W. Moye. 1989. Assessment of North Carolina Commercial Finfisheries 1985-1987 Fishing Seasons. Project 2-419-R. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries. Morehead City, NC. 293 p.

Ross, S.T., R.H. McMichael Jr., and D.L. Ruple. 1987. Seasonal and diel variation in the standing crop of fishes and macroinvertebrates from a Gulf of Mexico surf zone. Estuarine, Coastal, and Shelf Science 25: 391-412.

Ross, S.W. and J.E. Lancaster. 2002. Movements and site fidelity of two juvenile fish species using surf zone nursery habitats along the southeastern North Carolina coast. Environmental Biology of Fishes 63: 161-172.

SAFMC (South Atlantic Fisheries Management Council). 1998a. Final habitat plan for the South Atlantic region: Essential Fish Habitat requirements for fishery management plans of the South Atlantic Fishery Management Council. SAFMC, Charleston, SC.

SAS. 1985. SAS user's guide: Statistics, 5th ed. Cary, N.C.: SAS Institute, Inc.

Schaefer, R.H. 1965. Age and Growth of the northern kingfish in New York waters. New York Fish and Game Journal 12: 191-216.

Schwartz, F.J. 1976. Status of sea turtles, Chelonidae and Dermochelidae, in North Carolina. Journal of the Elisha Mitchell Science Society 92: 76-77.

Seaberg, W.C. 1988. Observations on inlet flow patterns derived from numerical and physical modeling studies. American Fisheries Symposium 3: 16-25.

SEAMAP. 2004. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY 2003. Report to NOAA No. NA77FS0012, South Carolina Department of Natural Resources, Marine Research Division, Charleston, SC.

Sigels, A.C., T.C. Hoering, and G.R. Helz. 1982. Composition of estuarine colloidal material: organic components. Geochimica Cosmochimica Acta 46: 1619-1626.

Smith, J.W. A large fish kill of Atlantic menhaden, *Brevoortia tyrannus*, on the North Carolina coast. Journal of the Elisha Mitchell Scientific Society 115: 157-163.

Smith, J.W. and C.A. Wenner. 1985. Biology of the southern kingfish in the South Atlantic Bight. Transactions of the American Fisheries Society 114: 356-366.

Smith, P. 2001. Reflective nets might aid dolphins. The Sun Journal. May, 19, 2001. New Bern

Street, M.W., A.S. Deaton, W.S. Chappell, and P.D. Mooreside. 2005. North Carolina CHPP. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC. 656 p.

Tagatz, M.E. and D.L. Dudley. 1961. Seasonal occurrence of marine fishes in four shore habitats near Beaufort, NC, 1957-1960. US Fish and Wildlife Service, Special Scientific Report No. 390.

Taylor, L. and N. Donello. 2000. Night vs. Day Bycatch Comparison For Shrimp Trawling In the Inland Waters Of The Southern District of North Carolina. North Carolina Fisheries Resource Grant 99-FEG—28 Final Report

Teal, J. 1962. Energy flow in salt marsh macrophyte production: a review. Ecology 43: 614-624.

Tenore, K.R. 1972. Macrobenthos of the Pamlico River estuary, North Carolina. Ecological Monographs 42: 51-69.

Thayer, G.W., W.J. Kenworthy, and M.S. Fonseca. 1984. The ecology of eelgrass meadows of the Atlantic coast: a community profile. US Fish and Wildlife Service, FWS/OBS-84/02 , 147 p.

Thieler, E.R., A.L. Brill, W.J. Cleary, C.H. Hobbs III, and R.A. Gammisch. 1995. Geology of the Wrightsville Beach, North Carolina shoreface: implications for the concept of shoreface profile of equilibrium. Marine Geology 126: 271-287.

Thieler, E.R., W.C. Schwab, M.A. Allison, J.F. Denny, and W.W. Danforth. 1998. Sidescan-sonar imagery of the shoreface and inner continental shelf, Wrightsville Beach, North Carolina. USGS Open-file Report 98-596, 16 p.

Thorpe, T., M. Hooper, and T. Likos. 2004. Bycatch potential, discard mortality and condition of fish and turtles associated with the spring commercial blue crab (*Callinectes sapidus*) pot fishery. Final Report to: North Carolina Marine Fisheries Commission Blue Crab Research Program. 04-POP-03.

Twilley, R.R., W.M. Kemp, K.W. Staver, J.C. Stevenson, and W.R. Boynton. 1985. Nutrient enrichment of estuarine submersed vascular plant communities. 1. Algal growth and effects on production of plants and associated communities. Marine Ecology Progress Series 23: 179-191.

Uncles, R.J., J.A. Stephens, and T.Y. Woodrow. 1988. Seasonal cycling of estuarine sediment and contaminant transport. Estuaries 11: 108-116.

US Office of the Federal Register. 2006a. Taking of marine mammals incidental to commercial fishing operations; Atlantic Large Whale Reduction Plan and Endangered Species Conservation; Restriction of fishing activities. Federal Register 71: 32 (16 February 2006): 8223-8227.

US Office of the Federal Register. 2006b. Taking of marine mammals incidental to commercial fishing operations; Atlantic Large Whale Reduction Plan and Endangered Species Conservation. Federal Register 71: 220 (15 November 2006): 66482-66495.

US Office of the Federal Register. 2006c. Right whale protection; Southeast US gillnet closure. Federal Register 71: 220 (15 November 2006): 66469-66471.

Van Dolah, R.F., R.M. Martore, A.E. Lynch, M.V. Levison, P.H. Wendt, D.J. Whitaker, and W.D. Anderson. 1994. Environmental evaluation of the Folly Beach nourishment project. SC Department of Natural Resources, Charleston, SC, Final Report prepared by US Army Corps of Engineers and Marine Resources Division of the South Carolina Dept of Natural Resources. 100 p.

Van Dolah, R.F., P.H. Wendt, and M.V. Levisen. 1991. A study of the effects of shrimp trawling on benthic communities in two South Carolina sounds. Fisheries Research 12: 139-156.

Van Dolah, R.F., P.H. Wendt, R.M. Martore, M.V. Levison, and W.A. Roumillat. 1992. A physical and biological monitoring study of the Hilton Head beach nourishment project. Final Report prepared for the Town of Hilton Head Island and South Carolina Coastal Council. SC DNR, Charleston, SC, 159 p.

Viosca, P. 1959. Kingfish, blonde and brunette. Louisiana Conservationist 11: 8-20.

Voudrias, E.A. and C.L. Smith. 1986. Hydrocarbon pollution from marinas in estuarine sediments. Estuarine Coastal Shelf Sciences 22: 271-284.

Walters, C.J. and S.J.D. Martell. 2004. Fisheries Ecology and Management. Princeton University Press, Princeton, NJ.

Wannamaker, C.M. and J.A. Rice . 2000. Effects of hypoxia on movements and behavior of selected estuarine organisms from the southeastern United States. Journal of Experimental Marine Biology and Ecology 249: 145-163.

Watling, L. and E. Norse. 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. Conservation Biology 12(6): 1180-1197.

Weis, J.S., P. Weis, and T. Proctor. 1998. The extent of benthic impacts of CCA-treated wood structures in Atlantic coast estuaries. Archives of Environmental Contamination and Toxicology 34(4): 313-322. Weis, J.S. and P. Weis. 1989. Effects of environmental pollutants on early fish development. Aquatic Sciences 1(1): 45-55.

Wells, J.T. 1989. A scoping study of the distribution, composition, and dynamics of water-column and bottom sediments: Albemarle-Pamlico estuarine system. Institute of Marine Sciences, UNC-Chapel Hill, Morehead City, NC, 89-05, 39 p.

Welsh, W.W. and C.M. Breder. 1923. Contributions to the life histories of Sciaenidae of the eastern United States coast. Bulletin of US Bureau of Fisheries 39: 141-201.

Wendt, P.H., R.F. Van Dolah, M.Y. Bobo, and J.J. Manzi. 1990. Effects of marina proximity on certain aspects of the biology of oysters and other benthic macrofauna in a South Carolina estuary. South Carolina Wildlife and Marine Resources Department, Charleston, SC, South Carolina Marine Resources Center Tech. Rep. No. 74, 49 p.

Wilbur, A.R. and M.W. Pentony. 1999. Human-induced nonfishing threats to essential fish habitat in the New England region. p. 299-321 *in* L.R. Benaka (ed.). Fish Habitat: Essential Fish Habitat and Rehabilitation. American Fishery Society, Silver Springs, MD, Symposium 22, 459 p.

Zar, J.H. 1984. Biostatical Analysis, 2nd ed. Prentice-Hall Book Co., Englewood Cliffs, NJ. 718pp.

12. APPENDICES

12.1 APPENDIX 1. NCMFC POLICIES FOR THE PROTECTION AND RESTORATION OF MARINE AND ESTUARINE RESOURCES FROM BEACH DREDGING AND FILLING AND LARGE-SCALE COASTAL ENGINEERING

NORTH CAROLINA MARINE FISHERIES COMMISSION HABITAT AND WATER QUALITY STANDING ADVISORY COMMITTEE: NOVEMBER 6, 2000

NORTH CAROLINA MARINE FISHERIES COMMISSION:
NOVEMBER 16, 2000

Policy Context

This document establishes the policies of the North Carolina Marine Fisheries Commission (Commission) regarding protection and restoration of the state's marine and estuarine resources associated with beach dredge and fill activities, and related large-scale coastal engineering projects. The policies are designed to be consistent with the overall habitat protection policies of the Commission, adopted April 13, 1999, as amended February 17-18, 2000, as follows:

It shall be the policy of the North Carolina Marine Fisheries Commission that the overall goal of its marine and estuarine resource protection and restoration programs is the long-term enhancement of the extent, functioning and understanding of those resources.

Toward that end, in implementing the Commission's permit commenting authority pursuant to N.C.G.S. §143B-289.52(a)(9), the Chairs of the Habitat and Water Quality Standing Advisory Committee, in consultation with the Commission Chair, shall, to the fullest extent possible, ensure that state or federal permits for human activities that potentially threaten North Carolina marine and estuarine resources:

(1) are conditioned on (a) the permittee's avoidance of adverse impacts to marine and estuarine resources to the maximum extent practicable; (b) the permittee's minimization of adverse impacts to those resources where avoidance is impracticable; and (c) the permittee's provision of compensatory mitigation for all reasonably foreseeable impacts to marine and estuarine resources in the form of both informational mitigation (the gathering of base-line resource data and/or prospective resource monitoring) and resource mitigation (in kind, local replacement, restoration or enhancement of impacted fish stocks or habitats); and

(2) result, at a minimum, in no net loss to coastal fisheries stocks, nor functional loss to marine and estuarine habitats and ecosystems.

The findings presented below assess the marine and estuarine resources of North Carolina which are potentially threatened by activities related to the large-scale movement of sand in the coastal ocean and adjacent habitats, and the processes whereby those resources are placed at risk. The policies established in this document are designed to avoid, minimize and offset damage caused by these activities, in accordance with the laws of the state and the general habitat policies of this Commission.

Marine and Estuarine Resources At Risk from Beach Dredge and Fill Activities

The Commission finds:

1. In general, the array of large-scale and long-term beach alteration projects currently being considered for North Carolina together constitute a real and significant threat to the marine and estuarine resources of the United States and North Carolina.

2. The cumulative effects of these projects have not been adequately assessed, including impacts on public trust marine and estuarine resources, use of public trust beaches, public access, state and federally protected species, state critical habitats and federal essential fish habitats.

3. Individual beach dredge-and-fill projects and related large-scale coastal engineering activities rarely provide adequate assessment or consideration of potential damage to fishery resources under state and federal management. Historically, emphasis has been placed on the logistics of sand procurement and movement, and economics, with environmental considerations dominated by compliance with limitations imparted by the Endangered Species Act for sea turtles, piping plovers and other listed organisms.

4. Opportunities to avoid and minimize impacts of beach dredge-and-fill activities on fishery resources, and offsets for unavoidable impacts have rarely been proposed or implemented.

5. Large-scale beach dredge and fill activities have the potential to cause impacts in four types of habitats:

    a. waters and benthic habitats near the dredging sites;
    b. waters between dredging and filling sites;
    c. waters and benthic habitats near the fill sites; and
    d. waters and benthic habitats potentially affected as sediments move subsequent to deposition in fill areas.

6. Certain nearshore habitats are particularly important to the long-term viability of North Carolina's commercial and recreational fisheries and potentially threatened by large-scale, long-term or frequent disturbance of sediments:

    a. inlets;
    b. the swash and surf zones and beach-associated bars; and
    c. underwater soft-sediment topographic features, both onshore and offshore
    d. underwater hard-substrate topographic features.

7. Large sections of North Carolina waters potentially affected by these projects, both individually and collectively, have been identified as Essential Fish Habitats (EFH) by the South Atlantic Fishery Management Council (SAFMC) and the Mid-Atlantic Fishery Management Council (MAFMC). Affected species under federal management include:

    a. summer flounder (various nearshore waters, including the surf zone and inlets; certain offshore waters);
    b. bluefish (various nearshore waters, including the surf zone and inlets);
    c. red drum (ocean high-salinity surf zones and unconsolidated bottoms to a depth of 50 meters);
    d. several snapper and grouper species (live hard bottom from shore to 600 feet, and – for estuarine-dependent species [e.g., gag grouper and gray snapper] –

unconsolidated bottoms and live hard bottoms to the 100 foot contour);
e. spiny dogfish (various coastal waters from the surf zone to 200 miles);
f. black sea bass (various nearshore waters, including unconsolidated bottom and live hard bottom to 100 feet, and hard bottoms to 600 feet);
g. penaeid shrimps (offshore habitats used for spawning and growth to maturity, and waters connecting to inshore nursery areas, including the surf zone and inlets);
h. coastal migratory pelagics (sandy shoals of capes and bars, barrier island and ocean-side waters from the surf zone to the shelf break inshore of the Gulf Stream; all coastal inlets);
i. corals of various types (hard substrates and muddy, silty bottoms from the subtidal to the shelf break);
j. calico scallops (unconsolidated bottoms northeast and southwest of Cape Lookout in 62-102 feet);
k. sargassum (wherever it occurs out to 200 miles);
l. many large and small coastal sharks, managed by the Secretary of the Department of Commerce (inlets and nearshore waters, including pupping and nursery grounds).

8. Beach dredge and fill projects also potentially threaten important fish habitats for anadromous species under federal, interstate and state management (in particular, inlets and offshore overwintering grounds), as well as essential overwintering grounds and other critical habitats for weakfish and other species managed by the ASMFC and the State of North Carolina. The SAFMC identified for anadromous and catadromous species those habitats that have been EFH if there had been a council plan (inlets and nearshore waters).

9. Many of the habitats potentially affected by these projects have been identified as Habitat Areas of Particular Concern by the SAFMC. The specific fishery management plan is provided in parentheses:

    a. all nearshore hard bottom areas (SAFMC, snapper-grouper);
    b. all coastal inlets (SAFMC, penaeid shrimps, red drum, and snapper-grouper);
    c. near-shore spawning sites (SAFMC, penaeid shrimps, and red drum)
    d. well-known seafloor features, including the Point, Ten Fathom Ledge and Big Rock (SAFMC, snapper-grouper, coastal migratory pelagics, and corals);
    e. pelagic and benthic sargassum (SAFMC, snapper-grouper);
    f. sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras (SAFMC, coastal migratory pelagics) and;
    g. Bogue Sound and New River Estuary (SAFMC, coastal migratory pelagics).

10. Habitats likely to be affected by beach dredge and fill projects include many being recognized in North Carolina Fishery Management Plans as important for state-managed species. Many of these habitats are in the process of being recognized as Critical Habitat Areas by the Commission, in either FMPs or in CHPPs. Examples include:

    a. inlets (Blue Crab FMP, Red Drum FMP, River Herring FMP);
    b. oceanic nearshore waters (Blue Crab FMP, Red Drum FMP); and
    c. many others as FMPs and CHPPs are adopted over the coming years.

11. Recent work by scientists in east Florida has documented exceptionally important habitat values for nearshore, hard-bottom habitats often buried by beach dredging projects, including use by over 500 species of fishes and invertebrates, and juveniles of many reef fishes. Equivalent scientific work is just beginning off North Carolina, but life histories suggest that similar habitat use patterns will be found.

Threats to Marine and Estuarine Resources from Beach Dredge and Fill Activities

The Commission finds that beach dredge-and-fill activities and related large-scale coastal engineering projects (including inlet alteration projects) threaten the marine and estuarine resources of North Carolina through the following mechanisms:

1. Direct mortality and displacement of organisms at and near sediment dredging sites;
2. Alteration of seafloor topography and associated current and waves patterns and magnitudes at dredging areas;
3. Alteration of seafloor sediment size-frequency distributions at dredging sites, with secondary effects on benthos at those sites;
4. Elevated turbidity and deposition of fine sediments down-current from dredging sites;
5. Direct mortality and displacement of organisms at initial sediment fill sites;
6. Elevated turbidity in and near initial fill sites, especially in the surf zone, and deposition of fine sediment down-current from initial fill sites;
7. Alteration of near-shore topography and current and waves patterns and magnitudes associated with fill;
8. Movement of deposited sediment away from initial fill sites, especially onto hard bottoms;
9. Alteration of large-scale sediment budgets, sediment movement patterns and feeding and other ecological relationships, including the potential for cascading disturbance effects;
10. Alteration of large-scale movement patterns of water, with secondary effects on water quality and biota;
11. Alteration of movement patterns and successful inlet passage for larvae, post-larvae, juveniles and adults of marine and estuarine organisms;
12. Alteration of long-term shoreline migration patterns (inducing further ecological cascades with consequences that are difficult to predict); and
13. Exacerbation of transport and/or biological uptake of toxicants and other pollutants released at either dredge or fill sites.

Commission Policies for Beach Dredge and Fill Projects and Related Large Coastal Engineering Projects

The Commission establishes the following general policies related to large-scale beach dredge-and-fill and related projects, to clarify and augment the general policies already adopted on April 13, 1999:

1. Projects should fulfill the Commission’s general habitat policy by avoiding, minimizing and offsetting damage to the marine and estuarine resources of North Carolina;

2. Projects should provide detailed analyses of possible impacts to each type of Essential Fish Habitat (EFH), with careful and detailed analyses of possible impacts to Habitat

Areas of Particular Concern (HAPC) and Critical Habitat Areas (CHA), including short and long term, and population and ecosystem scale effects;

3. Projects should provide a full range of alternatives, along with assessments of the relative impacts of each on each type of EFH, HAPC and CHA;

4. Projects should avoid impacts on EFH, HAPCs and CHAs that are shown to be avoidable through the alternatives analysis, and minimize impacts that are not;

5. Projects should include assessments of potential unavoidable damage to marine resources, using conservative assumptions;

6. Projects should be conditioned on the avoidance of avoidable impacts, and should include compensatory mitigation for all reasonably predictable impacts to the marine and estuarine resources of North Carolina, taking into account uncertainty about these effects. Mitigation should be local, up-front and in-kind wherever possible;

7. Projects should include baseline and project-related monitoring adequate to document pre-project conditions and impacts of the projects on the marine and estuarine resources of North Carolina;

8. All assessments should be based upon the best available science, and be appropriately conservative so as to be prudent and precautionary; and

9. All assessments should take into account the cumulative impacts associated with other beach dredge-and-fill projects in North Carolina and adjacent states, and other large-scale coastal engineering projects that are ecologically related.

Literature Cited

Butler IV, M.J., J.H. Hunt, W.F. Herrnkind, M.J. Childress, R. Bertelsen, W. Sharp, T. Matthews, J.M. Field, and H.G. Marshall. 1995. Cascading disturbances in Florida Bay, USA.: cyanobacteria blooms, sponge mortality, and implications for juvenile spiny lobsters *Panulirus argus*. Marine Ecology Progress Series 129:119-125.

Dodge, R. E., R. C. Aller and J. Thomson. 1974. Coral growth related to resuspension of bottom sediments. Nature 247: 574-576.

Gilmore, R. G., Jr. 1977. Fishes of the Indian River Lagoon and adjacent waters, Florida. Bulletin of the Florida State Museum, Biological Sciences Series 22(3), 147 p.

Gilmore, R. G., Jr. 1992. Striped croaker, *Bairdiella sanctaeluciae*. pp. 218-222. In C. R. Gilbert, ed. Rare and endangered biota of Florida. II. Fishes. Univ. Press of Florida, Gainesville, FL, 242 p.

Hackney, C.T., M. Posey, S. Ross and A. Norris. 1996. A review and synthesis of data on surf zone fishes and invertebrates in the South Atlantic Bight and the potential impacts from beach renourishment. Report to the US Army Corps of Engineers, Wilmington District.

Kirtley, D. W. and W. F. Tanner. 1968. Sabellariid worms: builders of a major reef type. Journal of Sedimentary Petrology 38(1):73-78.

Lindeman, K. C. 1997. Comparative management of beach systems of Florida and the Antilles: applications using ecological assessment and decision support procedures. pp.134-164. In: G. Cambers, ed. Managing beach resources in the smaller Caribbean islands. UNESCO Coastal Region & Small Island Papers # 1, 269 p.

Lindeman, K.C. and D.B. Snyder. 1999. Nearshore hardbottom fishes of southeast Florida and effects of habitat burial caused by dredging. Fishery Bulletin 97(3):508-525.

Nelson, W. G. 1989. Beach nourishment and hard bottom habitats: the case for caution. pp. 109-116. In: S. Tait, ed. Proc. 1989 National Conf. Beach Preserv. Technol. Fl. Shore and Beach Preserv. Assoc., Tallahassee, FL, 236 p.

Nelson, W. G. and L. Demetriades. 1992. Peracariids associated with sabellariid worm rock (*Phragmatopoma lapidosa* Kinberg) at Sebastian Inlet, Florida, USA. Journal of Crustacean Biology 12(4):647-654.

Odum, W. E. 1982. Environmental degradation and the tyranny of small decisions. BioScience 32(9):728-29.

Pandolfi, J., D. R. Robertson, and D. R. Kirtley. 1998. Sabellariid worms: builders of a major reef type. Coral Reefs 17:120.

Peterson, C.H., D.H.M. Hickerson and G.G. Johnson. 2000. Short-term consequences of nourishment and bulldozing on the dominant large invertebrates of a sandy beach. Journal of Coastal Research 16(2): 368-378.

Sedberry, G. R. and R. F. Van Dolah. 1984. Demersal fish assemblages associated with hard-bottom habitat in the South Atlantic Bight of the U. S. A. Environmental Biology of Fishes 11(4):241-258.

South Atlantic Fishery Management Council. 1998. Final habitat plan for the South Atlantic region: Essential Fish Habitat requirements for fishery management plans of the South Atlantic Fishery Management Council. 457 pp plus appendices.

Telesnicki, G.J. and W.M. Goldberg. 1995. Effects of turbidity on the photosynthesis and respiration of two South Florida reef coral species. Bulletin of Marine Sciences 57(2):527-539.

Wilber, P. and M. Stern. 1992. A re-examination of infaunal studies that accompany beach nourishment projects. Proceedings of the 1992 National Conference on Beach Preservation Technical Report pp: 242-256.

12.2 APPENDIX 2. INCIDENTAL CAPTURE OF SPECIES OF CONCERN THAT MAY BE AFFECTED BY NORTH CAROLINA FISHERIES FOR KINGFISHES

I. ISSUE

Incidental capture of species of concern in North Carolina's fisheries for kingfishes and possible management actions.

II. BACKGROUND

Some of the negative perception of gill nets, beach seines and shrimp trawl fisheries stems from the incidental capture of species of concern, particularly marine mammals, sea turtles, and birds. The controversy intensified with recorded incidences of sea turtle strandings in North Carolina estuarine waters and observed takes of bottlenose dolphin in the beach seine fishery. Most recently, National Marine Fisheries Service (NMFS) determined that a right whale mortality was the result of an entanglement by gill net gear within the Southeast US Restricted Area during the restricted period (November 15 to March 31). Net bans in other states have also added pressure to states such as NC that continue to allow these gear in state waters.

Gear Descriptions

Gill nets are monofilament nets of small mesh (<5 inch stretched mesh length), large mesh (>=5 inch stretched mesh length), anchored or non-anchored, float, sink, or drift nets that are deployed and left from only a few hours to several days depending on water temperature and depth. Gill nets used to target kingfishes (*Menticirrhus* spp.) are typically 2 ½ to 3 inch, but kingfishes can be an incidental bycatch in large mesh gill nets.

Beach seines are constructed of both monofilament-nylon and multifilament-nylon nets, set using dories launched from the beach, and retrieved back to the beach with 4-wheel drive trucks. Mesh sizes used to target kingfishes are approximately 2 ⅞ to 3 ¼ inch stretched mesh. The fishery presently occurs along the northeastern coast.

Shrimp trawls are usually otter trawls constructed of twine webbing that becomes funnel shaped when towed through the water. Two large otter trawl doors are attached to the front of the trawl to keep the mouth of the net open during operation.

Gill net, beach seines and shrimp trawls catch kingfishes in the near shore waters of the Atlantic Ocean, while gill nets and shrimp trawls are also used in the estuarine waters of the state. The use of shrimp trawls is prohibited in Albemarle Sound.

III. CURRENT AUTHORITY

15A NCAC 3J .0103 Gill Nets, Seines, Identification, Restrictions
15A NCAC 3I .0107 Endangered or Threatened Species

IV. DISCUSSION

Endangered, Threatened, and Protected Species

Section 7 of the Endangered Species Act (ESA) requires federal agencies to ensure that any activity they authorize, fund or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of any critical habitat of such species. Depending on the protected species that may be affected, NMFS jurisdiction manages marine and anadromous species, while US Fish and Wildlife Service (USFWS) jurisdiction manages land and fresh water species.

Marine mammals are protected under the Marine Mammal Protection Act (MMPA) enacted in 1972. Primary goals of the MMPA are to maintain marine mammal stocks at their optimum sustainable population level and to restore depleted stocks. The MMPA divides jurisdiction of marine mammals between the Secretary of the Interior and the Secretary of Commerce. The Secretary of the Interior issues authority to the USFWS and is responsible for sea otters, polar bears, manatees, dugongs and walruses. The Secretary of Commerce issues authority to NOAA Fisheries, which is responsible for all other marine mammal species.

The following protected species could be found in the same waters that are used by NC kingfishes fisheries. A number of them are listed under the ESA as endangered or threatened, while others are identified as protected under the MMPA. Although all of the species listed may be found in the general geographical area where kingfishes might be a target species, it would be a rare occurrence for these species to be affected by the fishery for kingfishes. Some species may inhabit areas other than those in which the fishery is prosecuted, prefer a different depth or temperature zone, or may migrate through the area at times when the fishery is not in operation.

Cetaceans

North Atlantic right whale (*Eubalaena glacialis*)	Endangered
Humpback whale (*Megaptera novaeangliae*)	Endangered
Fin whale (*Balaenoptera physalus*)	Endangered
Minke whale (*Balaenoptera acutorostrata*)	Protected
Bottlenose dolphin (*Tursiops truncates*)	Protected

Sirenia

West Indian manatee (*Trichechus manatus)*	Endangered

Sea Turtles

Leatherback sea turtle (*Dermochelys coriacea*)	
	Endangered
Kemp's ridley sea turtle (*Lepidochelys kempii)*	Endangered
Green sea turtle (*Chelonia mydas*)	
Loggerhead sea turtle (*Caretta caretta*)	Threatened
Hawksbill sea turtle (*Eretmochelys imbricata*)	Endangered

Fish

Shortnose sturgeon (*Acipenser brevirostrum)*	Endangered

Birds

Bald eagle (*Haliaeetus leucocephalus*)	Delisted**
Roseate tern *(Sterna dougallii dougallii)*	Threatened
Piping plover *(Charadrius melodus)*	Threatened

** Protected under the Bald and Golden Eagle Protection Act (see http://www.fws.gov/migratorybirds/issues/BaldEagle/NationalBaldEagleManagementGuidelines.pdf)

Protected Species Potentially Affected by Fisheries for Kingfishes:

North Atlantic Right Whale

The North Atlantic right whale population, which numbers less than 300 animals, ranges from wintering and calving grounds in the southeastern US to summer feeding grounds in New England, the northern Bay of Fundy and the Scotian Shelf (NEFMC 2006). New England waters are the primary feeding ground, and at least some portion of the right whale population is present in New England waters throughout most months of the year. Mid-Atlantic waters are used as a migratory pathway from the spring and summer feeding/nursery areas to the winter calving grounds off the coast of Georgia and Florida.

Sources of mortality include ship strikes and entanglement in fixed fishing gear. Considered to be the most endangered whale in the world, the current death rate far exceeds the birth rate in the western North Atlantic population. Given the known anthropogenic sources of right whale mortality, their low population size, and their poor reproductive rate, the loss of even one northern right whale because of gear may appreciably reduce the likelihood of both survival and recovery of this species (NEFMC 2003).

Humpback Whale

Humpback whales mate and calve in the West Indies and migrate to feeding areas in the northwestern Atlantic during the summer months. Humpback whales use the Mid-Atlantic as a migratory pathway. However, observations of juvenile humpbacks since 1989 in the Mid-Atlantic have been increasing during the winter months, peaking January through March (Swingle et al. 1993). Biologists theorize that non-reproductive animals may be establishing a winter-feeding range in the Mid-Atlantic since they are not participating in reproductive behavior in the Caribbean. The whales using this Mid-Atlantic area were found to be residents of the Gulf of Maine and Atlantic Canada (Gulf of St. Lawrence and Newfoundland) feeding groups, suggesting a mixing of different feeding stocks in the Mid-Atlantic region. New information has become available on the status and trends of the humpback whale population in the North Atlantic that indicates the population is increasing.

The major known sources of anthropogenic mortality and injury of humpback whales include entanglement in commercial fishing gear such as sink gill net gear, and ship strikes.

Fin Whale

Fin whales are widespread in the North Atlantic and occur from the Gulf of Mexico and Mediterranean Sea northward to the edges of the Arctic pack ice (NMFS 1998). A number of researchers have suggested the existence of fin whale subpopulations in the North Atlantic, but NMFS has designated one stock of fin whale for US waters of the North Atlantic (Waring et al. 2003) where the species is commonly found from Cape Hatteras northward. The latest published stock assessment (Waring et al 2003) gives a best estimate of abundance for fin whales of 2,814 (CV=0.21). However, this is considered an underestimate due to limited information.

The major known sources of mortalities and injuries of fin whales include ship strikes and entanglement in commercial fishing gear such as sink gill net gear. However, many of the reports cannot be attributed to a particular source. Although several fin whales have been observed entangled in fishing gear, with some being disentangled, no mortalities have been attributed to gear entanglement. In general, known mortalities of fin whales are less than those recorded for right and humpback whales. This may be due to the more offshore distribution of fin whales where they are less likely to encounter entangling gear, and/or less likely to be noticed when gear entanglements or vessel strikes do occur.

Minke Whale

Minke whales are widely distributed in polar, temperate, and tropical waters. Minke whales off the eastern coast of the US are considered to be part of the population that extends from off Newfoundland to the Gulf of Mexico. The species is common and widely distributed along the US continental shelf. Their seasonal distribution peaks in the spring and summer, and decreases in the fall to very low winter numbers.

Minke whales are known to interact with sink gill net gear that is used to catch multispecies finfish such as cod (*Gadus morhua*), haddock *(Melanogrammus aeglefinus*), and monkfish (*Lophius americanus*). Takes have also been documented in trawl fisheries. Waring et al. (2003) has described the estimated total take of minkes in all fisheries to be below the potential biological removal (PBR) established for that species. PBR level is the maximum number of animals (not including natural mortality) that can be removed from the stock while allowing the stock to reach or maintain its optimum sustainable population level.

Coastal Bottlenose Dolphin

The coastal form of the bottlenose dolphin occurs in the shallow, relatively warm waters along the US Atlantic coast from New Jersey to Florida and the Gulf of Mexico. They rarely range beyond the 25-meter contour north of Cape Hatteras. Although they interact with coastal sink gill net operations for bluefish (*Pomatomus saltatrix*), Atlantic croaker (*Micropogonias undulatus*), spiny (*Squalus* acanthias) and smooth dogfish (*Mustelus canis*), kingfishes, Spanish mackerel (*Scomberomorus maculatus*), spot (*Leiostomus xanthurus*), striped bass (*Morone* saxatilis) and weakfish (*Cynoscion regalis*). These fisheries occur in the shallower limits of the coastal bottlenose dolphin range. Waring et al. (2003) infers that anchored set gill nets and drift gill nets used in the groundfish fishery may take this species. The groundfish fishery is a general description that encompasses both trawls and gillnets used to harvest demersal fishes including cod, haddock, and several other species (NEFMC 1985).

The bottlenose dolphins are protected under the MMPA because fishery-related mortality and serious injury exceed Potential Biological Removal (PBR).

Manatees

Two West Indian manatee sightings have occurred in the Pamlico Sound in the last 22 years. The peak warm season population in North Carolina is not thought to exceed a dozen individuals (Lee and Socci 1989). There has not been any recorded stranding of manatees resulting from interactions with gill nets along the southeastern United States from 1993 through 1999 (NMFS Southeast Region Marine Mammal Human Interaction Summary 1999). Interactions between oceanic or estuarine gill nets, shrimp trawls, and manatees are unlikely to occur due to their low abundance in North Carolina.

Leatherback Sea Turtle

The leatherback sea turtle is the largest living turtle and ranges farther than any other sea turtle species. Evidence from tag returns and strandings in the western North Atlantic suggests that adults engage in routine migrations between boreal, temperate and tropical waters (NMFS and USFWS 1992). Leatherback turtles are found throughout the western North Atlantic during the warmer months along the continental shelf, and near the Gulf Stream edge in the US. Leatherbacks are predominantly a pelagic species and are thought to follow their preferred jellyfish prey. Leatherbacks are night feeders, and deep divers, but may feed in shallow waters if there is an abundance of jellyfish near shore.

Anthropogenic impacts to the leatherback population include fishery interactions as well as exploitation of the eggs (Ross 1979). Adult mortality has also increased significantly, particularly as a result of driftnet and longline fisheries (Eckert 1996; Spotila et al. 1996). Numerous fisheries that occur in both US state and federal waters are known to negatively impact juvenile and adult leatherback turtles including: bottom trawls, off-bottom trawls, purse seines, hook and line, gill nets, drift nets, traps, long haul seines, pound nets, beach seines, surface longlines, lobster pots, and crab pots (NMFS and USFWS 1992).

Kemp’s Ridley Sea Turtle

The Kemp’s ridley is the most endangered of the world’s sea turtle species. Of the world’s seven extant species of sea turtles, the Kemp’s ridley has declined to the lowest population level. However, the Turtle Expert Working Group [TEWG (1998; 2000)] indicated that the Kemp’s ridley population appears to be in the early stage of exponential expansion.

Juvenile Kemp’s ridleys use northeastern and Mid-Atlantic coastal waters of the US Atlantic coastline as primary developmental habitat during summer months, with shallow coastal embayments serving as important foraging grounds. Kemp’s ridleys migrate to more southerly waters from September to November with the onset of winter and the decline of water temperatures (Keinath et al. 1987; Musick and Limpus 1997). Turtles that do not head south soon enough face the risks of cold stunning in northern waters. Cold stunning can be a significant natural cause of mortality.

Like other turtle species, the severe decline in the Kemp’s ridley population appears to have been heavily influenced by a combination of exploitation of eggs and impacts from fishery interactions. Takes have been recorded in the Northeast otter trawl, pelagic longline, gill net, southeast shrimp trawl, and summer flounder bottom trawl fisheries.

Green Sea Turtle

Green sea turtles are distributed worldwide. In the western Atlantic they range from Massachusetts to Argentina, including the Gulf of Mexico and Caribbean, but are considered rare north of Cape Hatteras (Wynne and Schwartz 1999). Green turtles use Mid-Atlantic and northern areas of the western Atlantic coast as important summer developmental habitat. Like loggerhead and Kemp's ridleys, green sea turtles that use northern waters during the summer return to warmer waters when water temperatures drop or risk cold stunning. Green turtles prefer marine grasses and algae habitats in shallow bays (Rebel 1974).

Anthropogenic impacts to the green sea turtle population are similar to those discussed for other sea turtle species. Human activities such as habitat destruction, dredging, pollution, and fishing account for an unknown level of mortality. Takes have been recorded in the pelagic driftnet, pelagic longline, gill nets, southeast shrimp trawl, and summer flounder bottom trawl fisheries.

Loggerhead Sea Turtle

The loggerhead sea turtle is the most abundant of the sea turtles. Loggerhead sea turtles occur throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans in a wide range of habitats. These include open ocean, continental shelves, bays, lagoons, and estuaries (NMFS and USFWS 1995).

The status of the northern loggerhead subpopulation is of particular concern, and may be due to the fact that the northern subpopulation produces predominantly males (65%). Surveys suggest that sea turtles emigrating from northern waters in fall and winter months may concentrate in nearshore and southerly areas influenced by warmer Gulf Stream waters (Epperly et al. 1995). Loggerhead sea turtles are found in Virginia as early as April. They leave the Gulf of Maine by mid-September, but remain in the Mid-Atlantic as late as December.

They are exposed to a suite of fisheries in the waters off the coastal US in federal and state waters including: trawl, scallop dredge, purse seine, hook & line, gill net, pound net, longline, and trap fisheries.

Hawksbill Sea Turtles

The hawksbill occurs in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. They are widely distributed in the Caribbean Sea and western Atlantic Ocean, with representatives of some life history stages regularly occurring in southern Florida and the northern Gulf of Mexico (especially Texas). The species is recorded in the continental US from all the Gulf states and along the eastern seaboard as far north as Massachusetts, but sightings north of Florida are rare.

Hawksbill sea turtles use different habitats at different stages of their life cycle. Post hatchlings occupy the pelagic environment, taking shelter in weed lines. Coral reefs are widely recognized as the resident foraging habitat of juveniles, subadults and adults. Hawksbills are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent.

International commerce for hawksbill shells is the single most significant factor endangering hawksbill populations around the world. Poaching of hawksbill eggs is also a serious problem. Erosion of nesting beaches, beach re-nourishment and beachfront development are significant threats to nesting success. Gill nets, longlines, and shrimp trawls all take hawksbill sea turtles, particularly in the Gulf of Mexico.

Shortnose Sturgeon

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 (Ross et al. 1988)]. Although these two areas likely harbor distinct population segments, the Cape Fear population may number less than 50 fish and there has been only one adult male captured from the Albemarle region. Eight were captured during intensive, targeted gill-net sampling in the Cape Fear River from 1989 to 1993 (Moser & Ross 1995). Historical reports from the 19th century indicate that shortnose sturgeon inhabited the Pamlico and Neuse rivers, but obstructions and poor water quality may have eliminated shortnose sturgeon from these rivers since that century.

Bald Eagle

The preferred habitats of bald eagles in North Carolina include coastal areas, marshes, lakes, and rivers. Nesting activity has been reported from the Outer Banks in Dare County, and in Pender, Beaufort, Hyde, and Washington counties (Lee and Parnell 1990). The Bald Eagle's recovery led to delisting the Bald Eagle from the Endangered/Threatened Species List. There are no reported incidence of a bald eagle captured in fishing gear in North Carolina.

Roseate Tern

Migrating roseate terns are occasional visitors along the Outer Banks, south of Cape Hatteras, particularly at Cape Point within the Cape Hatteras National Seashore. There are two confirmed nesting records for North Carolina, one in Oregon Inlet in 1939, and the other in Lighthouse Bay, Carteret County in 1973 (Lee and Socci 1989). North Carolina State Museum records indicate that migrating individuals occur in May, and from August through September (Lee and Socci 1989; Lee and Parnell 1990). The majority of these birds transit the state over near shore or coastal waters. Roseate terns feed on small, schooling fishes that are captured by diving from the air into the water (Plunge-diving). This species feeds on schooling bait fish and it is extremely unlikely that it will interact with estuarine gill nets, but birds may be encountered when fishing beach seines and gill nets along the NC coast.

Piping Plover

Nest sites have been noted in North Carolina along barrier beaches from Pea Island to Shackleford Banks, with Sunset Beach being the southern most nesting site. Most nesting occurs north of Cape Lookout. The recent decline in the population has been attributed to residential development in the breeding habitat. Critical breeding habitat has been identified in sections along the Outer Banks from south of Oregon Inlet to the North Carolina-South Carolina state line (USFWS 2001). Vehicular traffic and human presence can indirectly lower productivity by disrupting territorial establishment, courtship, egg laying, and incubation activities. In hopes of increasing the numbers of chick fledged out of eggs hatched, the National Park Service (NPS) staff, Cape Hatteras National Seashore, initiated temporary nighttime and area closures (2005). The seashore closures were so controversial that the NPS is currently developing an ORV (off-road vehicle) Management Plan, with various stakeholders instrumental in development of the plan (2006).

Interactions could occur between commercial beach seine operations and piping plovers because the beach seine fishery is dependent on a vehicle to launch and retrieve the beach seine from the surf. However, the NPS has begun to establish pre-nesting areas for protected shorebird species at the Cape Hatteras National Seashore (March 27, 2006). The goal is to provide adequate pre-nesting areas, while allowing for continued ORV access. The pre-nesting closure area will be marked with "symbolic fencing".

Actions to Minimize Interactions with Protected Species:

NMFS Marine Mammal Protection Act (MMPA)

<u>Take Reduction Teams (TRT):</u>

The MMPA was amended in 1994 to put into place a long-term management strategy. Under the Amendment, NMFS is required to establish Take Reduction Teams (TRT) to develop and implement Take Reduction Plans for reducing incidental mortality and serious injury to strategic marine mammals that interact with commercial fisheries. The MMPA provides guidance regarding membership and composition of the TRT, such that members shall have expertise regarding conservation or biology of the marine mammal species which the plan addresses, or have expertise of fishing practices which result in incidental mortality or serious injury of such species. The teams shall "consist of an equitable balance among representatives of resource user interests and nonuser interests". Further specifics of TRT members can be found in the MMPA, section 118(f)(6)(C). NC TRT members are identified in Attachment 2.

<u>List of Fisheries</u>:

The MMPA requires that every US commercial fishery be placed in one of three categories, depending on the expected frequency of serious injury or mortality of marine mammals incidental to fishing operations: fisheries that have high levels of incidental serious injury/mortality of marine mammals are designated as Category I fisheries; fisheries that are expected to have occasional marine mammal serious injury/mortality are designated as Category II fisheries; and those fisheries whose operations have a remote likelihood of serious injury/mortality of marine mammals are place in Category III. Together, the fisheries in each category comprise the MMPA List of Fisheries, which is posted in the Federal Register, annually. Depending on what category a fishery is placed in, participating fishermen must comply with different regulations designed to recover and sustain marine mammal populations. Fishermen participating in Category I and II fisheries must comply with applicable take reduction plans (TRPs). MMPA's most recent List of Fisheries for the Atlantic Ocean (January 4, 2006, FR, Vol 71, No. 2) affected by take reduction plans are itemized in Table 1.

Table 1. List of fisheries currently affected by Take Reduction Plans[1].

Take reduction plan	Affected fisheries
Atlantic large whale	Northeast sink gillnet
	Mid-Atlantic gill net
	Southeast Atlantic gillnet
	Southeastern US Atlantic shark gillnet
	Northeast/mid Atlantic American lobster trap/pot
Harbor porpoise	Northeast sink gillnet
	Mid-Atlantic gillnet
Bottlenose dolphin	Atlantic blue crab trap/pot
	Mid-Atlantic gillnet
	North Carolina inshore gillnet
	Southeast Atlantic gillnet
	Mid-Atlantic haul/beach seine
	North Carolina long haul seine
	North Carolina roe mullet stop net
	Virginia pound net

1=Modified from MMPA List of Fisheries in the Atlantic Ocean, January 4, 2006, FR, Vol. 71, No. 2

Atlantic Large Whale Take Reduction Plan (ALWTRP):

Proposed Rules (6/21/2005):

The NMFS, authorized and mandated by the MMPA, must reduce the incidental mortality and serious injury of marine mammals associated with commercial fisheries. The ALWTRP was originally developed to reduce the level of serious injury and mortality of three endangered species of whales (fin humpback, and North Atlantic right) interacting with Category I and II commercial fisheries (Table 1). Measures were also identified in the ALWTRP that would provide conservation benefits to a fourth species, minke whales, which are not listed as endangered or threatened under ESA, but are known to be taken incidentally in gill net and trap/pot fisheries. The ALWTRP relies on a combination of fishing gear modifications and time/area closures to reduce the risk of whales becoming entangled in commercial fishing gear which may result in potentially suffering serious injury or mortality.

Although the ALWTRP addresses a number of gear and areas, proposed rules specific to the NC kingfishes fishery addressed herein are for the Mid-Atlantic/South-Atlantic Coastal Gill Net Waters. Specific proposed gear regulations for the mid/south Atlantic coastal gill nets are listed in Attachment 1. Most of the proposed rules will become effective 6-months after the publication of a final rule, with the exception of required sinking/neutrally buoyant groundlines, which become fully effective in 2008.

Environmental Assessment & Temporary Rule (2/2006):

An Environmental Assessment (EA) of the temporary rule implementing the ALWTRP gear restrictions addresses the interactions between gill net fisheries in the southeastern US and the North Atlantic right whale within the context measures outlined in the ALWTRP (NMFS 2006). This authorization was deemed necessary to protect North Atlantic right whales from further serious injury or mortality in the Southeast US Restricted Area due to entanglement in gill net gear.

The recent entanglement and death of a right whale, discovered on January 22, 2006, within the Southeast US Restricted Area during the restricted period (November 15-March 31), resulted in a temporary gill net prohibition off the southeastern US (FR Vol. 71, No. 32, 2/16/2006). NMFS announced temporary restrictions to prohibit, February 14-March 31, 2006, any vessel from fishing with any gill net gear in the Atlantic Ocean waters between 32º 00' N. lat. (near Savannah, GA) and 27º 51' N. lat (near Sebastian Inlet, FL) and extending from the shore eastward out to 80º 00' W. long (the Southeast US Restricted Area; 50 CFR 229.32(f)(1)(i)). This temporary rule became permanent in 2007.

Commercial fishermen target various finfish and shark species using gill net gear of varied sizes and deployment techniques in southeast Atlantic waters. Fisheries expected to be affected by the closure of the southeast US Restricted area to gill net fisheries include, but are not limited to, the Southeastern US Atlantic shark gillnet fishery and the Southeast Atlantic gill net fishery.

The Southeastern US Atlantic shark gill net fishery uses 5 inch or greater stretch mesh gill net gear, typically targeting various shark species. NMFS believes there are six to eight active vessels in this fishery, two of which are NC commercial fishermen. Participation in this fishery is limited to only those who have shark permits, and is managed by the NMFS Office of Sustainable Fisheries, Highly Migratory Species Division.

The Southeast Atlantic gill net fishery operating in the Southeast U. S. Restricted Area typically uses smaller mesh gill net gear, less than 5 inch stretch mesh. There have been recent increases in fishing activity by fishermen specifically using sink gill net gear of various mesh size targeting demersal finfish, primarily southern kingfish. Overall finfish landings, number of trips, and the value of demersal finfish landings have been increasing since 2002, mostly by fishermen who target kingfishes with gill nets in this area.

This issue is important for NC commercial fisheries because activity, or lack thereof, in this fishery directly influences fishing effort in NC waters on a variety of species [sharks, kingfishes, bluefish, Atlantic croaker, weakfish, king (*Scomberomorus cavalla*) and Spanish mackerel]. A few NC commercial fishermen had been targeting kingfishes during this time and season since 2002. At least two more NC commercial fishermen targeted small coastal sharks during this time and season for the first time in 2005. Both fisheries had the potential for being lucrative, and an alternative fishery to the NC ocean sink net fishery. However, a southeast closure will force more gill net fishermen to target finfish during the winter months in North Carolina waters, adding to the gill net pressure on Atlantic croaker, bluefish, weakfish, and kingfishes.

NMFS sought assistance and recommendations from the ALWTRT at their April 2006 meeting in order to evaluate whether permanent closures within the Southeast US Restricted Area are necessary. On November 15, 2006, NOAA's NMFS published two rules addressing gillnet fishing in the Southeast US during the right whale calving season (FR Volume 71, Number 220): a proposed rule, consisting of permanent measures, and an emergency rule, consisting of temporary measures. The permanent rule prohibits gillnet fishing or gillnet possession during annual restricted periods associated with the right whale calving season in the southeast US restricted area and in waters within 35 nautical miles of the South Carolina coast. Exemptions are included that address transit of gear through the area. The rule is effective November 15, 2006 to April 15, 2007.

Bottlenose Dolphin Take Reduction Plan (BDTRP):

Final Rule (4/26/2006):

The NMFS is mandated under the MMPA to reduce the incidental mortality and serious injury of the Western North Atlantic coastal bottlenose dolphin. The proposed BDTRP affects the following Category I and II fisheries: Mid-Atlantic coastal gill net, Virginia pound net, the Mid-Atlantic haul/beach seine, Atlantic blue crab trap/pot, NC inshore gill net, NC roe mullet stop net, NC long haul seine, southeast Atlantic gill net, and Southeastern US Atlantic shark gill net (Table 1). Of these fisheries, the final rule (FR Vol. 71, No. 80, 4/26/06) impacts only the southeast Atlantic gill net fishery, of which only the small mesh ($\leq$5 inch stretched mesh) gill net regulations are applicable to kingfishes (Table 2). The regulations in this final rule became effective on May 26, 2006 (Final Rule http://www.nmfs.noaa.gov/pr/interactions/trt/bdtrp.htm).

Table 2. Summary of BDTRP Regulations, small mesh, Final Rule, April 26, 2006, FR, Vol 71, No.80

Fishing area	Time period	Small gillnet mesh requirements (< 5" stretched mesh)
VA/NC border to Cape Lookout, NC	May1-Oct 31	In State waters, net length must be less than or equal to 1,000 ft
Cape Lookout, NC south to the NC/SC Border	None	None

The BDTRP final rule regulates all US waters within 6.4 nautical miles of shore from the New York-New Jersey border southward to Cape Hatteras, NC, and within 14.6 nautical miles of shore from Cape Hatteras southward to, and including, the east coast of Florida down to the demarcation line between the Atlantic Ocean and the Gulf of Mexico (50 CFR 600.105), with the exception of exempted waters. (Exempted waters: all waters landward of the first bridge over any embayment, harbor, or inlet).

The BDTRP rule includes regulatory and non-regulatory components. Regulatory requirements are for fishermen to stay within a set distance of their gear; gear marking requirements; prohibitions on nighttime fishing in certain areas; gear restrictions in certain areas; and gear length and mesh size restrictions.

This rule proposes to use effort reduction measures, gear proximity rules, gear or gear deployment modifications, fishermen training, outreach and education and time/area closures and size restrictions on large mesh fisheries to reduce incidental takes to reduce dolphin bycatch below the stock's PBR.

Harbor Porpoise Take Reduction Plan (HPTRP):

NMFS published the rule implementing the Harbor Porpoise Take Reduction Plan on December 1, 1998. The HPTRP includes measures for gear modifications and area closures, based on area, time of year, and gill net mesh size. The Mid-Atlantic Component addresses mesh sizes >5" which are not applicable to the NC fishery for kingfishes, and will not be discussed herein.

NC Pamlico Sound Gill Net Restricted Area (PSGNRA)/Sea Turtles:

As sea turtle populations continue to increase under the protection of the ESA, the number of interactions will likely increase, resulting in the imposition of restrictions on other fisheries. Unfortunately, these protective measures can be difficult for state and federal managers to implement and may be costly to the fishing industry.

Such was the case for Pamlico Sound in 1999, when a significant increase in strandings in the southeastern portion of the Pamlico Sound, coupled with observed incidental takes in the flounder gill net fishery resulted in the NMFS issuing an emergency closure of this area to large mesh (≥ 5 inch stretched mesh) gill nets. Since this initial closure, the entire Pamlico Sound from N 35° 46' .300 south to N 35° 00' .000 and west to 76° 30' .000 had restrictions in place for all gill net operations from September through December of each year. This area is referred to as the Pamlico Sound Gill net Restricted Area [PSGNRA (Figure 1)].

The PSGNRA is an example of an ESA section 10(a)(1)(B) incidental take permit (ITP) that authorizes exceptions to the strict take prohibitions established under the ESA. In order to maintain a fishery in this area, NCDMF, in conjunction with the NMFS-Office of Protected Resources (OPR), applied for and received Section 10 permits under the ESA inclusive with comprehensive habitat conservation plans (HCP) in 2000, 2001, 2002-2004, and 2005. The fisheries operating under the PSGNRA permit are lawful, and incidental take of sea turtles have been documented in certain components. Thus, the NCDMF developed and implemented a conservation plan to reduce the incidental capture of sea turtles. The plan includes monitoring, enforcement, and funding provisions. The permit anticipates a take level that is likely to result from the conservation plan. As long as this take level is not exceeded, the incidental take is authorized under the ESA.

The ITP authorizes protected species interactions, allowing the fishery to operate under certain restrictions. Although the fishery continues to operate in the shallow-water fishing grounds along the Outer Banks, and mainland side of Pamlico Sound, the deep-water fishing grounds are permanently closed at this time.

All observed sea turtle interactions have occurred in large mesh (≥ 5 inch stretched mesh) commercial gill net operations in the shallow water from September through December of each year in the PSGNRA to date. The primary species observed has been green turtles, which represented 70% of all observed species, and most (70%) of the interactions were live takes resulting in identification, sampling, tagging, and releasing the sea turtles in good condition at or near inlets along the Outer Banks. NCDMF has been able to successfully manage the large mesh gill net in fisheries in Pamlico Sound from September-December, and observed levels of sea turtle interactions in gill net fisheries remain below the threshold as established by the ITPs in 2001, 2002, 2003, and 2004 (Gearhart 2003, 2002; Price 2005, 2004). Although kingfishes are not a target species of large mesh gill nets (≥ 5 inch stretched mesh), a small portion (<1%) of the commercial harvest is caught incidentally while fishing this mesh size.

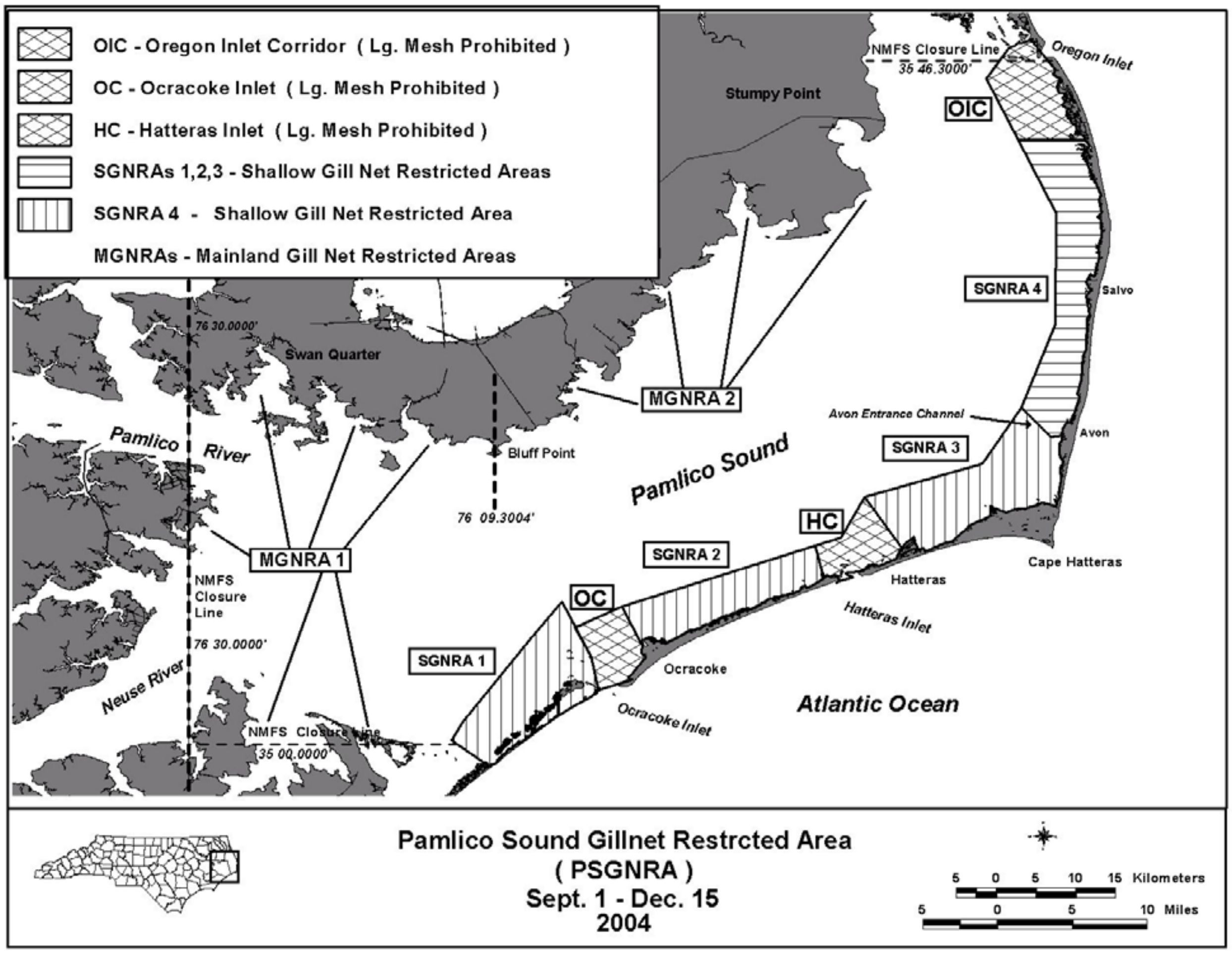

Figure 1. Map depicting the 2004 Pamlico Sound Gill Net Restricted Area (PSGNRA) from September through December.

Shrimp Trawl Tow Times/Sea Turtles

A Section 10 (ESA 1973) experimental permit allowing the use of shrimp trawl tow times in place of Turtle Excluder Devices (TEDs) has been established since 1996 in an area around Brown’s Inlet, North Carolina (60 FR 28741, June 2, 1995). NCDMF applied for and received this permit due to a prevalence of algae concentrations in this area, which at times are so thick that it is impossible to work the area because nets quickly fill with algae. Prior to the TED requirement, tow times were often decreased in order to trawl in the area. Problems quickly developed with the implementation of federal regulations requiring the use of TEDs in shrimp nets. TEDs in shrimp nets operated from Rich’s to Brown’s Inlet become clogged with algae rendering the TED useless in releasing turtles (FR 57348, December 4, 1992).

The ITP has authorized the use of reduced tow times in place of TEDs from April 1 through November 30 of each year since 1996. The area is approximately 30 nautical miles (nm) long, between Rich’s Inlet, NC (34° 17.6’ N. latitude), and Brown’s Inlet, NC (34° 35.7’ N. latitude) and extends offshore 1 nm (“North Carolina restricted area”). Stipulations of the permit are established through proclamation authority granted to the Director of Marine Fisheries. These include:

- Mandatory tow time permit; Observer coverage for 5% of trips
- Fishermen log book reporting requirements; NCDMF reporting requirements
- Maximum tow time of 55 minutes from April through October
- Maximum tow time of 75 minutes from November 1 through November 30
- NCDMF surveillance by land based observers, vessels, and aircraft
- Use of TEDs when algae and grasses not prevalent
- Monitoring strandings through North Carolina Wildlife Resources Commission
- Termination of permit should related strandings exceed 10 turtles

All shrimp trawl regulations may directly impact the commercial harvest of kingfishes because shrimp trawls are an important commercial gear used to harvest kingfishes.

Sea Turtle Advisory Committee (STAC):

A Sea Turtle Advisory Committee (STAC) was formed (2003) by the NC Marine Fisheries Commission (NCMFC) in response to continuing problems with protected species interactions in fisheries throughout North Carolina. The STAC is comprised of stakeholders concerned with the bycatch of protected sea turtle species in commercial and recreational fisheries. Although the committee decided to concentrate its efforts on inshore fisheries, it did recognize that oceanic commercial fisheries in NC state waters can and do result in bycatch of sea turtles (e.g. Epperly et al. 1995). The STAC has identified current management problems and solutions, and discussed them in a completion report (April 2006). Gears of primary concern included: large mesh gill nets, shrimp trawls, pound nets, and rod and reel. Gears of other concern included: butterfly nets, crab pots, crab trawls, other set anchored gill nets, long haul seines, skimmer trawls, swipe nets, and channel nets.

Pound nets and hook and line gears were identified as gears of primary concern because of the number of sea turtle interactions that occur in those gears. However, these gears are typically non-lethal to sea turtles and there are anecdotal reports of the same turtles coming back to feed in the same NC pound nets day after day. NMFS staff have used pound net gear to capture and release sea turtles for tagging studies. Hook and line is the primary gear for recreational fishery; however the location of the fishery should limit encounters.

Set gill nets (sink) < 5 inch mesh is the predominant gill net fished to harvest kingfishes. This gear is not considered to be of primary concern for sea turtle interactions because few sea turtles get entangled in the small mesh gill net, the seasonal nature when it is fished inshore, and seasonal (May 1-November 1) attendance requirements for estuarine waters. The NC nearshore ocean small mesh gill net fishery for kingfishes primarily occurs during late winter/early spring. Water temperatures are cold and sea turtle interactions are not likely.

V. RESEARCH RECOMMENDATIONS

Gear modifications, such as multifilament gill nets, acoustic reflective gill nets, and sonic avoidance devices or pingers, have been utilized in ocean studies to avoid sea bird and mammal interactions with some positive consequences (NFCC 2000; Smith 2001). Looking for alternative solutions that allow fishing to occur while reducing interactions with non-target species is the primary goal of gear development.

During the STAC discussions all members agreed that information was limited in many areas regarding the status of sea turtles and fishery interactions. To address this, the STAC recommended support and funding for analyses and dissemination of results from existing studies. In addition to funding, the following areas for research were recommended: sea turtle status, fishery interactions and gear development (NCMFC Sea Turtle Advisory Committee, April 2006).

VI. MANAGEMENT OPTIONS

(+ Potential positive impact of actions)
(- Potential negative impact of action)

1. Status quo; The NCDMF will continue working with federal agencies and stakeholder groups to address interactions and management between category I & II commercial fisheries and high profile species.
   - \+ Less administrative costs for meetings.
   - \+ Increases communication between user groups and management agencies.
   - \+ Allows further development of alternate solutions to the problem
   - \- Administrative costs increase to cover meetings and added expenses with more people involved in the process.

2. Determine what new federal rules will be and react accordingly.
   - \+ Less administrative costs for meetings.
   - \+ Less time spent in meetings where recommendations are not incorporated into rules.
   - \- Increased replacement costs and short timeline for necessary gear modifications.
   - \- Decreased effort and decreased catches of target species
   - \- Increased effort on lower diversity of species

VII. RECOMMENDATIONS

The PDT and AC recommended that the NCDMF continue to work with federal agencies and stakeholders to address interactions and management between category I & II commercial fisheries and high profile species (Option 1).

VIII. LITERATURE CITED

Eckert, S.A., E.H. Chan, H.C. Liew, and K.L. Eckert. 1996. Shallow water diving by Leatherback Turtles in the South China Sea. Chelonian Conservation and Biology 2(2): 237-24.

Epperly, S.A., P. Braun, A.J., Chester, F.A. Cross, J.V. Merriner, and P.A. Tester. 1995. Winter distribution of sea turtles in the vicinity of Cape Hatteras and their interactions with the summer flounder trawl fishery. Bulletin of Marine Science 56:547-568.

Gearhart, J. 2001. Sea turtle bycatch monitoring of the 2000 fall flounder gill net fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1259. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 26pp.

Gearhart, J. 2002. Sea turtle bycatch monitoring of the 2001 fall flounder gill net fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1348. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 44 pp.

Gearhart, J. 2003. Sea turtle bycatch monitoring of the 2002 fall flounder gill net fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1398. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 39 pp.

Keinath, J.A., J.A. Musick, and R.A. Byles. 1987. Aspects of the biology of Virginia's sea turtles: 1979-1986. Virginia Journal of Science 38(4):329-336.

Lee, D.S. and J.F. Parnell (eds.). 1990. Endangered, Threatened, and Rare Fauna of North Carolina. Part III, Birds. Occasional Papers of the North Carolina Biological Survey 1990. 48 p.

Lee, D.S. and M. Socci 1989. Potential Impact of Oil Spills on Seabirds and Selected Other Oceanic Vertebrates off the North Carolina Coast. Prepared by the North Carolina State Museum of Natural Science for the State of North Carolina, Department of Administration, Raleigh, NC. 85 pp.

Musick, J.A. and C.J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. In: Lutz, P.L. and J.A. Musick (eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, FL. Pp 146. National Fisheries Conservation Center (NFCC). 2000. National evaluation of cooperative data gathering effort in fisheries. A report to the National Marine Fishery Service. 78 pp.

NEFMC 1985. Fishery Management Plan, Environmental Impact Statement, Regulatory Impact Review, and Initial Regulatory Flexibility Analysis for Northeast Multispecies Fishery. Saugus, MA, August 1985.

NEFMC 2003. Northeast Multispecies Amendement 13 Supplemental Environmental Impact Statement, December 18, 2003.

NEFMC, MAFMC, NMFS (2006). Draft Framework Adjustment 42 to the Northeast Multispecies Fishery Management Plan. January 19, 2006.

NMFS, USFWS (1992) Recovery plan for leatherback turtles in the US Caribbean Sea, Atlantic Ocean and Gulf of Mexico. National Marine Fisheries Service and US Fish and Wildlife Service.

National Marine Fisheries Service (NMFS). 2006. Environmental Assessment of the Temporary Rule Implementing the Atlantic Large Whale Take Reduction Plan Gear

Restrictions, National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Department of Commerce (DOC).

NC Marine Fisheries Commission, Sea Turtle Advisory Committee, 2006. Sea Turtle Interactions With North Carolina Commercial Fisheries Review and Recommendations.

Price, B. 2004. Sea turtle bycatch monitoring of the 2003 fall flounder gill net fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1398. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 26 pp.

Price, B. 2005. Sea turtle bycatch monitoring of the 2004 fall flounder gill net fishery of Southeastern Pamlico Sound, North Carolina. Completion report for ITP 1398. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. 27 pp.

Rebel, T.P. 1974. Sea turtles and the turtle industry of the West Indies, Florida, and the Gulf of Mexico. University of Miami Press, Coral Gables, FL, 250 p.

Ross, S.W., F.C. Rohde, and D.G. Lindquist 1988. *Acipenser brevirostrum*, Shortnose Sturgeon. In Endangered, Threatened, and Rare Fauna of North Carolina. Part II. Occasional Papers of the North Carolina Biological Survey 1988(7):4-7.

Ross, S.W., and M.L.Moser. 1995. Habitat use and movements of shortnose and Atlantic Sturgeons in the Lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society. 124:225-234.

Smith, P. 2001. Reflective nets might aid dolphins. The Sun Journal. May, 19, 2001. New Bern

Schwartz, F.J. 1976. Status of sea turtles, Chelonidae and Dermochelidae, in North Carolina. Journal of the Elisha Mitchell Science Society 92: 76-77.

Spotila, J.R., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? Chelonian Conservation and Biology 2:209-222.

Swingle, W.M., S.G. Barco, T.D. Pitchford, W.A. McLellan and D.A. Pabst. 1993. Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9:309-315.

Turtle Expert Working Group. 1998. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the Western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-409. 96pp.

Turtle Expert Working Group. 2000. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-444. 115pp.

US Fish and Wildlife Service and National Marine Fisheries Service. 1992. Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). National Marine Fisheries Service, St. Petersburg, FL. 40pp.

US Fish and Wildlife Service (USFWS) (Web page). 2001. All About Piping Plovers. Fact Sheet. http://plover.fws.gov/facts/html, [Accessed May 17, 2001].

Waring, G.T., R. Pace, J. Quintal, C. Fairfield, and K. Maze-Foley. 2003. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessment. NOAA Technical Memorandum. NMFS-NE-182. 269p.

Wynne, K. and M. Schwartz. 1999. Marine Mammals and Turtles of the U. S. Atlantic and Gulf Of Mexico. Rhode Island Sea Grant, Narragansett, Rhode Island, 114pp.

ATTACHMENT 1.

Anchored gill net: An anchored gill net is defined as "any gill net gear, including a sink gill net or stab net, that is set anywhere in the water column and which is anchored, secured, or weighted to the bottom of the sea. Also called a "set gill net" (50 CFR 229.2)". Thus, ALWTRP anchored gill net regulations include those gillnets that are weighted to the ocean floor, even those that do not have an anchor attached on either end. The current ALWTRP regulations require anchored gill net gear to have all buoys attached to the main buoy line with a weak link having a maximum breaking strength no greater than 1,100 lb, and all net panels must contain weak links with a maximum breaking strength no greater than 1,100 lb in the middle of each floatline of each 50 fathom (300 ft) net panel or every 25 fathoms (150 ft) for longer panels. All gill nets in the Mid/South Atlantic Gill net Waters must return to port with the vessel or, if leaving the gear set overnight, contain five or more weak links depending on the length of the net panel, with a maximum breaking strength no greater than 1,100 lb for each panel; have an 1,100 lb weak link on all flotation and/or weighted devices, including buoys, toggles, and leaded lines attached to the buoy line; and be anchored at each end with an anchor capable of holding power of at least a 22-lb Danforth-style anchor. NMFS is proposing this requirement to reduce entanglements of large whales at night when gillnet gear is not returned to port with the vessel. The gear requirement will be effective 6-months after publication of final rule.

Drift gillnet: In Mid/South Atlantic Gill net Waters, when drift gill net gear is fished at night (i.e., tended), all net panels would be required to contain weak links with a maximum breaking strength no greater than 1,100 lb in the middle of the floatline of each 50-fathom (300 ft) net panel, or every 25 fathoms (150 ft) for longer panels. "Tended" means "fishing gear that is physically attached to a vessel in a way that is capable of harvesting fish, or to fish with gear attached to the vessel". (effective 6 months after publication of a final rule).

Sinking/Neutrally Buoyant Groundlines: the Northeast anchored gil lnet, Northeast anchored float gill net fishery, Mid-Atlantic anchored gill net, and Southeast Atlantic gill net fisheries would be required to use groundline composed entirely of sinking and/or neutrally buoyant line in the areas and time periods covered under the ALWTRP in 2008. Though this requirement would not become fully effective until 2008, NMFS believes that fishermen will begin to phase in this type of groundline prior to that date.

Weak links: to further reduce the risk of serious injury and mortality from entanglement in gillnet gear, weak links of the appropriate breaking strength would be required on all flotation devices and/or weighted devices attached to the buoy line such as buoys, toggles, and/or leaded lines (effective 6 months after publication of a final rule). This requirement would apply to all current and proposed ALWTRP regulated areas and gill net fisheries. The weak link requirement is intended to reduce the risk of entanglement and serious injury or mortality due to entanglements in buoy lines and surface systems.

Gillnet Gear Marking : Currently, there is no gear marking requirement for the two gill net fisheries operating in the Mid-Atlantic: the Mid-Atlantic anchored gill net and Mid-Atlantic drift gill net. Under this proposed rule, however, NMFS would require that these fisheries mark their buoy lines with one 4" blue mark every 10 fathoms (60 ft) or in the center of the buoy line for lines that are 10 fathoms or less.

ATTACHMENT 2.

ATLANTIC LARGE WHALE TAKE REDUCTION TEAM (ALWTRT), NC MEMBERS:
David Beresoff, Bolivia
Jodie Gay, Hampstead
Chris Hickman, Hatteras
Bill McLellan, Wilmington
Fentress (Red) Munden, Morehead City

BOTTLENOSE DOLPHIN TAKE REDUCTION TEAM (BDTRT), NC MEMBERS:
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Paul Biermann, Beaufort
Douglas Guthrie, Salter Path
Chris Hickman, Hatteras
Bill McLellan, Wilmington
Fentress (Red) Munden, Morehead City
Michael Peele, Hatteras, NC
Andrew Reed, Beaufort
Jerry Schill, New Bern
Rob West, Hatteras
AD (Drew) Willis, New Bern
Alternates:
Bill Evans, Ocracoke
Joey Frost, Salter Path
Jeff Oden, Hatteras
Dave Swanner, Hatteras

12.3 APPENDIX 3. MANAGEMENT MEASURES FOR KINGFISHES

I. ISSUE

The implications of different management strategies to ensure a sustainable harvest of kingfishes.

II. BACKGROUND

The North Carolina commercial harvest of kingfishes averaged 581,000 lb from 1999 to 2004, which accounted for 45% of the Atlantic coast commercial landings and ranked North Carolina as the top producer [personal communication, National Marine Fisheries Service (NMFS), Fisheries Statistics Division]. Most of the commercial landings occurred in the late fall and spring as the fish migrated, with gill nets harvesting 70.6% of the catch since 1999. Two regulations, closing the flynet fishery south of Cape Hatteras and the implementation of the "50-50" rule (shrimp or crab biomass: finfish) for the shrimp and crab trawl fisheries significantly impacted the commercial catch of kingfishes. Consequently, the years from 1999 to 2004 were used as baseline to compare future commercial landings in this Issue paper.

The recreational catch from 1999 to 2004 averaged 326,211 lb and North Carolina ranked 2nd on the east coast in the number of kingfishes harvested. The recreational catch of kingfishes has ranked as high as 4th in the number of fish caught in North Carolina and represents a significant fishery (personal communication, NMFS, Fisheries Statistics Division).

A stock assessment was conducted for North Carolina southern kingfish and reviewed by fisheries scientists from outside of the North Carolina Division of Marine Fisheries (NCDMF). The reviewers found flaws in the age-based and biomass dynamic stock assessments. The Plan Development Team (PDT) determined the data were insufficient to accurately assess the southern kingfish stock. Some of the deficiencies included: a lack of migration (mixing) data to determine the movement of kingfishes along North Carolina as well as the Atlantic coast, a lack of correlation between the indices used in trend analysis and the biomass dynamic model, gaps in the aging data from 1997 to 2001 along with a low sample size of aged fish, and a change in the commercial fish house sampling regime. A detailed trend analysis was developed to provide information on the trends in abundance of kingfishes and assist with decisions regarding possible management measures. The majority of the trends included in the trend analysis for southern kingfish were positive (See Trend Analysis Section).

A stock assessment for kingfishes should be conducted by either the Atlantic States Marine Fisheries Commission (ASMFC) or the South Atlantic Fisheries Management Council (SAFMC). The ASMFC or SAFMC should be able to conduct a more robust investigation of kingfishes populations since a greater geographic range would be covered. This would reduce the need for migration data and may increase the correlation in the indices, which could be influenced by water temperature.

The Fisheries Reform Act requires a fishery management plan be updated every five years. The status will remain unknown without a peer reviewed stock assessment. While data are lacking and the NCDMF is not able to provide quantitative evaluations of reductions of fishing mortality, F, in many of the management options, this does not negate the use of a management approach that is based on instituting "consensus based" measures that would likely ensure a sustainable harvest of kingfishes. 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 F and determine any necessary reductions.

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 a sustainable harvest. The degree to which the FMP for kingfishes succeeds will be based on the new data collection programs to enable the determination of a stock status and implementation of "consensus based" measures that would achieve a sustainable harvest of kingfishes.

Fishing restrictions can be accomplished in a variety of ways. Options include: quotas, size limits, bag and/or trip limits, gear restrictions, catch restrictions, seasonal closure, area closure, and limited entry. Limited entry can only be explored if management measures cannot achieve the target fishing mortality levels. Since the southern kingfish stock assessment did not pass peer review, biological reference points, which are used to develop target fishing mortality rates, have not been identified. Therefore, a limited entry is not a legal option to manage kingfishes. Size limits, bag limits, and gear restrictions are described in the greatest amount of detail as requested by the Advisory Committee (AC) and PDT. This issue paper is a condensed paper that includes all management options for kingfishes. The setup for the remainder of the issue paper is as follows:

- III. Legal Authority
- IV. Discussion/Impact of Management Options
  - Status Quo
  - Management Triggers
  - Recommend ASMFC or SAFMC Conduct an Assessment
  - "Consensus Based" Approaches
    - Quota
    - Size limit
    - Seasonal closure
    - Area closure
    - Trip/Vessel limits
    - Gill net mesh size restriction
    - Bycatch reduction devices
    - Tow time limits in shrimp trawl fishery
- V. Research Recommendations
- VI. Management Options
- VII. Proposed Recommendations
- VIII. Proposed Kingfish Rule
- IX. Literature Cited

III. CURRENT AUTHORITY

15A NCAC 3J .0104 (a) (1). Trawl Nets
15A NCAC 3J .0104 (b) (5) (A) (B) 8 (D) (E) Trawl Nets
15A NCAC 3J .0104 (b) (1) (3) Trawl Nets
15A NCAC 3J .0202 (1) (2) (8). Net Rules Atlantic Ocean
15A NCAC 3J .0208. Net Rules New River
15A NCAC 3J .0202 (5) Net Rules Atlantic Ocean Temporary rule effective 12/97
15A NCAC 3N .0104 and 3N .0105 (a) (b). Nursery Area Prohibited Gear
15A NCAC 3J .0104 (d) Trawl Nets
15A NCAC 3J.0103 Gill Nets, Seines, Identification, Restrictions

IV. DISCUSSION/IMPACT OF MANAGEMENT OPTIONS

Various management options are available for the fisheries of kingfishes including: status quo, management triggers, recommend ASMFC or SAFMC conduct a stock assessment for kingfishes, and/or a "consensus based" approach to reduce fishing mortality by placing restrictions on the fisheries for kingfishes. The lack of a stock assessment limits the NCDMF's ability to determine the status of the stock and detect overfishing, but management triggers or a "consensus based" approach should help to maintain or obtain a sustainable harvest of kingfishes. Potential management strategies are addressed for most of the fisheries landing kingfishes but will focus on the three major fisheries: commercial gill nets, commercial shrimp trawls and the recreational hook and line fishery. The management strategies for North Carolina developed by the PDT are presented below. Recommendation can include a single option, a combination of different options, or the AC can propose their own options for consideration.

Status quo

This option would result in no change in the current management of kingfishes. This option is least likely to prevent overfishing in the future.

Management triggers

This option would result in no change in the current management of kingfishes but would establish a threshold for an initiation of management options. Several different alternatives are available in the development of triggers for management of kingfishes.

A change in management will be considered if:

1) Relative Percent Change in Landings:
    - A) The most recent year's commercial landings are less than 50% of the previous three year's average landings.
    - B) The most recent year's commercial landings are below or above the 90% confidence interval (CI) of the average commercial landings (1999 - 2004 base years for average).
    - C) The most recent year's commercial landings are above 800,000 lb or below 300,000 lb, which are 1.5 or 0.5 times the average commercial landings from 1999 to 2004.
    - D) The most recent year's recreational landings are less than 50% of the previous three year's average landings.
    - E) The most recent year's recreational landings are below or above the 90% CI of the average recreational landings (1999 to 2004 base years for average).

2) Biological Data Monitoring:
    - A) The most recent year's mean length data from the recreational fishery to the average of the last five years' mean lengths.
    - B) The most recent year's mean size (length and weight) data from the commercial fishery to the average of the last five years' mean size (length and weight) data.
    - C) The proportion of age one kingfishes increases to greater than 50% of all age class for fish 11.0 to 11.8" TL.

3) Commercial Catch per Unit Effort (CPUE) by Gear :

   A) The most recent year's CPUE is less than two-thirds of the average CPUE from 1999 to 2004.

4) Marine Recreational Fisheries Statistic Survey (MRFSS) CPUE (based on ocean samples from beach bank, pier, private boats, and rental boats to examine catch rates on an annual basis):
   A) The most recent year's CPUE is less than two-thirds of the average CPUE from 1999 to 2004.

5) Surveys:
   A) The young of the year (YOY) indices in the Pamlico Sound or Southeast Area Monitoring and Assessment Program (SEAMAP) survey fall two standard deviations below the long term average.
   B) The adult indices in the Pamlico Sound or SEAMAP survey fall two standard deviations below the long term average.

Recommend ASMFC or SAFMC Manage Kingfishes

A stock assessment for kingfishes should be conducted by either the ASMFC or SAFMC. Efforts to determine the status of kingfishes stocks should combine data from other states with North Carolina's since these fishes are primarily oceanic as adults and likely migrate along the South Atlantic Bight. The management of kingfishes can be conducted on the state level to allow flexibility in the management regimes for each state but must remain in compliance with the ASMFC or SAFMC mandates. This option asks the North Carolina Marine Fisheries Commission (NCMFC) to draft a letter and request ASMFC or SAFMC manage kingfishes. The management of kingfishes would be based on a stock assessment with information from all states that are managed by these entities and would address the entire stock of kingfishes.

"Consensus Based" Approaches

<u>Quotas</u>

A quota is the maximum amount of fish a fishery can land within a specified period. A quota could be used in the kingfishes fishery to prevent expansions in either the commercial or the recreational fisheries. Since benchmarks have not been established to determine the status of the stock and overfishing cannot be determined, a quota is not recommended. This type of harvest restriction has a high cost associated with monitoring the fishery, no benchmarks for sustainable harvest rates, new permits for commercial reporting may be required, and the effect may be disproportional for all fisheries.

<u>Trip Limits and Bag Limits</u>

Bag limits are a common option used in fisheries management to limit the harvest of a species. Bag limits or catch restrictions have been used by fisheries managers to maintain fish stocks, extend fishing seasons, allocate resources, and reduce bycatch. In North Carolina, this method is used to reduce the targeting of marketable finfish with shrimp trawls. From December 1 through February 28, it is unlawful to use trawl nets in internal waters to take more than 500 lb of finfish, and from March 1 through November 30, no more than 1,000 lb of finfish may be taken (15A NCAC 3J .0104 (a) (1)). Additionally, in the Atlantic Ocean it is unlawful to possess finfish caught incidental to shrimp trawling from December 1 through March 31 unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish, except that 300 lb of kingfishes may be taken south of Bogue Inlet in addition to the weight of crabs and shrimp (15A NCAC 3J .0202 (5 (a) (b)).

The lack of a reference point for sustainable harvest hinders a quantitative threshold for the basis of trip or bag limits. It will be difficult to determine an equitable bag limit for both recreational and commercial fisheries while minimizing regulatory discards (fish thrown back as a result of a regulation). Estimates of catch per trip for the recreational fishery are in Table 1. The number of fish per angler is low with 70% of the anglers catching less than 3 fish. The commercial catch per trip are described with greater detail in the commercial section. Gillnets have a few trips (1%) that account for 21% of the landings. Most trips have less than 50 lb. Shrimp trawls also have a small number of trips accounting for a large percent of the landing, but most trips landed less than 50 lb.

Additionally, kingfishes are caught seasonally in the commercial and recreational fisheries. If the trip/bag limits are set based on a yearly catch per trip, then the catches during the peak fishing for kingfishes would result in a high amount of regulatory discards and would have a greater effect on the commercial gill net and recreational fisheries.

Size limits

Size limits are usually based on the reproductive biology of fish. Minimum size limits are used to protect juvenile fish from harvest pressure and ensure most fish (>50%) are able to spawn at least once. Maximum size limits are used to protect adult breeding stocks from fishing pressure. Harvest slot limits can be used to protect both juvenile and large adult fish. Finally, protected slot limits are used to protect medium sized fish by only allowing small and large fish to be harvested. A simple approach would be to establish a minimum size limit for kingfishes based on size at maturity.

The length at maturity (length at 50% mature) estimated by NCDMF's reproductive sampling was 8.2 inches for southern kingfish females while all males were mature by 8.2 inches (See Life History Section). Size limits of 8, 9, and 10 inches were considered. It is important to note the different weights at these sizes and how they change as the fish grow. Kingfishes weigh 3.0 ounces at 8 inches, 4.3 ounces at 9 inches, and 5.6 ounces at 10 inches. Their weight increases nearly two fold as the fish grows from 8 to 10 inches.

Size information was collected from commercial fish house surveys of the gill net, flounder pound net, beach seine, long haul seine, sciaenid pound net, and winter trawl fisheries by NCDMF. The commercial fisheries sampled from 1994 to 2004 included the beach seine (n=58 trips), long haul seine fishery (n=239), sciaenid pound net (n=76), gill net (n=404), and winter trawl [n=223 (NCDMF Biological Database)]. Since the flounder pound net fishery only had 10 observations, this fishery was not analyzed. The gill net fishery and size limit ramifications will be addressed under "Gear Restrictions". Methods and management options to reduce kingfishes bycatch in the shrimp trawl fishery are also discussed below (Seasonal Closure, Area Closure, Bycatch Reduction Devices, and Tow Time Restrictions). Recreational data from Marine Recreational Fisheries Statistics Survey (MRFSS) were analyzed to estimate the impact of 8, 9, and 10 inch size limits. The recreational catch percent reduction was based on the number of trips that captured fish less than each size and extrapolated to the total number of trips.

Table 1. Number of kingfish per angler by species captured by recreational fishermen in North Carolina, 1996 - 2004. (Source: MRFSS).

Fish Per Angler	Species of Kingfish					
	Southern		Gulf		Northern	
	Number	Percent	Number	Percent	Number	Percent
0	789	14.9	89	9.5	455	12.7
1	2,429	45.8	490	52.6	1,602	44.8
2	811	15.3	178	19.1	624	17.4
3	384	7.2	69	7.4	288	8.0
4	268	5.1	40	4.3	178	5.0
5	139	2.6	18	1.9	112	3.1
6	121	2.3	15	1.6	84	2.3
7	61	1.1	3	0.3	43	1.2
8	39	0.7	11	1.2	64	1.8
9	33	0.6	4	0.4	14	0.4
10	43	0.8			23	0.6
11	18	0.3	3	0.3	6	0.2
12	23	0.4	4	0.4	5	0.1
13	25	0.5	5	0.5	19	0.5
14	13	0.2			5	0.1
15	9	0.2			16	0.4
16	10	0.2			3	0.1
17	3	0.1			5	0.1
18	5	0.1			3	0.1
19	2	0.0			4	0.1
20	7	0.1			9	0.3
21	4	0.1			2	0.1
22	6	0.1			1	0.0
23	5	0.1				
24	3	0.1	1	0.1		
25	4	0.1			1	0.0
26	4	0.1				
27	2	0.0				
28	8	0.2				
>30	37	0.7	2	0.2	13	0.4

The fisheries were analyzed in two ways: one on the basis of trips effected, and the second on the number of fish reduced. In the first analysis, the proportion of trips that included fish less than 8, 9, and 10 inches were determined. The gill net and beach seine fisheries had the fewest trips with kingfishes under 8 and 9 inches and only 3.7% of the trips had fish under 10 inches (Table 2). The long haul seine fishery had the highest percentage of trips with fish under 8 (4.2%), 9 (16.7%), and 10 inches (36.4%). The winter trawl had the next highest, but few fish have been caught in this fishery since 1998. The recreational fishery had the second highest percent of trips for 8 and 10 inch size limit and was third for a 9 inch size limit. Overall if a size limit of 9 inches or less was established, less than one out of every five trips for all fisheries would have an undersized fish. If the size limit was increased to 10 inches, the long haul seine and recreational fishery would have greater than 20% of the trips with an undersized fish.

All trips were re-analyzed to estimate the proportion of fish under 8, 9, and 10 inches that were present in the catches. The combined trips from all commercial fisheries indicated that, on average, 2.0% of the fish per trip were less than 8 inches, 3.8% per trip were less than 9 inches, and 7.3% per trip were less than 10 inches. The long haul seine fishery averaged the highest percent (9%) of fish less than 10 inches (Table 2) followed by the sciaenid pound net fishery with 8% of the catch less than 10 inches. The winter trawl fishery averaged 2% of the measured fish less than 10 inches. In the beach seine and gill net fisheries, on average, less than 1% of the fish were under 10 inches and there were no fish under 8 inches. Analysis of the recreational fishery indicated harvest reductions of 2.2% at 8 inches, 7.5% at 9 inches, and 22.1% at 10 inches.

The percent reduction in the recreational fishery has a spatial component (Table 3). Fishermen south of Cape Hatteras will have a greater percent reduction. Also fishermen fishing from manmade structures will have the greatest percent reduction for all purposed size limits.

Table 2. The number of trips, % of trips with kingfishes under each proposed size limit, and the per trip geometric mean of kingfishes under each size limit. The commercial fisheries included data from 1994 to 2004 and the recreational fishery included data from 1996 to 2004. (Source: NCDMF Biological Database and MRFSS)

		8" Size Limit		9" Size Limit		10" Size Limit	
Fishery	Trips sampled	% of Trips with undersized fish	Average % undersized	% of Trips with undersized fish	Average % undersized	% of Trips with undersized fish	Average % undersized
Beach Seine	58	0.0	0.0	0.0	0.0	1.7	0.3
Long Haul Seine	239	4.2	1.5	16.7	3.4	36.4	8.9
Sciaenid Pound Net	76	2.6	5.0	5.2	5.5	10.5	8.1
Gill Net	404	0.0	0.0	0.7	0.4	3.7	0.5
Winter Trawl	223	2.7	0.7	10.8	1.2	16.1	2.4
Recreational	2,312	3.7	2.2	10.6	7.5	23.4	22.1

Table 3. The percent reduction of kingfishes with purposed size limit of 8, 9, and 10 in for manmade structures, beach/bank, charter boats, and private boats North and South of Cape Hatteras, 1996 to 2004. (Source: MRFSS)

	Manmade		Beach/Bank		Charter Boat*		Private Boat	
Inches	North of Hatteras	South of Hatteras	North of Hatteras	South of Hatteras	North of Hatteras	South of Hatteras	North of Hatteras	South of Hatteras
8	0.59	7.45	0.94	3.58	-	-	0	1.8
9	4.5	19	3.7	10.3	-	-	2.9	6.8
10	17.7	39.9	12.8	24.6	-	-	11.4	27.6

*Too few observations from Charter Boat.

Although biologically it might make sense to propose a size limit based on size at maturity, management of a fishery should consider the potential for increased regulatory discards, the financial burden to the fishermen, and the elimination of bait that is used in other fisheries. A size limit will increase regulatory discards of kingfishes. Some culling occurs at sea and has been documented in the shrimp trawl fishery off South Carolina (Smith and Wenner 1985). Placing a 9 inch or greater size limit on kingfishes, which are bycatch in several fisheries, would result in regulatory discards in the shrimp trawl, long haul seine, beach seine, sciaenid pound net, winter trawl, and recreational fisheries as well as the gill net fishery. Observer data from the shrimp trawl fishery and other commercial fisheries would provide information on the number harvested, the length frequency, and the discard disposition of the kingfishes captured. These data would be useful in estimation of reduction due to size limits as well as future stock assessments.

Little is known on the economic impacts of establishing a size limit, but most likely it will reduce the amount harvested. A slight economic impact would be felt in the commercial fisheries particularly the long haul seine fishery, which had the highest percent of kingfishes (by number) under the proposed size limits in the commercial fisheries, and the recreational fishery, which had higher trip rates of undersized kingfishes than any commercial fishery (average 7.7%). Data are needed on the socioeconomics of the fisheries for kingfishes. Currently, the economic impact of altering management regimes cannot be estimated.

Heads of kingfishes are used as bait in the recreational red drum fishery. If a size limit is established, kingfishes cannot be filleted or cut-up until fishing has ceased (Marine Fisheries Rule 15A NCAC 3M.0101). A provision for a limited number of mutilated fish has been allowed in other fisheries but may be difficult to enforce.

Seasonal Closure

A seasonal closure could be established to limit the harvest in gill nets during the spring prior to the spawning season (April and May) when the gill net fishery generally targets kingfishes. Since this stock has not been determined to be overfished nor is overfishing occurring, justifying the need for a closed season may be difficult. Reduced fishing effort during this time-period would benefit other species typically harvested with kingfishes including spiny dogfish (*Squalus acanthias*), smooth dogfish (*Mustelus canis*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), and Atlantic croaker (*Micropogonias undulatus*). A seasonal closure during the summer and fall would limit the harvest of kingfishes with shrimp trawls and long haul seines. However, since kingfishes are a bycatch in these fisheries, a closed season would increase regulatory discards and not protect kingfishes.

Harvest seasons have been used to reduce bycatch by relegating fishing activity to times of maximum target species abundance, or by limiting activity during times of high bycatch (e.g. Special Secondary Nursery areas can only be opened to trawling by proclamation from August 16 through May 15). The use of harvest seasons to manage bycatch of kingfishes in the shrimp trawl fishery might be an option for ocean waters greater than 3 miles. During February and March with 1996 and 1997 excluded, landings of kingfishes from this area averaged 1,605 lb, while shrimp landings averaged 899 lb (Table 4). The bycatch of kingfishes from shrimp trawls in other waters appears to be a non-directed bycatch fishery. However, it is important that fishery dependent data be collected from all areas to adequately assess the potential impact that this fishery has on the stocks of kingfishes.

Table 4. Average shrimp trawl landings and % of total trip for shrimp and kingfishes by month and waterbody, 1994 – 2004 (1996 and 1997 were removed due to targeted trips with shrimp trawls). CH=Cape Hatteras (Source: NCDMF Biological Database)

			Month												Overall
Waterbody	Group	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	average
Ocean 0-3 mi, S of CH	Kingfishes	% of tot	3.63%	0.53%	1.30%	1.92%	1.60%	1.72%	1.87%	1.79%	2.32%	21.95%	50.36%	11.04%	
		Avg	1,934	282	691	1,022	850	915	996	952	1,234	11,699	26,846	5,885	53,305
	Shrimp	% of tot	1.30%	0.41%	0.28%	0.26%	2.68%	10.93%	18.55%	8.94%	16.80%	22.90%	11.95%	5.01%	
		Avg	16,934	5,297	3,674	3,431	34,896	142,303	241,437	116,361	218,674	298,094	155,557	65,226	1,301,884
Pamlico Sound	Kingfishes	% of tot	0.04%	0.10%	0.03%	0.25%	1.29%	4.98%	19.17%	24.59%	13.09%	18.23%	15.84%	2.38%	
		Avg	15	41	10	99	512	1,976	7,603	9,752	5,193	7,228	6,280	946	39,654
	Shrimp	% of tot	0.12%	0.03%	0.00%	0.09%	0.88%	4.05%	33.11%	26.14%	14.80%	13.70%	6.29%	0.77%	
		Avg	4,292	1,098	133	3,453	32,149	147,647	1,206,296	952,532	539,373	499,150	229,162	28,153	3,643,436
Ocean < 3 miles*	Kingfishes	% of tot	2.52%	24.35%	1.84%	6.13%	2.43%	2.30%	5.43%	2.13%	2.46%	8.06%	30.51%	11.86%	
		Avg	369	3,564	269	897	355	337	794	312	360	1,180	4,466	1,735	14,638
	Shrimp	% of tot	1.11%	0.64%	0.49%	1.14%	5.28%	16.45%	19.35%	8.49%	13.79%	18.07%	11.26%	3.92%	
		Avg	4,011	2,321	1,770	4,110	19,106	59,481	69,954	30,682	49,872	65,326	40,702	14,188	361,522
Ocean >3 mi, S of CH	Kingfishes	% of tot	2.02%	0.35%	10.58%	1.09%	4.09%	5.53%	2.91%	1.40%	1.92%	20.73%	43.81%	5.56%	
		Avg	191	33	999	103	386	523	275	132	182	1,959	4,138	525	9,447
	Shrimp	% of tot	2.11%	0.83%	0.32%	0.06%	3.17%	12.32%	23.66%	6.41%	16.60%	20.15%	8.87%	5.49%	
		Avg	3,213	1,261	493	97	4,831	18,753	36,001	9,749	25,267	30,661	13,504	8,362	152,193
Ocean > 3 miles*	Kingfishes	% of tot	0.08%	26.28%	17.49%	3.32%	0.87%	0.72%	5.56%	2.93%	1.67%	4.60%	13.66%	22.81%	
		Avg	6	1,927	1,282	244	64	53	408	215	123	337	1,001	1,673	7,332
	Shrimp	% of tot	0.52%	1.20%	1.51%	0.24%	6.18%	11.72%	23.28%	13.41%	12.22%	9.01%	13.74%	6.97%	
		Avg	346	796	1,002	161	4,088	7,752	15,405	8,869	8,082	5,962	9,089	4,610	66,162
Ocean >3 mi, N of CH	Kingfishes	% of tot	0.00%	0.00%	0.00%	0.00%	1.98%	0.00%	0.13%	2.71%	5.16%	22.49%	67.52%	0.00%	
		Avg	0	0	0	0	7	0	0	9	17	76	227	0	336
	Shrimp	% of tot	12.14%	0.00%	0.00%	0.00%	0.74%	0.00%	1.09%	12.75%	20.24%	34.09%	18.95%	0.00%	
		Avg	1,619	0	0	0	99	0	145	1,700	2,699	4,546	2,526	0	13,335
Ocean 0-3 mi, N of CH	Kingfishes	% of tot	4.61%	0.00%	0.00%	0.08%	0.00%	0.00%	0.01%	0.30%	0.70%	6.16%	27.18%	60.96%	
		Avg	74	0	0	1	0	0	0	5	11	98	434	974	1,598
	Shrimp	% of tot	10.41%	0.00%	0.00%	0.02%	0.00%	0.06%	1.33%	10.37%	5.98%	10.58%	17.94%	43.30%	
		Avg	1,185	0	0	2	0	7	151	1,180	680	1,203	2,041	4,925	11,374

*Phased off trip tickets beginning in 1998.

Area Closures

Area closures have been established to protect the spawning stock or spawning areas for a variety of species. Area restrictions for trawling have been used to deal with allocation, resource, habitat, and safety issues in North Carolina. Trawling was prohibited in Albemarle Sound and its tributaries in 1987 (15A NCAC 3J .0104 (b) (3)) to protect the flounder gill net fishery in this area (allocation issue). Since 1978, over 147,000 acres of estuarine nursery areas have been closed to trawling to protect juvenile fish and crustaceans (Street et al. 2005). NCMFC rule 3N .0102 (a) defines Nursery Areas “as those areas in which for reasons such as food, cover, bottom type, salinity, temperature and other factors, young fish and crustaceans spend the major portion of their initial growing season.” There are approximately 80,000 acres of Primary Nurseries, 35,500 acres of Secondary Nursery areas, and 31,000 of special Secondary Nursery areas. Primary and Secondary Nursery areas are permanently closed to trawling, while Special Secondary Nursery areas can only be opened to trawling by proclamation from August 16 through May 15. In the mid 1990’ s, the sea grass beds along the Outer Banks were closed to trawling to protect this critical habitat. Over 39,000 acres of military target areas are also closed to trawling for safety reasons. North Carolina has 2,147,000 acres of estuarine surface waters with just over 1,000,000 acres (46%) closed to trawling (Street et al. 2005). The 2004 North Carolina Shrimp FMP also made recommendations to close portions of various creeks and rivers to minimize shrimp trawl bycatch (NCDMF 2006).

Area closures could benefit kingfishes by protecting nursery and adult habitats. Kingfishes are associated with muddy bottoms in the estuaries, inlets, and ocean. Most of this bottom remains open to trawling since shrimp also utilize these areas. Inlets are an important habitat to protect since these areas are bottlenecks where estuarine dependent species enter or exist the estuary. Mouths of inlets and the adjacent plume are habitats for eggs and larval kingfishes (Bourne and Govoni 1988, Marcovsky 2004) and may be spawning areas. Closing trawling in inlets and river plumes may increase the juvenile recruitment for kingfishes and other estuarine dependent species. Currently there is a lack of data on the importance of inlets and river plumes as primary and secondary nursery areas. These data need to be collected throughout the state and could provide information to establish spawning sanctuaries for a variety of species such as the sanctuaries established in the NC Blue Crab FMP (NCDMF 2004).

Gear Restrictions - Gill nets

Gear restrictions will focus on the gill net fishery, which landed the most kingfishes of any commercial gear since 1982 and was responsible for 70.6% of the harvest from 1999 to 2004. Historically, this fishery utilized the minimum legal mesh size allowed in North Carolina for gill nets (2-1/2 inch stretched). This is the only fishery that uses this size mesh based on communication with NCDMF staff and NC Marine Patrol Officers. An increase in the minimum mesh size may provide benefit to the spawning stock based on gill net selectivity. With the spring fishery operating at the beginning of the spawning season (April and May), any decrease in the harvest of females that are beginning to develop for reproduction will provide an increase in the number of individuals in the spawning stock. However, the increase in mesh size will decrease the total landings from the sinknet fishery and may have a significant financial impact on the fishermen (Table 5).

Table 5. Number, weight, and percent reduction in each mesh size for the FRG conducted off Holden Beach.

Mesh Size	Number Caught	Percent Reduction from 2-1/2" by number	Weight Caught (lb)	Percent Reduction from 2-1/2" by weight
2-1/2"	1,673	-	1008	-
2-5/8"	1,445	14%	871	14%
2-3/4"	1,114	33%	734	27%
2-7/8"	566	66%	448	55%
3"	344	79%	295	70%

Data for the size limit restriction originated from three sources: a Fishery Resource Grant (FRG) on kingfishes gill net selectivity (Beresoff 1998), a NCDMF gill net selectivity study for weakfish (NCDMF unpublished data), and the North Carolina Trip Ticket Program (NCTTP). The FRG study was completed by a commercial fisherman in the near shore ocean water (< 3 miles) off Holden Beach in 1996 and 1997 using gill nets with 100 yards of 2-1/2, 2- 5/8, 2-3/4, 2-7/8, and 3 inch stretched mesh on 80 trips. The same twine size (#208) was used in each 100 yard anchored gill net. A NCDMF selectivity study in the weakfish gill net fishery was conducted off Cape Hatteras between 1991 and 1995. These data were collected over 25 trips and included marketable bycatch in the commercial gill nets. The data from these two studies were used to describe the lengths of kingfishes caught in different mesh sizes as well as species assemblages harvested in association with the mesh sizes. Additionally, data from the NCTTP were used to describe the landed catch associated with ocean gill net kingfishes landings by district (Northern, Central, and Southern). Only trips targeting kingfishes were used for this analysis and a target trip was defined as all trips in the ocean gill net fishery that landed greater than 50 lb of kingfishes.

The length and amount of kingfishes caught in gill nets is highly dependent on mesh size (Figure 1). The kingfishes FRG off Holden Beach reported the highest catch in the minimum mesh size (2-1/2 inches), which also retained the smallest kingfishes (Beresoff 1998). The modal length was 11 inches (280 mm) with a range from 8.7 to 15.4 inches (220 to 390 mm). The modal size of southern kingfish caught in the 2-5/8 inch mesh was 11.4 inches (290 mm) with a range from 9.8 to 15.0 inches (250 to 380 mm). The modal length continued to increase by 0.4 inch (10 mm) for each ¼ inch increase in mesh size.

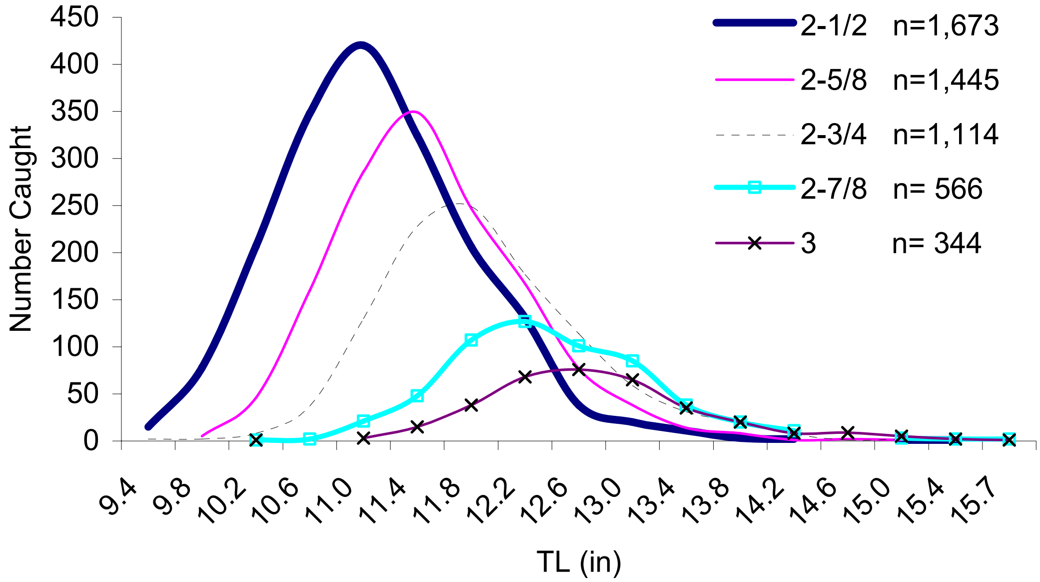

Figure 1. Gill net selectivity for southern kingfish harvested off Holden Beach, NC reported from a FRG. The effort was consistent among the five different mesh sizes, which ranged from 2-½ to 3 in stretched mesh.

The number caught per mesh size was greatest in the smallest mesh size (Figure 1). A 14% reduction in the number caught occurred from the 2-1/2 inch mesh to the 2-5/8 inch mesh (Table 5). Catches in mesh sizes greater than 2-5/8 inch continued to decline and were much lower than the catches in 2-1/2 inch and 2-5/8 inch meshes. Since the larger mesh sizes caught larger fish, the reduction in numbers may be compensated by an increase in weight. The total number for the mesh size was converted to weight by multiplying all the lengths for the kingfishes by the length-weight relationship (Life History Section) and summed for each mesh size. The total weight was highest in the 2-1/2 inch mesh and decreased as the mesh size increased. The total weight in each net was compared to the 2-1/2 inch mesh to estimate the percent decrease in the total weight of the harvest. The shift to larger mesh sizes decreased the total weight harvested by 14% in the 2-5/8 inch, 27% in the 2-3/4 inch, 55% in the 2-7/8 inch, and 70% in the 3 inch mesh (Table 5).

A more detailed analysis of the weight harvested by gill net mesh size was conducted using a yield per recruit (YPR) model. This model combined natural mortality rates, length-weight relationship, length-at-age relationships, and selectivity (Holt 1963) to determine the yield per individual. The highest YPR occurred in the smallest mesh size (Figure 2) but was very similar to the YPR from the 2-5/8 inch mesh. As the mesh size was increased beyond 2-5/8 inch, the YPR decreased.

Modal lengths by mesh size of southern kingfish collected in the selectivity study for weakfish off Cape Hatteras [1991-1995 (NCDMF unpublished data)] were similar to the modal lengths collected in the kingfishes FRG selectivity study off Holden Beach (1996-1997) but the low numbers of southern kingfish (n = 260) limited the development of mesh size selectivity. There were few fish in the 2-1/2 inch (n = 11) and 3 inch (n = 2) mesh. The highest catch occurred in the 2-5/8 inch mesh, then decreased as the mesh size was increased to 3 inch. The modal sizes of kingfishes captured in the 2-5/8 inch and 2-7/8 inch meshes were identical to the modal sizes observed in the kingfishes FRG study off Brunswick County (Table 6). The

2-3/4 inch mesh had modal sizes of 11.8 and 12.6 inches (300 to 320 mm). The 11.8 inches peak mode was the same as the modal size in the Holden Beach study. Since modal lengths were similar in the two areas, selectivity in each mesh size was most likely similar. *Selectivity is a key component of a YPR model and stock assessments and verifying selectivity patterns between the two areas is an important issue to be addressed for kingfishes.* Since selectivity is similar among the two areas studied, mesh size restrictions will likely have an equal effect on the southern kingfish harvest (assuming a uniform distribution of kingfishes along the coast). An increase in the minimum mesh size will decrease the harvest of kingfishes by 14 to 79% by number and 14 to 70% by weight (assuming fishermen maintain current effort levels).

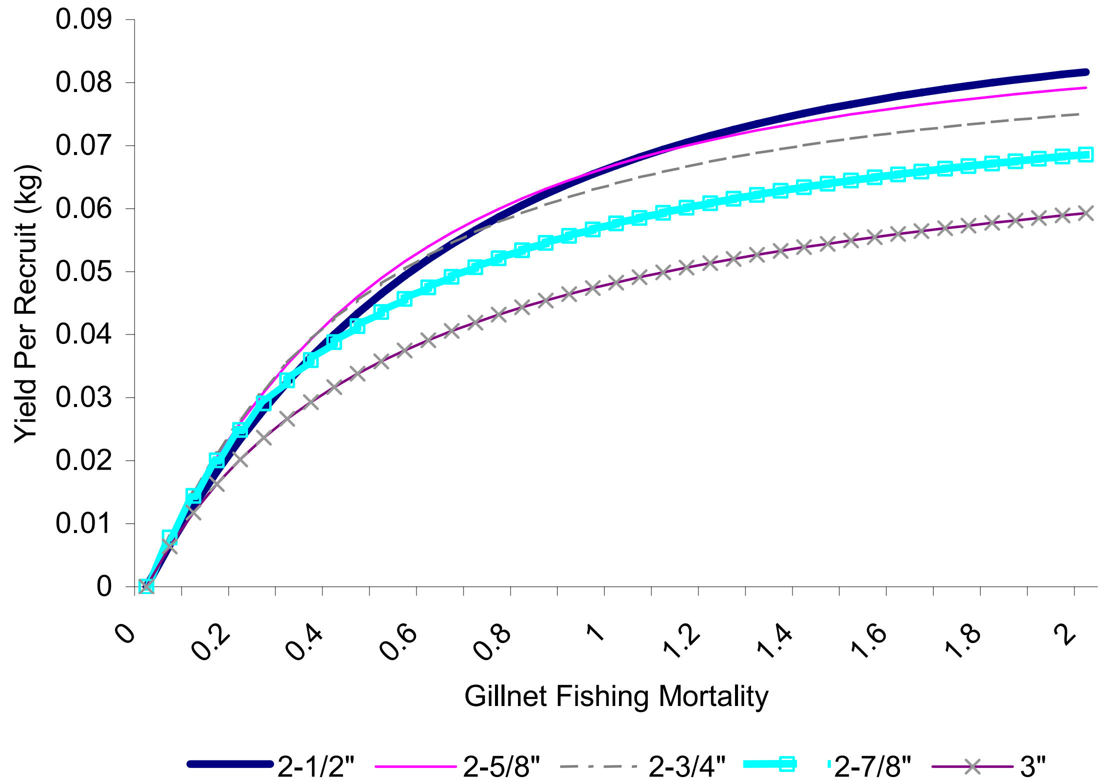

Figure 2. The yield per recruit curve for southern kingfish caught in gill nets based on a selectivity study for kingfishes. The thickest line represents the current minimum mesh size of 2-1/2 inch. The dotted lines are theoretical optimal selection lengths for mesh sizes smaller than 2-1/2 inch.

Table 6. A comparison of the modal sizes for two selectivity studies conducted in NC. The NCDMF observer study was conducted to determine weakfish selectivity and recorded data on southern kingfish lengths and catch.

Mesh Size	FRG Kingfishes Selectivity	NCDMF Observer Selectivity
2-1/2”	11.0	-
2-5/8”	11.4	11.4
2-3/4”	11.8	11.8 and 12.6
2-7/8”	12.2	12.2
3”	12.6	-

Species Diversity in Gillnet Catches with Kingfishes

Management of kingfishes needs to consider the potential effects on other species when altering the minimum mesh sizes. Data on the entire catch associated with the different mesh sizes were collected for the kingfishes FRG but only data on marketable catch were collected for the NCDMF weakfish study. A total of 51 species was caught during the kingfishes FRG study with an average of 5 species caught per set. The most abundant species in all mesh sizes was southern kingfish (Atlantic menhaden numbers were not recorded) with the exception of the 3" mesh where smooth dogfish was the most common. Bluefish and weakfish, which ranked second and fourth in number of fish caught, had similar decreasing trends in catch as mesh size increased (Figure 3). Smooth dogfish, ranked 3rd, and spiny dogfish, ranked 5th, had an opposite catch trend. The number of the two dogfishes, which are vulnerable to overfishing due to their life history traits, increased as the mesh size increased. Most of these species are regulated by NCDMF. Bluefish are not experiencing overfishing but are overfished (NCDMF Stock Status Report for 2006). Smooth dogfish have no management plan. Spiny dogfish's most recent assessment reviewed in mid-2006 indicated that the stock is no longer overfished and overfishing is not occurring (ASMFC 2007). Weakfish are listed as "Concern" due to concerns in the declines in coastwide landings and the lack of a stock assessment accepted by peer review (NCDMF Stock Status Report for 2006). Any discussion on the implementation of mesh size restrictions should consider effects on these and other species. The bycatch described above are for Holden Beach and regional variation likely occurs along the NC coastline.

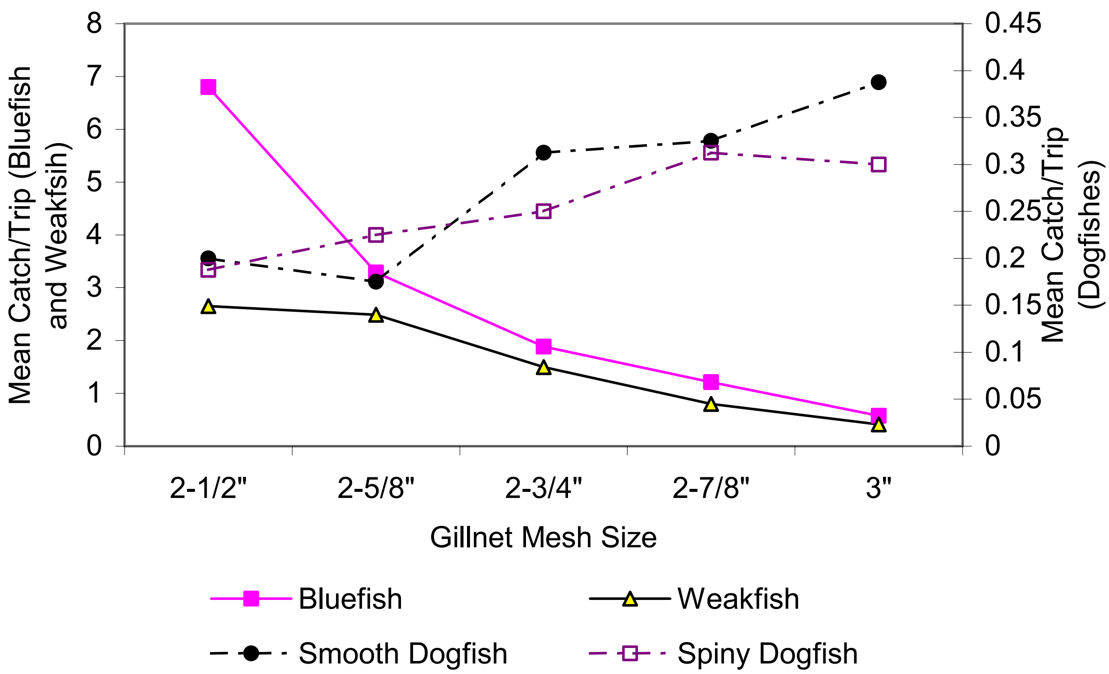

Figure 3. The mean number of fish caught per set for the top five species in abundance caught off Holden Beach in the FRG. Bluefish and weakfish are on the left axis and the dogfishes are on the right axis.

The NCDMF weakfish observer study conducted off Cape Hatteras did not have consistent effort in neither number of trips nor length of net by mesh size but it did give an indication which species were captured in association with a variety of mesh sizes. The data presented are from gill nets of 3 inch or less. The most abundant of the marketable species in the observer study was weakfish with over 12,000 captured. The highest catch per set for weakfish was observed in the 2-1/2 inch mesh and decreased as the mesh size increased until mesh size was 2-7/8 inch (Figure 4). The 3 inch mesh caught more weakfish than did the 2-7/8 inch and the catch was greater than the average catch at 2-3/4 inch. Atlantic croaker, the second most abundant marketable species, had the highest catch rate in the 2-3/4 inch mesh with lower catch rates observed in the smaller and larger mesh sizes. Kingfishes, third in number caught, and bluefish, fourth in number caught, had their highest catches in the 2-5/8 inch mesh and decreased as the mesh size increased to 3 inch. The minimum mesh size of 2-1/2 inch had very low catches for kingfishes and bluefish.

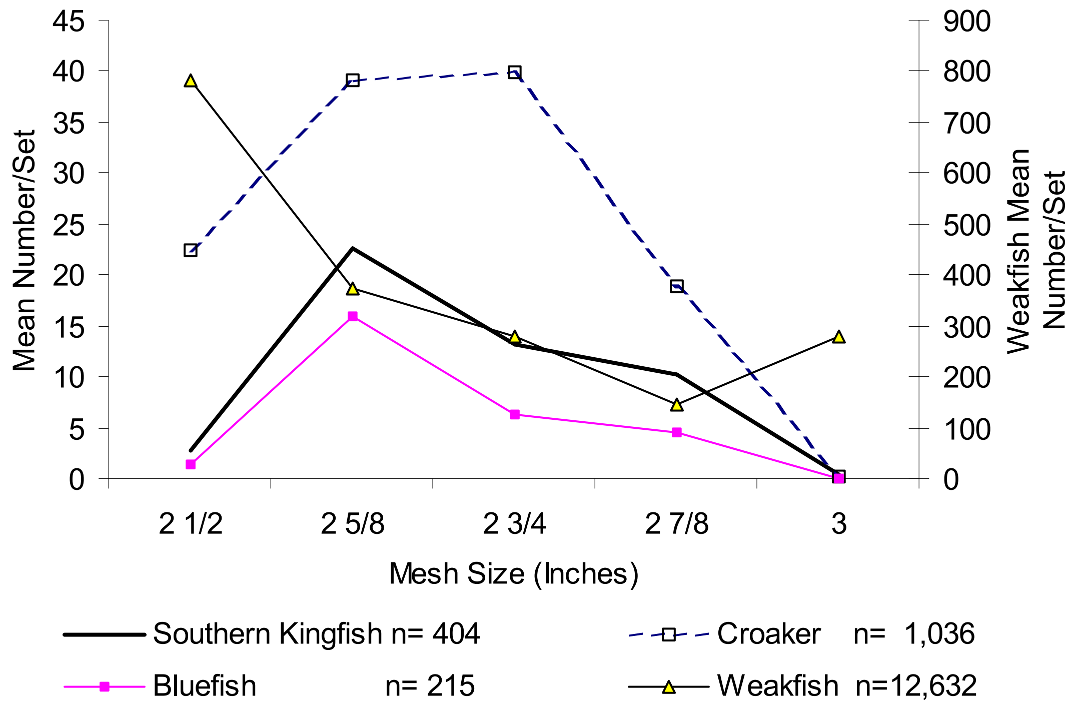

Figure 4. The mean number of fish caught per set for the top four marketable species observed by NCDMF in commercial gill nets targeting weakfish off Cape Hatteras.

Based on NCTTP data, the most common species landed (excluding bait) when greater than 50 lb of kingfishes are caught included weakfish, spot, Atlantic croaker, bluefish, butterfish, and spiny dogfish. These landings were separated by districts to determine if regional differences were present. Weakfish and kingfishes landings had dramatic difference in regional catches (Figure 5). The weakfish landings were much higher in the central and northern districts compared to the southern district. Kingfishes landings had the highest landings in the southern district and decreased in the central and northern districts. Spot had highest catches in the southern district and decreased northward. Other species were a minor component of the fishery.

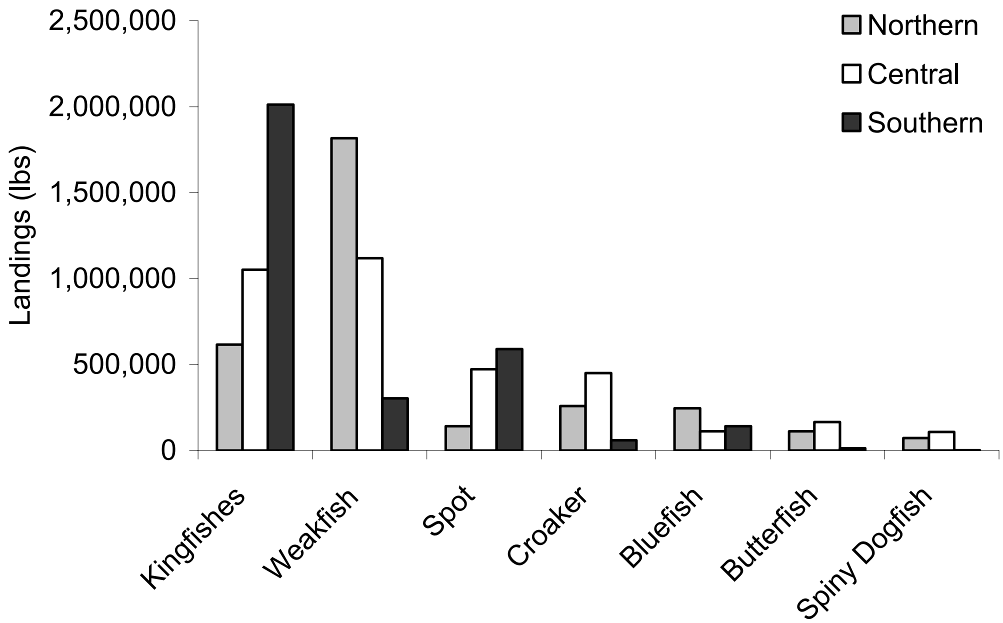

Figure 5. Combined landings of the top seven species by district excluding bait in directed kingfishes ocean gill net trips (1994 – 2004).

Since regulations were enacted to reduce the weakfish harvest and the northern district harvested the most weakfish with 50 lb of kingfishes, the landings in the northern district were investigated to determine if fishermen shifted from the weakfish fishery into the fishery for kingfishes. The weakfish landings decreased sharply after 1995 and since had a slight decreasing trend (Figure 6). Croaker was the only species to have an increase in landings until 2002 when kingfishes and croaker landings increased. These increases were not suspected to be increased effort from displaced weakfish fishermen but a function of new fishermen to the area and possibly a greater availability of kingfishes.

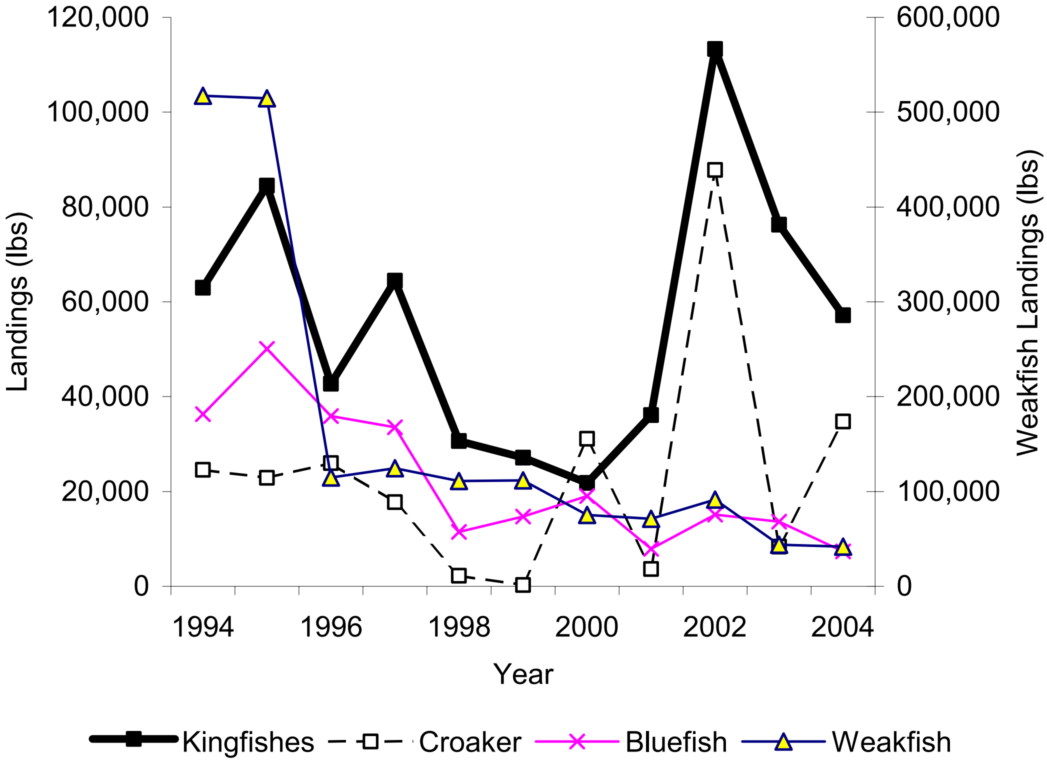

Figure 6. Landings by year for the northern district of the top four species associated with 50 lb or greater of kingfishes.

Gear Restrictions – Bycatch Reduction Devices (BRD)

During the 1980's the NCDMF and NMFS conducted studies on shrimp retention rates for various Turtle Excluder Devices [TEDs (1985 - 1986 NCDMF unpublished data, and 1988 - 1989 NMFS unpublished data)], and started work on identifying means to reduce finfish bycatch in the shrimp trawl fishery (Pearce et al. 1988, and Holland 1988). Amendment 1 to the Weakfish FMP was adopted in 1991. This amendment recommended that South Atlantic states implement programs to reduce bycatch mortality of weakfish in their shrimp trawl fisheries by 40% by 1 January, 1994 (ASMFC 1992). Based on results obtained during development work in 1990 and 1991 on NCDMF research vessels and operational testing conducted aboard a commercial trawler in 1992, the NCDMF required all shrimp trawlers working in state waters to equip their nets with functional fish excluders in October 1992. However, North Carolina was the only state that required finfish excluders. On 20 October, 1994 Amendment 2 of the Weakfish FMP was passed. This amendment required all South Atlantic states (NC-FL) to implement management measures to achieve the 40% reduction in bycatch of weakfish in the shrimp trawl fisheries by the start of the 1996 shrimping season (ASMFC 1994).

Since 1992, the NCDMF staff has worked with fishermen and used its own research vessel to test many different BRDs in a variety of waterbodies, seasons, and under various tidal and environmental conditions. The goal of the testing was to determine which devices would maximize finfish reduction, minimize shrimp loss and satisfy the requirements of Amendments 1 and 2 of the Weakfish FMP. In 1996, the NCMFC approved four BRDs for use in shrimp trawls. Proclamation SH-9-97, effective September 1, 1997, required shrimp trawlers to be equipped with one of the following approved designs: 1) a Florida fish excluder (FFE) measuring at least 5

1/2 x 6 ½ inches (inside measurement) positioned no more than 19 meshes from the top centerline of the tailbag and located no more than 65% up from the tailbag tie-off; 2) a large mesh funnel 8 or 10 inches stretched mesh; 3) a modified large mesh funnel excluder; or 4) a circular excluder constructed of PVC material measuring at least eight in in diameter, positioned no more than 15 meshes from the top centerline and located no more than 38% up from the tailbag tie-off. While these devices were approved for their ability to reduce weakfish bycatch, they also significantly reduce the bycatch of kingfishes in shrimp trawls. FFE devices reduce the bycatch of kingfishes by 39% (Table7). The large mesh funnel excluder had a 45% reduction in kingfishes (Table 8), and a 6 inch PVC excluder had a 70% reduction in southern kingfish (Table 9). Southern kingfish data from the 8 inch PVC excluder were analyzed but not included. The data collected had an increase in reduction rates for all species (except shrimp).

Table 7. Results of experimental tows with FFE designs for selected species (escapement opening GE 5½ x 6½ inches), tested aboard commercial trawlers in North Carolina, 1992 and 1994.

	Total weight (kg)			
n=165	Control	Experimental	Percent difference	P(T<=t)
Brown, white & pink shrimp	1,808.28	1,663.58	-8	0.00*
Spot	1,497.00	745.34	-50.21	0.00*
Kingfishes	**49.22**	**30.18**	**-38.67**	**0.00***
Atlantic croaker	2,810.17	1,277.42	-54.54	0.00*
Southern flounder	80.49	46.77	-41.89	0.00*
Summer flounder	89.85	90.28	0.48	0.93
Bluefish	34.14	15.32	-55.14	0.13
Spanish mackerel	31.37	20.3	-35.3	0.26
Weakfish (YOY)	133.36	40.93	-69.31	0.00*
Weakfish	314.63	167.33	-46.82	0.01*
Total weakfish	447.99	208.25	-53.52	0.00*
Total finfish	15,339.04	9,030.63	-41.13	0.00*

*significant difference at the P<=0.05 level or less

Table 8. Results of experimental tows with the large mesh extended funnel tested in Pamlico Sound North Carolina, 1994.

	Total weight (kg)			
n=36	Control	Experimental	Percent difference	P(T<=t)
Brown, white & pink shrimp	263.70	258.25	-2.07	0.54
Spot	668.11	191.05	-71.40	0.00*
Kingfishes	**26.16**	**14.38**	**-45.04**	**0.03***
Atlantic croaker	1612.29	595.06	-63.09	0.00*
Southern flounder	69.94	61.10	-12.64	0.50
Summer flounder	109.72	123.37	12.43	0.19
Bluefish	26.20	17.78	-32.11	0.05*
Spanish mackerel	2.51	0.42	-83.30	
Weakfish (YOY)	277.47	160.68	-42.09	0.00*
Weakfish	88.80	21.22	-76.11	0.00*
Total weakfish	366.28	181.90	-50.34	0.00*
Total finfish	3442.78	1558.76	-54.72	0.00*
Total catch	4434.38	2708.05	-38.93	0.00*

*significant difference at the P<=0.05 level or less

Table 9. Results of experimental tows with a 6 inch PVC excluder tested in Bay River, North Carolina, 1997.

	Total (kg)		
n=33	Control	"Sea Eagle"	Percent difference
Shrimp	187.8	175.45	-6.58
Spot	316.2	203.6	-35.61
Southern kingfish	**8.05**	**2.45**	**-69.57**
Atlantic croaker	169.5	107	-36.87
Southern flounder	29.55	24.15	-18.27
Bluefish	5.8	1.4	-75.86
Spanish mackerel	2	0	-100
Weakfish wgt.	67.3	41.65	-38.11
Weakfish #'s	1,158.00	820	-29.19
Total finfish	662.25	397.55	-39.97
Total catch	1,313.55	1,023.30	-22.1

No new devices have met the weakfish reduction requirements although BRD testing in North Carolina and other South Atlantic states continues. The preferred alternative for the certification of new BRDs in Amendment 6 to the FMP for the Shrimp Fishery of the South Atlantic Region recommended that for a new BRD to be certified, it must be statistically shown that the device can reduce the total weight of finfish by at least 30% (SAFMC 2004). This allowed for more flexible testing of BRDs and allowed the SAFMC to achieve an ecosystem approach in fisheries management. Review of available data for North Carolina indicated the current BRD requirements reduce bycatch of kingfishes by the 30% level.

Tow Time Restrictions

Shrimp trawl time restrictions can reduce bycatch of non-target species. It is unlawful to trawl for shrimp in the Atlantic Ocean off Brunswick County, from one hour after sunset to one hour before sunrise. This management measure was implemented primarily to reduce the bycatch of finfish. Ingraham (2003) examined this regulation by conducting a study of shrimp and finfish catch rates (day vs. night) in state waters from Topsail Inlet to Little River Inlet. Data from this study revealed that finfish bycatch was higher at night than during the day. Of the nine commercially important finfish species caught, southern flounder, spot, Atlantic croaker, and southern kingfish catch rates were significantly higher at night. The catch of shrimp did not vary statistically between nighttime and daytime trawling even though catches were slightly higher during the day. Further investigation is needed to determine if this trend is observed throughout state waters. Limiting the time of fishing may reduce bycatch and provide a benefit to several stocks.

V. Research recommendations

Stock Assessment

1. Determine migration and mixing of kingfishes along North Carolina and the Atlantic Coast.
2. Validate YOY and adult indices used in trend analysis and expand current indices to include a seine survey in the ocean.
3. Continue with aging studies to provide future stock assessments with aging data for each species of kingfish.
4. Determine selectivity patterns for a variety of fisheries along the North Carolina Coast to be used in YPR and other stock assessments.
5. Recommend a coastwide stock assessment be conducted for the Atlantic Coast or South Atlantic Bight.
6. Collect observer data from commercial fishing operations to estimate at sea species composition of the catch, discard rates, and lengths.

Size Limit

7. Improve data collection in MRFSS and commercial fish house sampling

Seasonal/Area Closure

8. Sample inlets and river plumes to determine the importance of these areas for kingfishes and other estuarine dependent species.

Gear Restrictions

9. Expand the NCDMF fishery independent gill net survey to provide data on species composition, abundance trends, and population age structure by including additional areas of North Carolina’s estuarine and near-shore ocean waters.
10. Continue bycatch reduction device studies to decrease bycatch.

Impacts of Management Actions

11. Conduct surveys for socioeconomic studies.

VI. Management Options

1. Status quo
   - \+ No rule changes or legislative actions
   - \+ No additional restrictions
   - \+ No additional burden to law enforcement
   - \- Possibility of over harvesting in the future resulting in an overfished stock status

2. Management triggers
   - \+ Proactive management measure
   - \+ Protects kingfishes from overfishing
   - \+ Enables rapid response to changes in population trends
   - \- Yearly analysis will be time consuming
   - \- Uncertainty in defining effective triggers
   - \- Data used to initiate trigger may not be representative of stock abundance

3. Recommend ASMFC or SAFMC manage kingfishes
   - \+ Would address stock issue for kingfishes assessment
   - \+ Data from managed states would be used to determine the status of the stock instead of just North Carolina
   - \+ Provides a forum to present data on a traditional fishery in North Carolina
   - \- Less involvement for the North Carolina stakeholders in the management process
   - \- NCMFC and NCDMF may not agree with management recommendations
   - \- Kingfishes not currently managed by ASMFC or SAFMC
   - \- Other states may not possess adequate data for a stock assessment
   - \- It could be years before a coast wide stock assessment is conducted

4. Limited Entry

   Cannot be considered for action unless there is no other means of achieving the target fishing mortality level, which is unknown.

5. Quotas
   - \+ Controls harvest levels
   - \+ Protects the stock from extremely high harvest rates
   - \- Not sensitive to fluctuations in recruitment or availability of fish to the fishery
   - \- Additional reporting burden to commercial dealers
   - \- Requires additional resources from NCDMF to implement
   - \- May restrict harvest more or less than necessary
   - \- Overfishing may still occur if recruitment is minimal
   - \- Potential to go over quota due to short period of high landings.

6. Trip/Vessel Harvest Limits
   - \+ Reduces effort in the fishery
   - \+ May reduce bycatch of incidental catch
   - \- Increase discards
   - \- May adversely impact some fisheries and fishermen more than others.
   - \- Increase the burden on law enforcement

7. Implement a size limit for kingfishes
   - \+ Increases the average size of kingfishes harvested
   - \+ Increases the spawning stock biomass
   - \+ Increases percent of females entering spawning stock
   - +/- Reduces the number of smaller or larger fish harvested in the catch
   - +/- Changes selectivity of commercial fishery
   - \- Increases the burden on law enforcement
   - \- Increases the regulatory discards in commercial and recreational fisheries
   - \- May decrease landings of kingfishes

8. Season closures
   - \+ No additional resources required to implement
   - \+ No reporting burden on fishermen or dealers
   - \+ Reduces effort from current level
   - \+ Reduce bycatch mortality
   - \- Forces fishermen to search for other sources of income
   - \- Weather may prevent fishing during open periods
   - \- Increase the burden on law enforcement
   - \- Fisheries are not affected equally

9. Area closures
   - \+ No additional resources required to implement
   - \+ No reporting burden on fishermen or dealers
   - \+ Protects kingfishes habitat
   - \+ May reduce bycatch mortality
   - \- Forces fishermen to search for other sources of income
   - \- Effort may shift into other areas reducing the effectiveness of the closure
   - \- May adversely impact some fisheries and fishermen more than others
   - \- Increase the burden on law enforcement

10. Mesh size restrictions in the sinknet fishery

    Option 1: Increase the current minimum mesh size to 2-5/8" or 2-3/4" stretched mesh
    - \+ Increases the average size of kingfishes harvested
    - \+ Will reduce total number of fish harvested
    - +/- Varying bycatch rates depending on mesh size and species
    - \- May decrease the landings of kingfishes
    - \- Cost to fishermen to modify gear
    - \- Increases the burden on law enforcement
    - \- Potential for increased amount of gear fished to recoup lost catch

    Option 2: Regional mesh size restrictions in the gill net fishery
    - \+ Increases the flexibility to minimize impacts of the kingfishes fishery on other species
    - \+ Maintains traditional kingfishes fishery in most of NC
    - +/- Varying bycatch rates depending on mesh size, region, and species
    - \- May decrease the landings of kingfishes
    - \- May be difficult to enforce
    - \- Cost to fishermen to modify gear

- Increases the burden on law enforcement
- Potential for increased amount of gear fished to recoup lost catch

11. Restrict Shrimp Trawling to Day Time Only

+ No reporting burden on fishermen or dealers
+ May reduce bycatch
+/- Likely to reduce the harvest of pink shrimp which occurs at night
- May force fishermen to search for other sources of income
- May increase amount of gear or tow times to account for the night closure
- May adversely impact some fisheries and fishermen more than others
- Increased the burden on law enforcement

VII. Recommendations:

PDT: The ASMFC or SAMFC manage kingfishes. Management triggers to determine when kingfishes are showing signs of overfishing and investigate management options to obtain or maintain a sustainable harvest. The triggers include all the management triggers listed in the issue paper with the exception of relative percent landings (Management Trigger 1. because effort is not considered). The management of kingfishes use proclamation authority to allow for flexibility in management actions to restore a sustainable harvest of kingfishes and to respond to mandates by ASMFC or SAFMC for kingfishes.

AC: Management triggers with proclamation authority. If a trigger is met, the director will have proclamation authority to protect the population of kingfish so as to obtain and maintain sustainable harvest. The Kingfish AC recommended that the draft proclamation and all relevant supporting information be released to the public for their review and comment to the Director. This comment period need not exceed thirty days, and may be made available to the public by publication on the Division's web site without the need for public meetings. The AC further recommended that after the comment period, within 10 days, the AC would be reconvened to discuss potential management action and public comment, and recommend a course of action to the Director.

Management Triggers include:

- Biological Monitoring
  - Mean length by fishery compared to last five years
  - Proportion of age one kingfishes greater than 50% of fish 11.0 to 11.8" TL
- CPUE
  - Commercial < 2/3 of the average 1999 to 2004
  - Recreational < 2/3 of the average 1999 to 2004
- Surveys Juvenile and Adult
  - Pamlico Sound fall 2/3 below mean CPUE
  - SEAMAP fall 2/3 below mean CPUE

VIII. Proposed kingfish Rule:

15A NCAC 3M .0517

.0517 KINGFISH
Kingfish (Sea Mullet)

The Fisheries Director may, by proclamation, impose any or all of the following restrictions on the taking of kingfishes:
(1) Specify season,
(2) Specify areas,
(3) Specify quantity,
(4) Specify means/methods,
(5) Specify size.

History Note: Authority G.S. 113-134; 113-182, 113-221, 143B-289.4;
Eff. _________, 2008

IX. Literature Cited

ASMFC 2007. Review of the Atlantic States Marine Fisheries Commision's Fishery Management Plan for Spiny Dogfish (*Squalus acanthias*). Washington, D.C.

ASMFC 2002. Amendment 4 to the Interstate Fishery Management Plan for Weakfish. Atlantic States Marine Fisheries Commision, Washington, D.C. Fisheries Management Report No. 39.

Beresoff, D.G. 1998. Gill net selectivity study. North Carolina Sea Grant. 96FEG-48.

Bourne, W.B. and J.J. Govoni. 1988. Distribution of fish eggs and larvae and patterns of water circulation in Narragansett Bay, 1972-1973. American Fisheries Society Symposium 3: 132-148.

Holland, B.F., JR. 1988. Evaluation of Certified Trawl Efficiency Devices (TEDs) in North Carolina's Nearshore Ocean. North Carolina Department of Environment and Natural Resources. Completion Report Project 2-439-R 38 pp.

Ingraham, B. 2003. Night vs. day bycatch comparison for shrimp trawling in the southern district of North Carolina. North Carolina Sea Grant Fishery Resource Grant 98-FEG-46.

Markovsky, W.C. 2004. The role of the Cape Fear River discharge plume in fisheries production: aggregation and trophic enhancement. Master's Thesis. University of North Carolina Wilmington.

NCDMF 2004. North Carolina Blue Crab Fishery Management Plan. North Carolina Department of Environment and Natural Resources, Morehead City, NC.

NCDMF 2006a. North Carolina Shrimp Fishery Management Plan. North Carolina Department of Environment and Natural Resources, Morehead City, NC.

NCDMF 2006b. Stock Status Report for 2006. www.ncfisheries.net/stocks/index.html accessed on 20 Feb, 2007

Pearce, K.B., D.W. Moye, and S.K. Strasser. 1988. Evaluation of trawl excluder devices in the Pamlico Sound shrimp fishery. Albemarle-Pamlico Estuarine Study Report No. 88-07. 46 pp.

SAMFC 2004. Final Amendment 6 to the Fishery Management Plan for the Shrimp Fishery of the South Atlantic Region: Including a Final Supplemental Environmental Impact Statement, Initial Regulatory Flexibility Analysis, Regulatory Impact Review, Social Impact Assessment, Fishery Impact Statement and Biological Assessment. South Atlantic Fishery Management Council. 305 pp.

Seagraves, R.J., 1991. Weakfish Fishery Management Plan Amendment #1. Atlantic States Marine Fisheries Commision, Washington, D.C. Fisheries Management Report No. 20. 68pp.

Smith, J.W. and C.A. Wenner. 1985. Biology of the southern kingfish in the South Atlantic Bight. Transactions of the American Fisheries Society 114:356-366.

Street, M.W., A.S. Deaton, W.S. Chappell, and P.D. Mooreside. 2005. North Carolina CHPP. NC Department of Environment and Natural Resources, Morehead City, NC.

12.4 APPENDIX 4. LENGTH FREQUENCY PLOTS FROM COMMERCIAL FISHERIES AND THE RECREATIONAL FISHERY

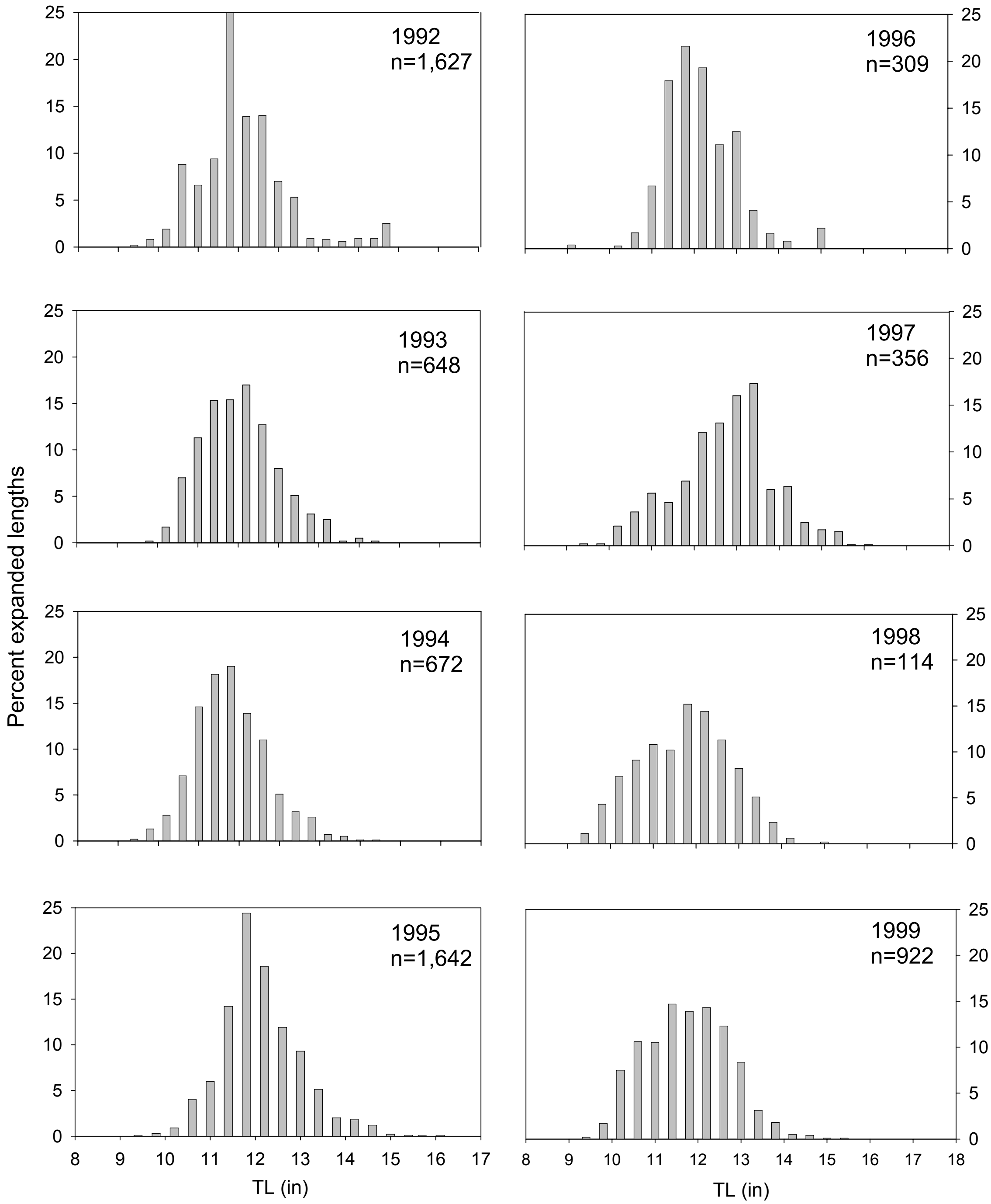

Figure 1. Length frequency plots of southern kingfish in the sink net fishery (1992 - 2004). Lengths are grouped into 0.4” size bins.

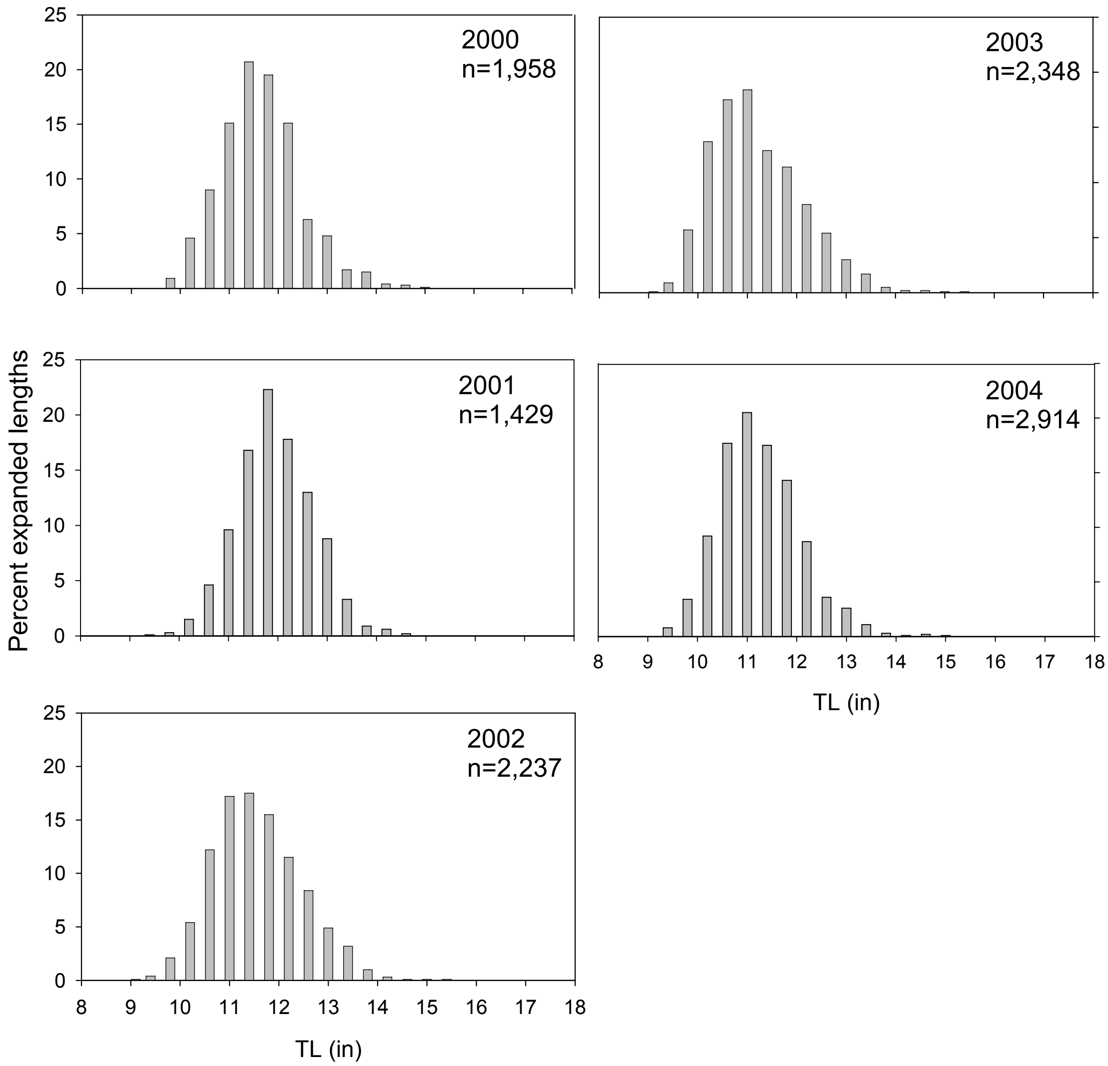

Figure 1. continued

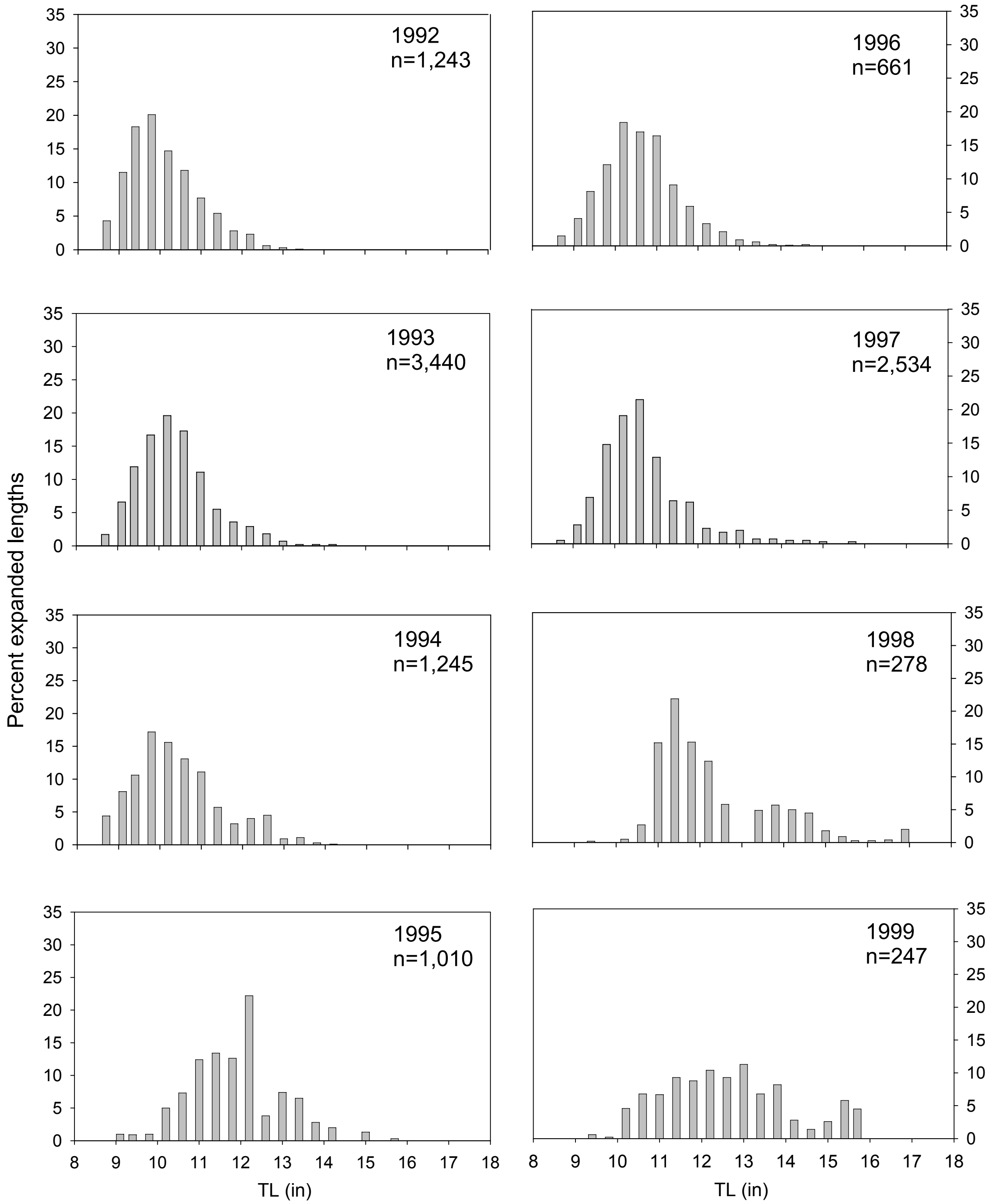

Figure 2. Length frequency plots of southern kingfish in the ocean trawl fishery (1992 - 2004). Lengths are grouped into 0.4" size bins.

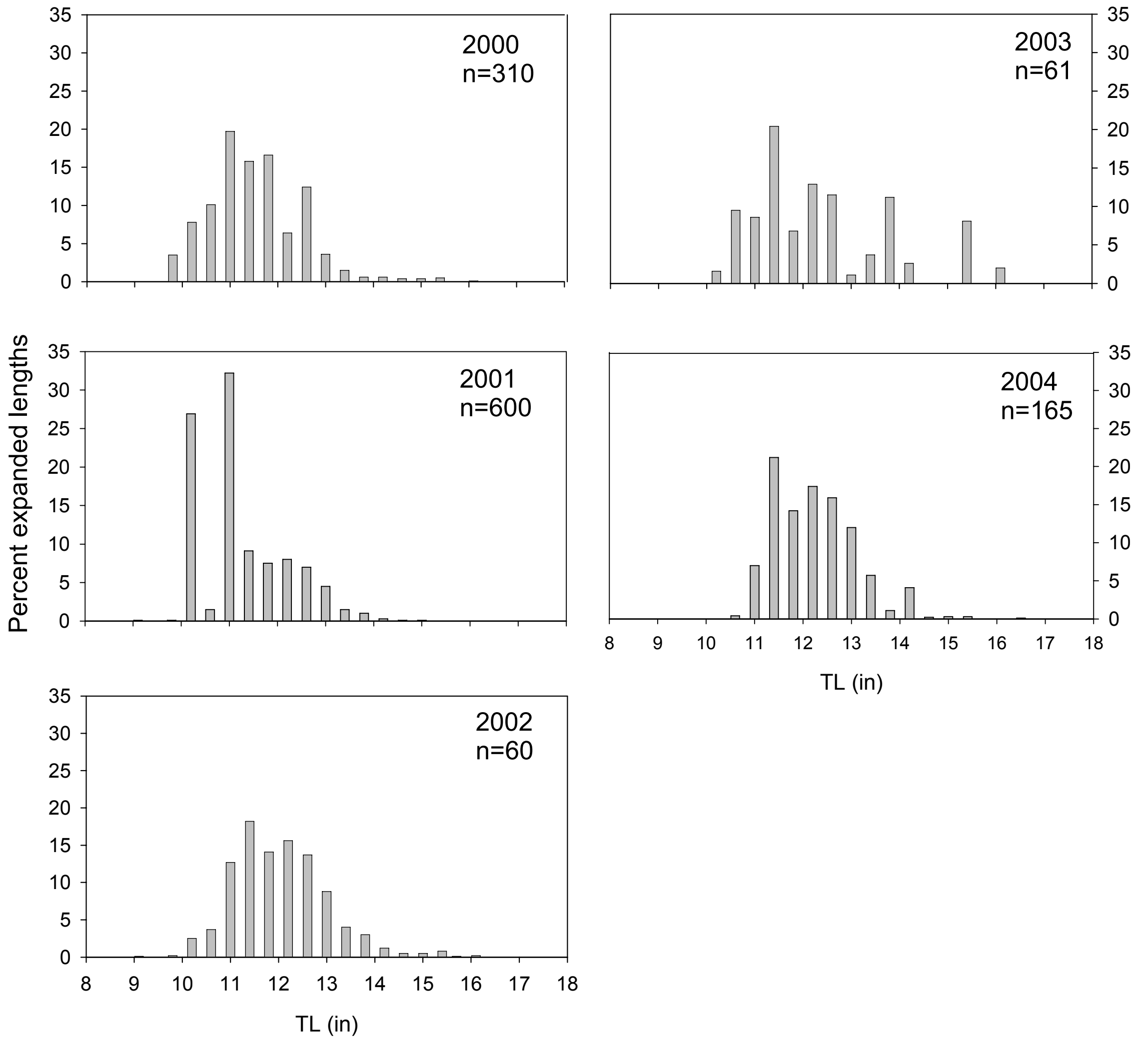

Figure 2. continued

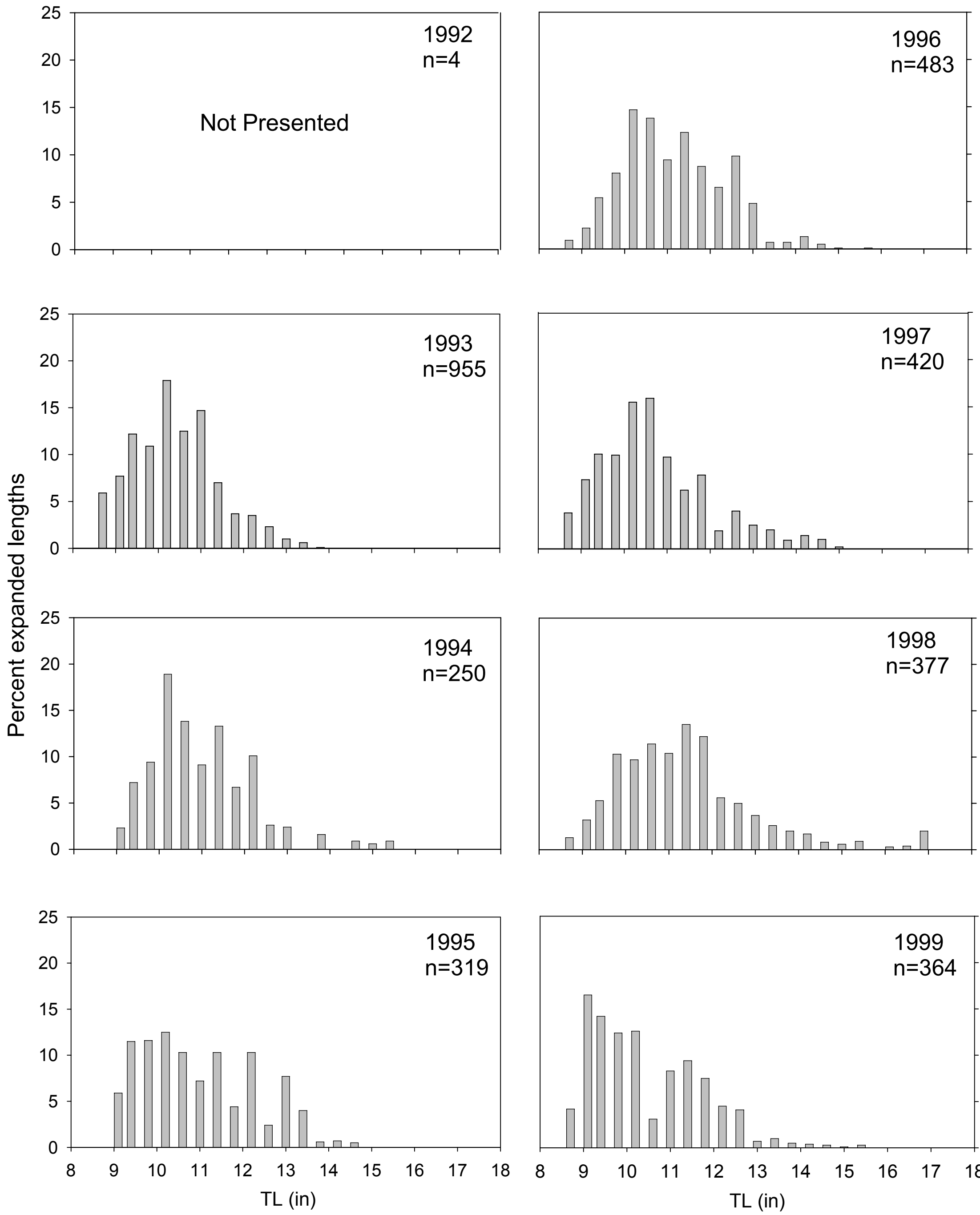

Figure 3. The length frequency plots of southern kingfish in the long haul seine fishery (1992 - 2004). Lengths are grouped into 0.4” size bins.

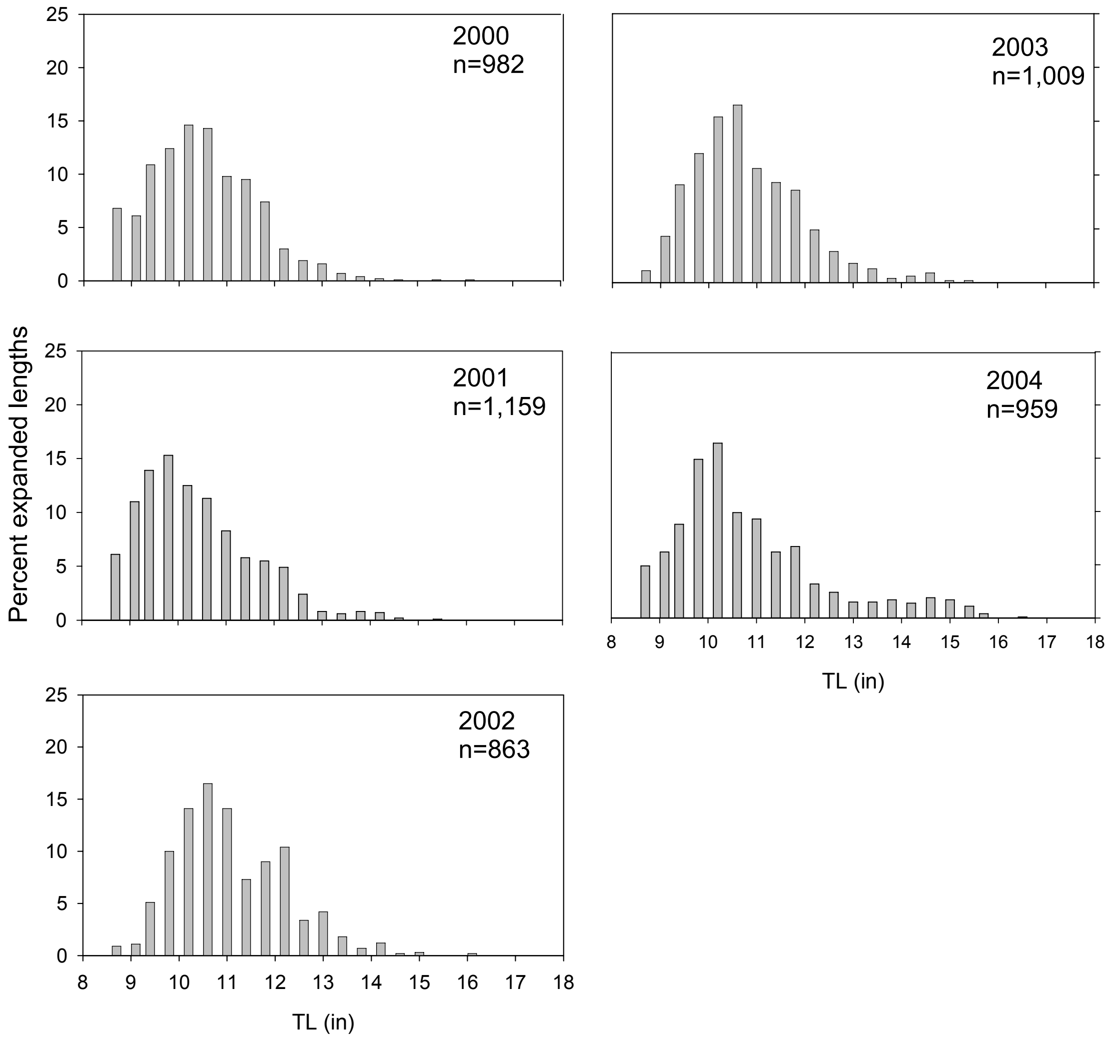

Figure 3. continued

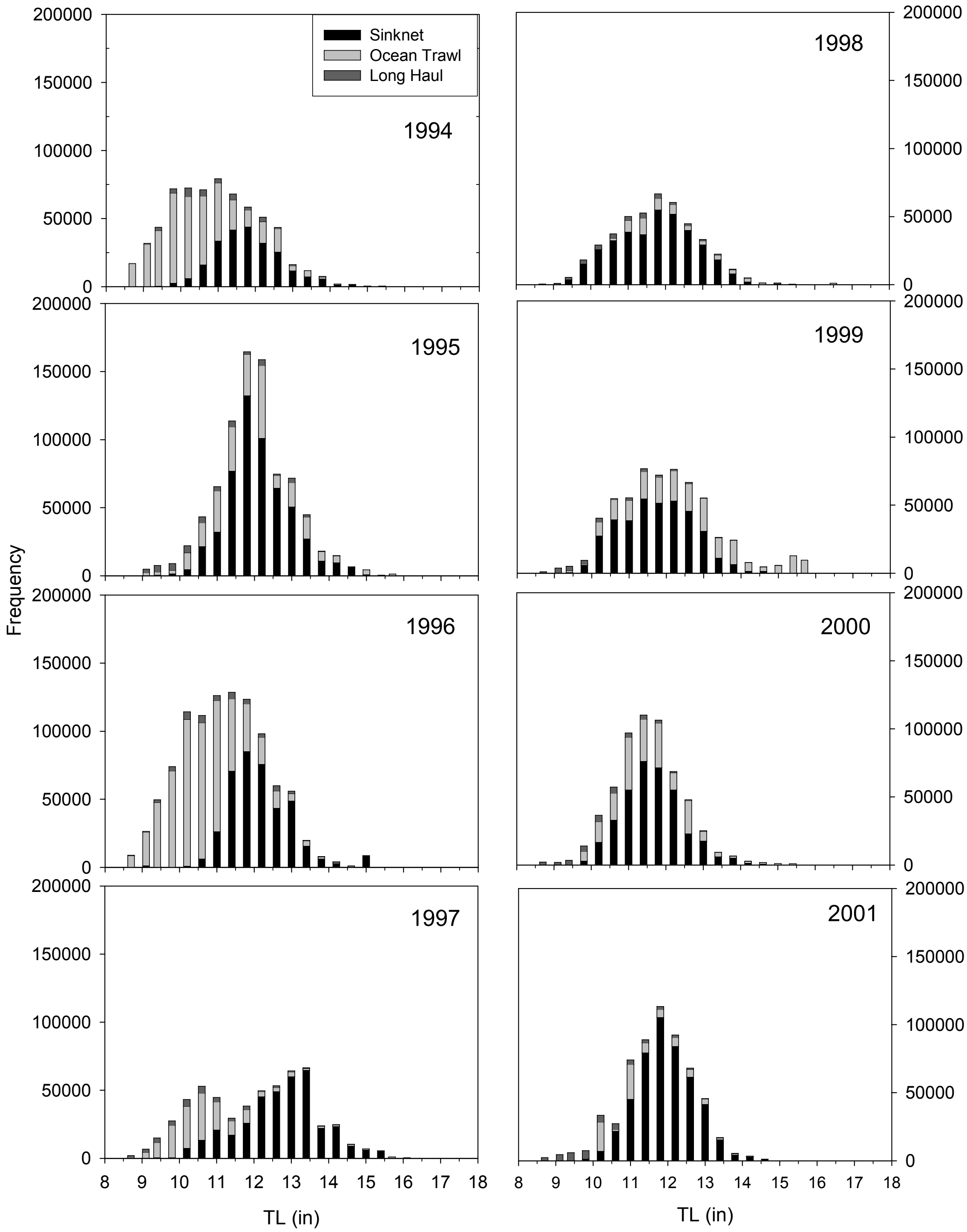

Figure 4. Length frequency plots based on fish house measurements for total numbers of southern kingfish caught by each fishery (1994 - 2004). Lengths were grouped into 0.4" size bins.

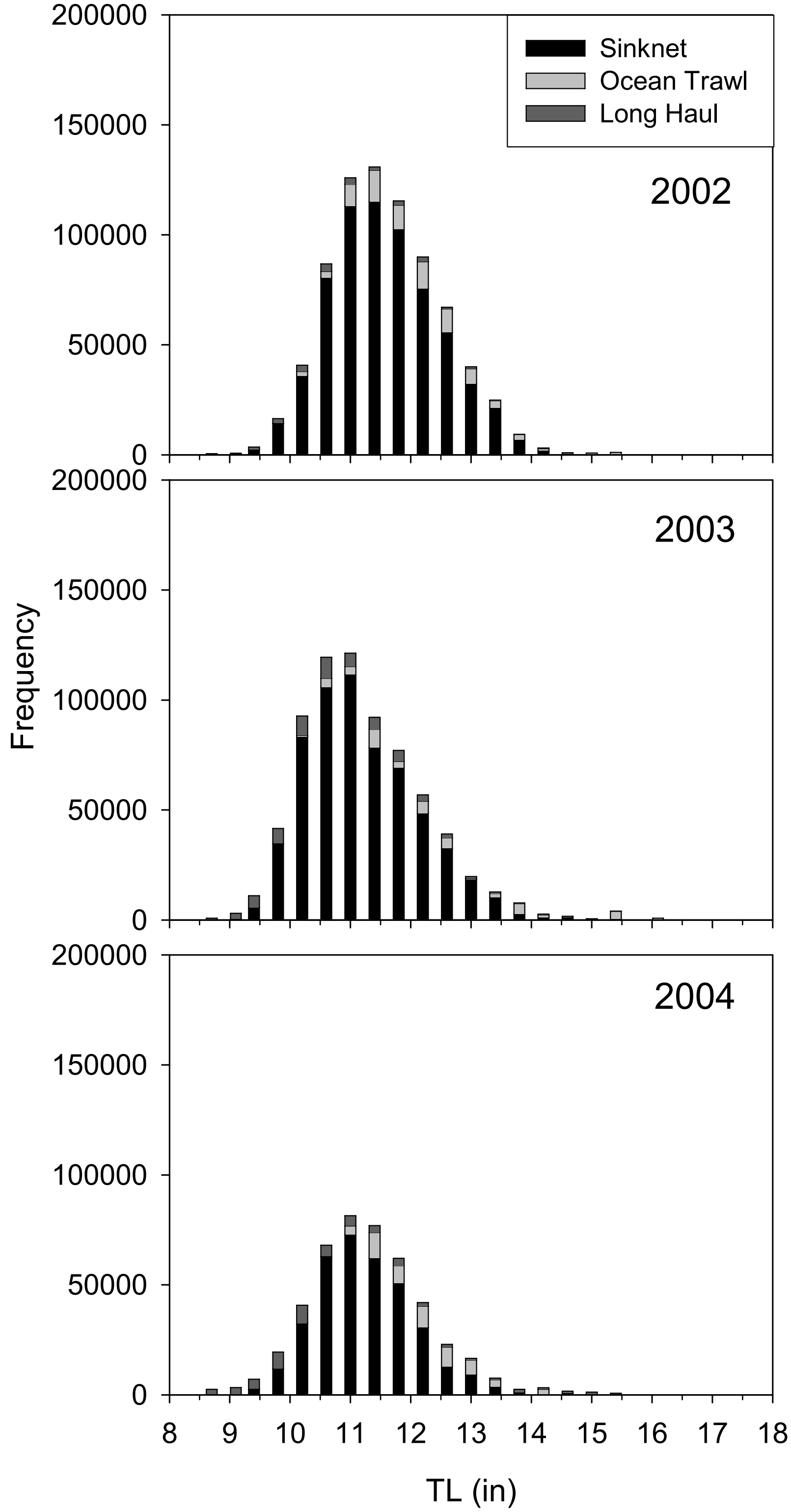

Figure 4. continued

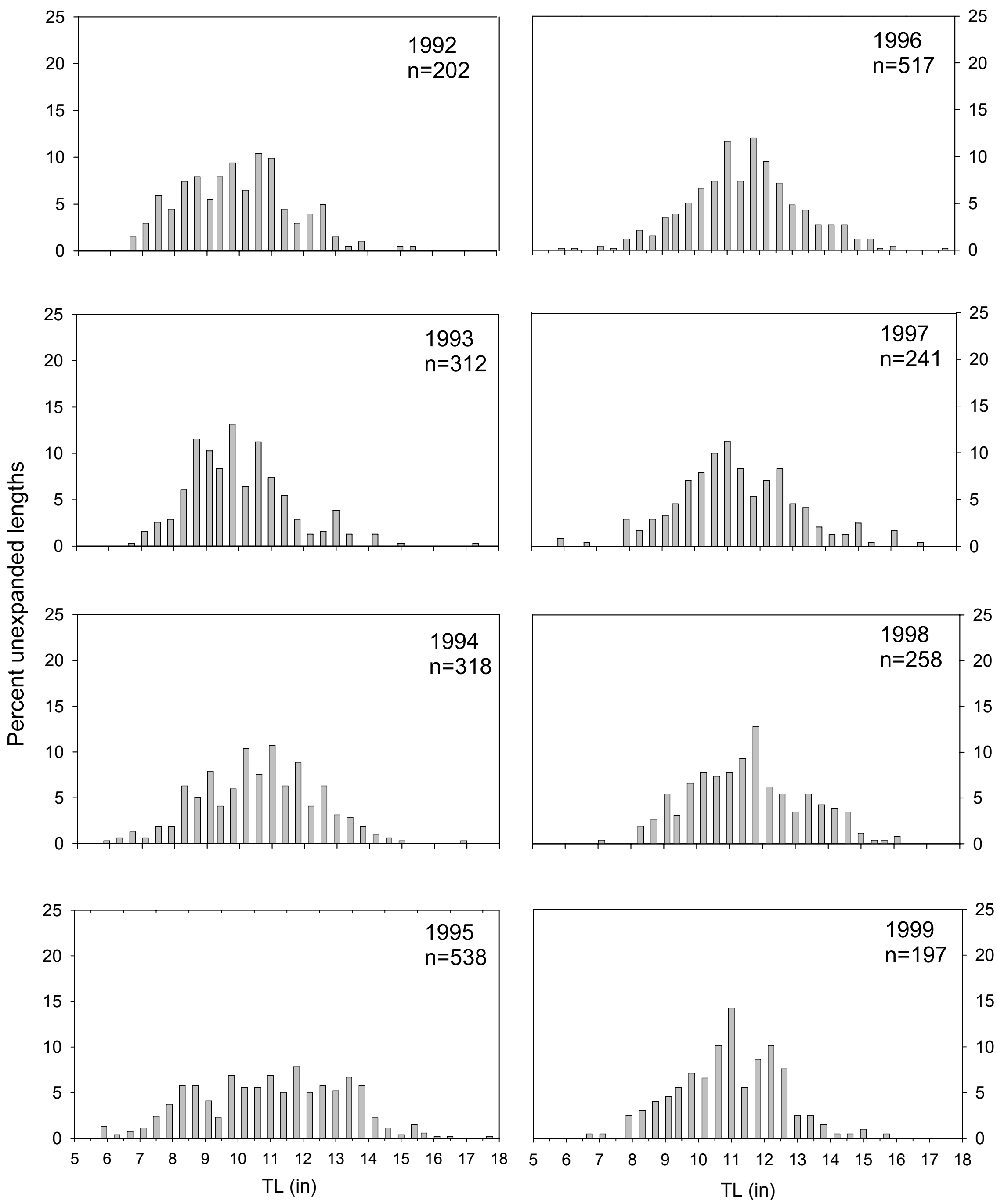

Figure 5. Recreational length frequency plots for southern kingfish measured by MRFSS port sampler (1992 - 2004). Lengths are grouped into 0.4” size bins.

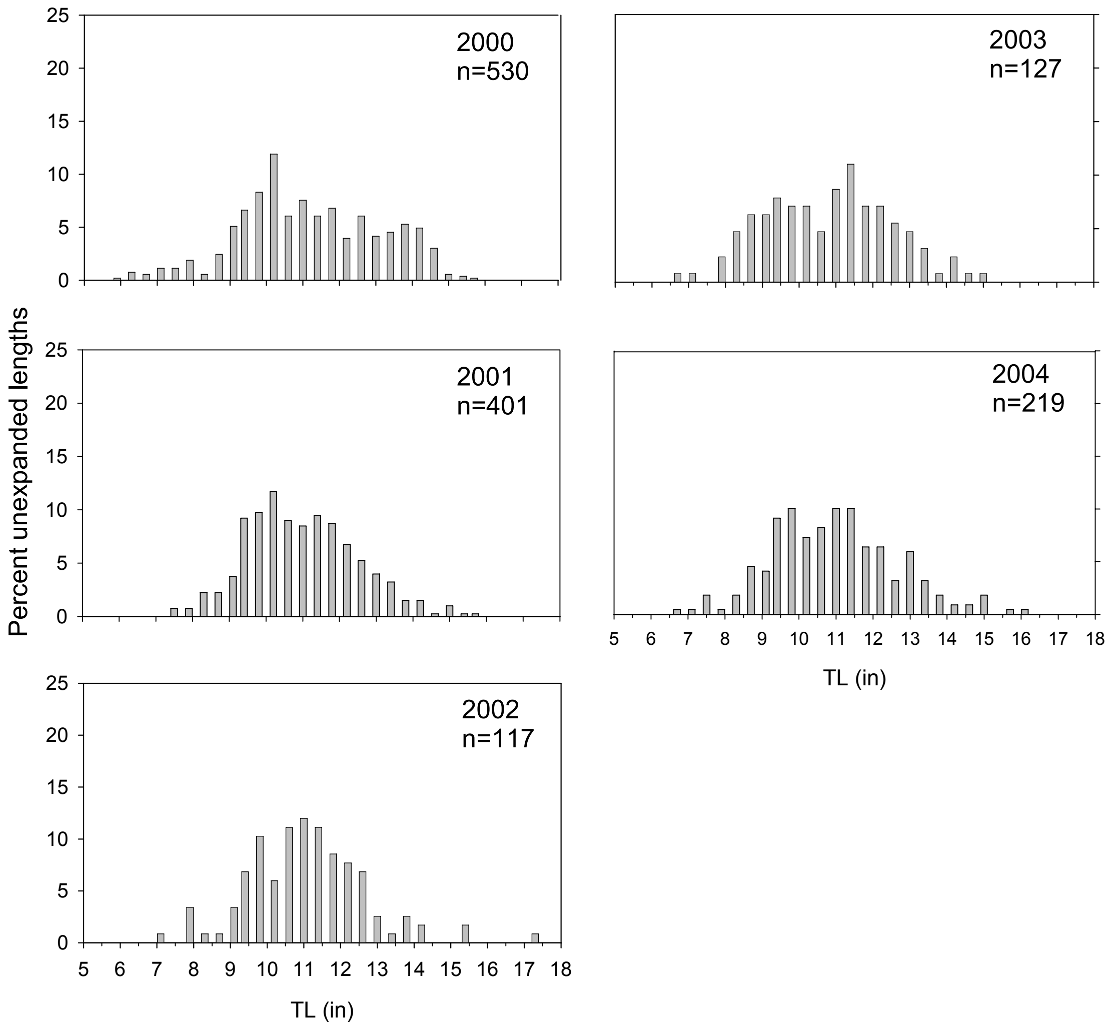

Figure 5. continued

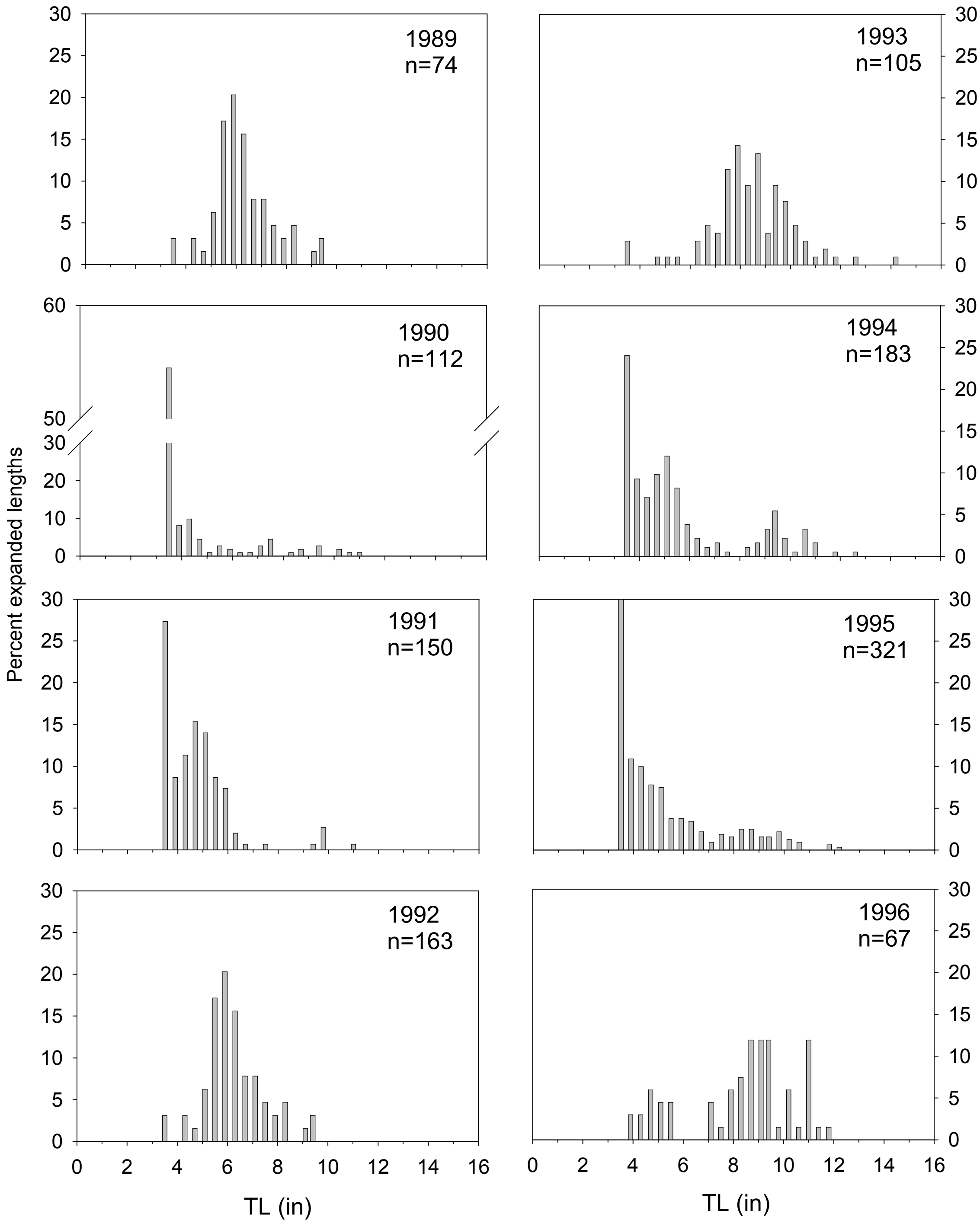

Figure 6. Length frequency plots for southern kingfish captured in the Pamlico Sound Survey (1989 - 2004). Lengths are grouped into 0.4" size bins.

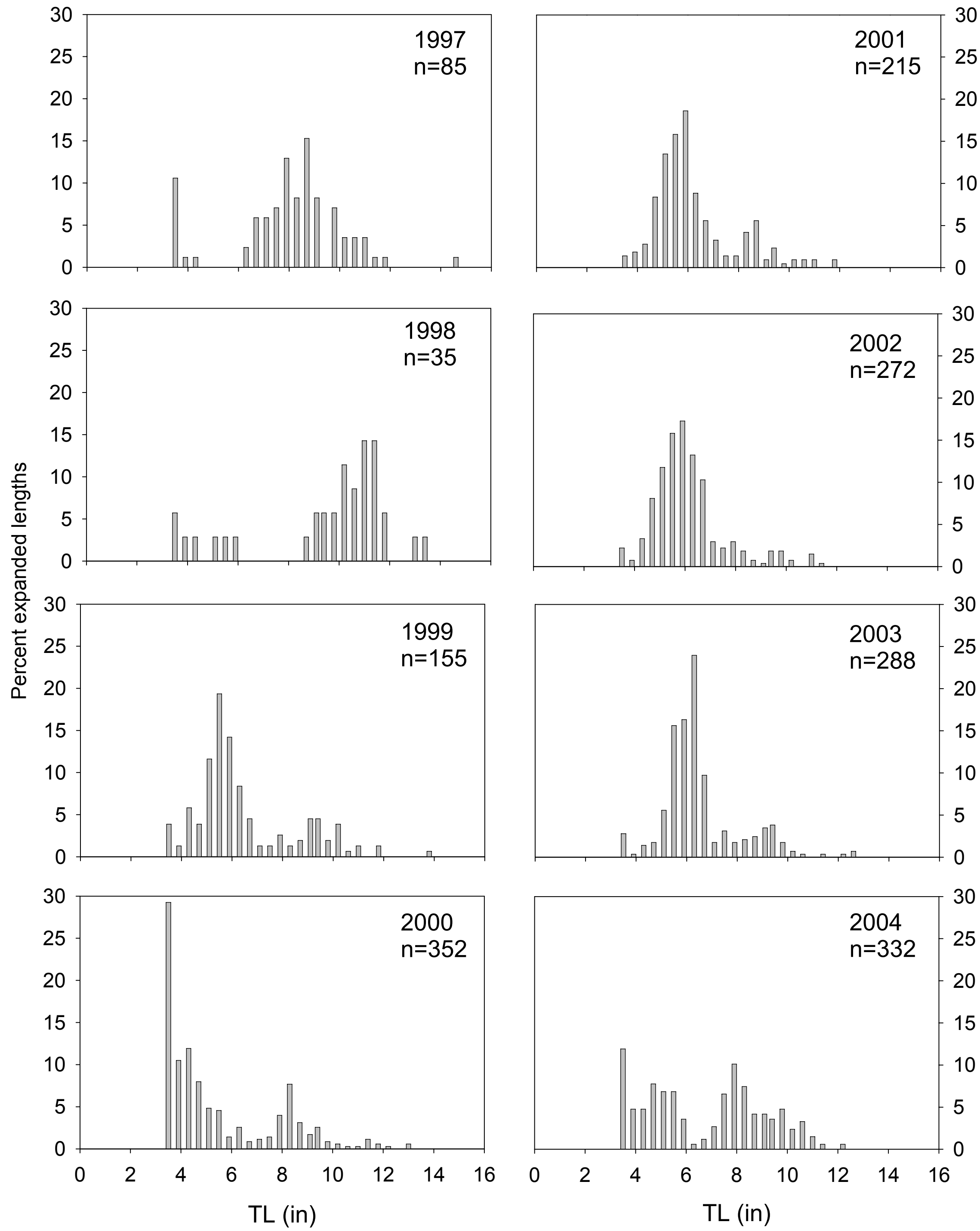

Figure 6. continued

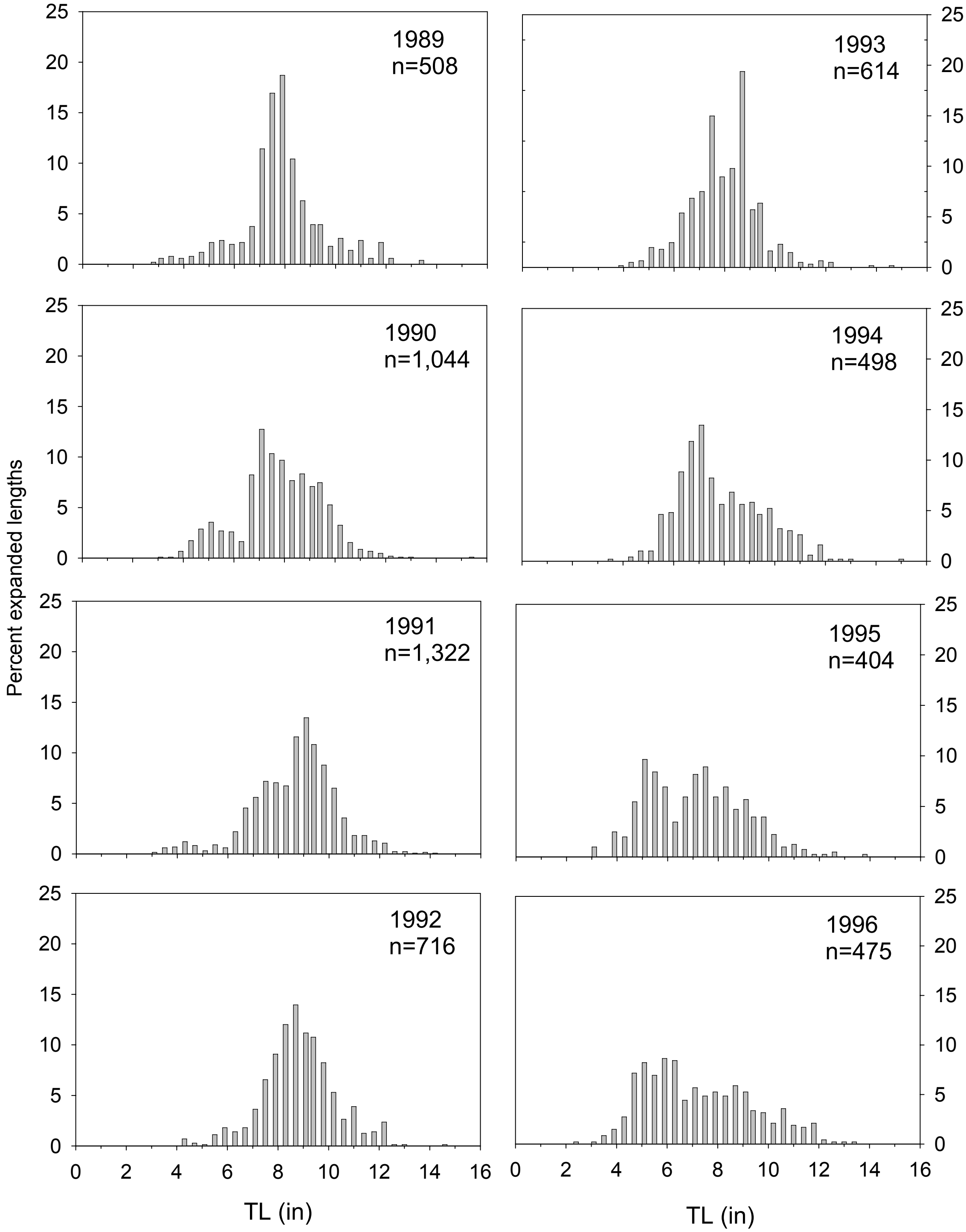

Figure 7. Lengths frequency plots of expanded numbers for southern kingfish in the summer and fall SEAMAP cruises (1989 - 2004). Lengths were grouped into 0.4” size bins.

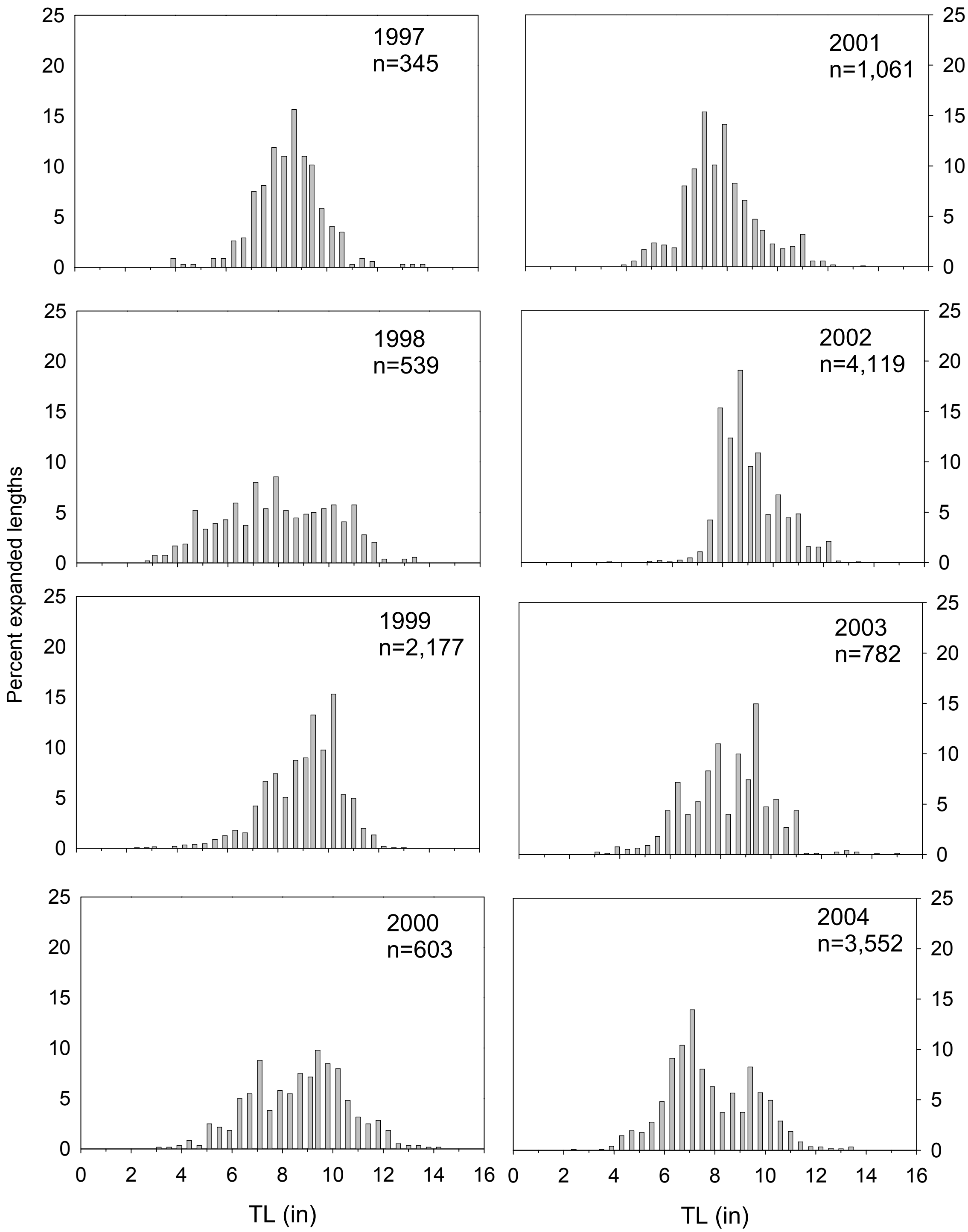

Figure 7. continued

12.5 APPENDIX 5. GLOSSARY OF BIOLOGICAL TERMS

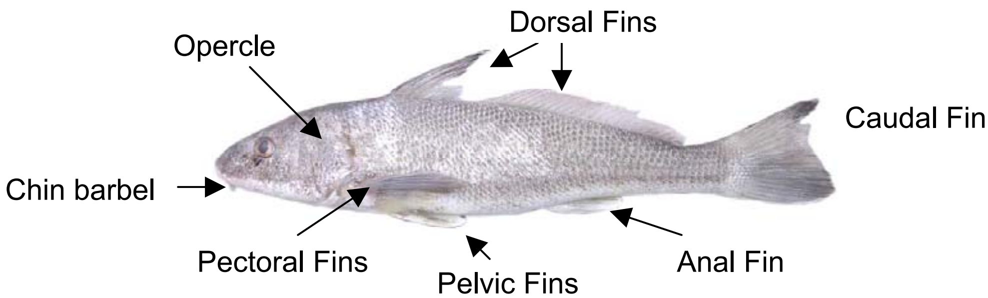

Figure 1. Picture of a gulf kingfish with some key anatomical features identified.

Anal fin – (see Figure 1).

Annulus – a conspicuous dark band on concentric bony structures (e.g. scales, otoliths) of fishes caused by a period of slow growth similar to growth rings on a tree. Age can be determined by annuli, if fish undergo predictable, yearly, periods of slow growth (e.g. cold winters in temperate climates).

Atrectic – degenerating.

Benthic – occurring on the bottom of a water body (e.g. sea floor, river floor).

Branchial – of, or relating to, the gills.

Carnivorous – feeding on animal tissue.

Catadromous – spending most of the life cycle in freshwater, yet spawning in marine water.

Caudal fin – (see Figure 1).

Detritus – dead plant or animal matter.

Detritivore – organism that feeds on detritus.

Diatomaceous microalgae – unicellular algae with cell walls made of silica.

Diel – occurring each day.

Dorsal fin – (see Figure 1).

Epiphyte – plant (or alga) that grows on the surface of another plant.

Euryhaline – able to tolerate a wide range of salinity changes.

Fecundity – the number of eggs in the ovaries of a female fish, a common measure of reproductive potential in fishes.

Gill lamellae – feather like structures in gill tissue that exchange gases between the gills and the aquatic environment.

Gill rakers – cartilaginous or bony teethlike projections on the gill arches of fishes that aid in capture or retention of prey.

Gonadosomatic Index (GSI) – weight of the gonads expressed as a percentage of the body weight, a common approach to documenting gonad development (Nielsen and Johnson 1992).

Gravid – carrying eggs.

Herbivorous – feeding on plant tissue.

Hermaphroditic – containing both male and female reproductive parts.

In vitro – in an environment outside of the living body; under laboratory conditions.

Isochronal – producing offspring in one batch.

Iteroparous – producing offspring over several periods (e.g. seasons, years).

Marine snow – suspended particles in the water column made of accumulated detritus, mineral grains, phytoplankton, and microorganisms bound in a mucous matrix (Larson and Shanks 1996).

Oil globule – first occurs during development of the egg and persists on the yolk during the yolk sac larval stage; important buoyancy and energy source for developing larva.

Oogenesis – the process of developing ova (eggs).

Opercle – bony plate that covers the gills (see Figure 1).

Osmoregulation – regulation of constant internal water concentration, even if the external environment fluctuates.

Otolith – one of three calcareous (made of calcium) “ear stones” in fishes, which function in equilibrium and detection of sound vibrations.

Pectoral fin – (see Figure 1).

Pelvic fin – (see Figure 1).

Phytoplankton – very small floating or suspended plant life in aquatic ecosystems (e.g. diatoms, microscopic blue-green algae).

Relative fecundity – the number of eggs carried by a fish divided by its body weight.

Spermatogenesis – the process of producing mature sperm cells.

Stenohaline – able to tolerate only a narrow range of salinity changes.

Trophic level – classification of organisms in an ecosystem according to feeding relationships, from first level autotrophs (i.e. plants, algae) through succeeding levels of herbivores, carnivores and decomposers (Smith 1980).

Vitellogenic – during a stage of reproductive development when vitellogenin (a major yolk protein) is incorporated into the oocytes (egg cells).

Yolk sac – pouch containing yolk reserves carried by early stage, free-swimming fish larvae.

Young-of-the-year (YOY) – first year of life for finfishes, also known as age 0.

Zooplankton – floating or weakly swimming animals in aquatic ecosystems (e.g. copepods, early stage fish larvae)

12.6 APPENDIX 6. PROPOSED RULE

15A NCAC 3M .0517
.0517 KINGFISH
Kingfish (Sea Mullet)

The Fisheries Director may, by proclamation, impose any or all of the following restrictions on the taking of kingfishes:
(6) Specify season,
(7) Specify areas,
(8) Specify quantity,
(9) Specify means/methods,
(10) Specify size.

History Note: Authority G.S. 113-134; 113-182, 113-221, 143B-289.4;
Eff. _________, 2008

Technical Amendment
Rule 15A NCAC 3J .0202 (5) was unintentionally changed when it was modified to address the flynet fishery south of Cape Hatteras. The language in the rule changed from "lawful" to "unlawful". The rule is supposed to allow 50% of the catch in the shrimp and crab trawl fisheries be finfish plus an <u>additional</u> 300 pounds of kingfish, which is what was approved originally.

Old Rule:
15A NCAC 3J .0202
(5) ~~Finfish taken with shrimp or crab trawls:~~
~~(a) It is unlawful to possess finfish (including pursuant to 15A NCAC 03M .0102) incidental to shrimp or crab trawl operations from December 1 through March 31 unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish except as provided in Sub-Item (5)(b) of this Rule;~~
~~(b) It is unlawful to possess more than 300 pounds of kingfish (Menticirrhus, sp.) taken south of Bogue Inlet regardless of the amount of shrimp, crabs, or finfish taken.~~

Amended Rule:
15A NCAC 3J .0202
(5) It is unlawful to possess finfish (including pursuant to 15A NCAC 03M .0102) incidental to shrimp or crab trawl operations from December 1 through March 31 unless the weight of the combined catch of shrimp and crabs exceeds the weight of finfish, except an additional 300 pounds of kingfish (*Menticirrhus*, spp.) may be taken south of Bogue Inlet.

12.7 APPENDIX 7. MANAGEMENT OPTION VOTES

Kingfish Fishery Management Plan Advisory Committee Votes on Rules and Regulations

Principal Issues:

Habitat: Passed
Water Quality: Passed
Protected Species: Passed
Management Measures
–Management Triggers: Passed
–ASMFC or SAFMC Manage Kingfish: Failed
–30 day Comment Period: Failed

See Table 1 for votes by commission and committees.

Research recommendations and technical amendment to rule 15A NCAC 3J .0202 were approved by all groups with no dissent.

Table 1. Management option votes by the NCMFC, Kingfish PDT, Kingfish AC, Northeast Regional Advisory Committee (NE), Central Regional Advisory Committee, Southeast Regional Advisory Committee (SE), Inland Regional Advisory Committee, and Finfish Advisory Committee.

	NCMFC	KF PDT	KF AC	NE**	Central	SE	Inland	Finfish
Habitat, water quality and protected species	Pass (6-0)	Pass	Pass (6-0)	Pass (5-0)	Pass (7-0)	Pass (7-0)	Pass (8-0)	Pass (8-0)
Management Triggers w/ Proclamation Authority	Pass (6-0)	Pass	Pass (6-0)	Pass (5-0)	No Comment	Pass (7-0)	Pass (8-0)	Pass (5-1)
ASMFC or SAFMC manage kingfish stocks	Failed (6-0)	Pass	Failed (5-1)	Failed (5-0)	No Comment	Failed (7-0)	Failed (8-0)	Failed (7-0)
30 day comment period prior to proclamation to allow AC to review	Failed (6-0)	Failed	Failed (6-0)	Pass (3-2)	No Comment	Failed (7-0)	Failed (8-0)	Failed (7-0)