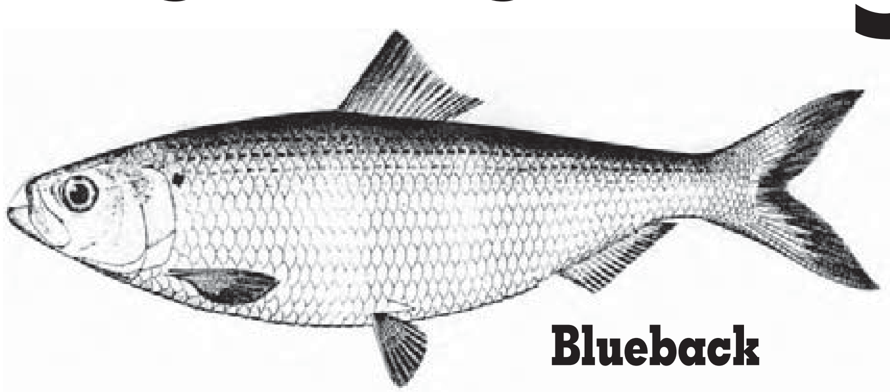
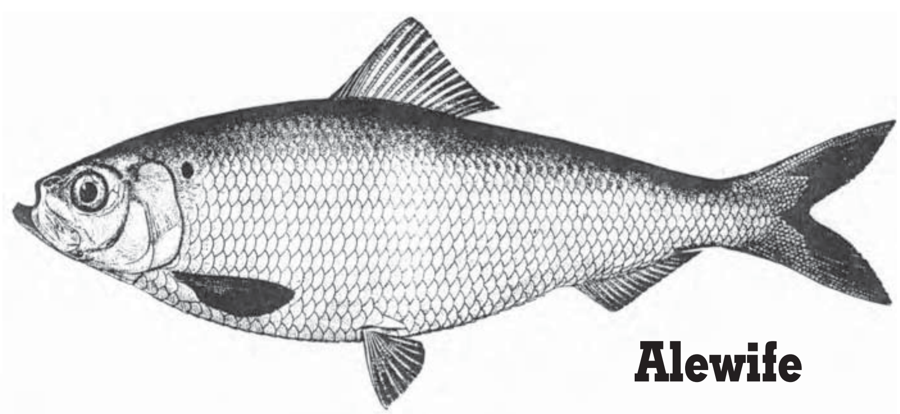
North Carolina
Fishery Management Plan

Amendment 1
River Herring



Blueback



Alewife

September 2007

North Carolina Fishery Management Plan

Amendment 1

River Herring

Blueback Herring (*Alosa aestivalis)*
Alewife (*Alosa pseudoharengus*)

North Carolina Division of Marine Fisheries
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September 2007

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1. ACKNOWLEDGEMENTS

The 2006 North Carolina River Herring Fishery Management Plan was developed by the North Carolina Division of Marine Fisheries (DMF) under the direction of the North Carolina Marine Fisheries Commission (MFC) and with the advice of the River Herring Public Advisory Committee (AC). Deserving special recognition are the members of the AC and the DMF's Plan Development Team.

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3. EXECUTIVE SUMMARY

3.1 Goals and Objectives

The goal of the 2007 North Carolina River Herring Fishery Management Plan (FMP) is to restore and manage river herring (blueback herring, *Alosa aestivalis*, and alewife, *Alosa pseudoharengus*) in North Carolina in a manner that is biologically, economically and socially sound while protecting the resource, the habitat, and its users. The management plan for river herring will be adaptive and involve regular reviews and responses to new information about the current state of the resource, the habitat and its users. The development of the 2007 FMP is based on blueback herring as the indicator species for determining stock status.

To achieve these goals, it is recommended that the following objectives be met:

1. Identify and describe fishery and population attributes necessary to sustain long-term stock viability.

2. Restore river herring stocks to viable status.

3. Protect, restore and enhance spawning and nursery area habitats.

4. Manage the stocks in a manner to sustain long-term stock viability, traditional harvest and forage uses, and prevent recruitment overfishing.

5. Initiate, enhance, and/or continue programs to collect and analyze biological, social, economic, fishery, and environmental data needed to effectively monitor and manage the river herring fishery.

6. Promote a program of education and public information to help the public understand the causes and nature of problems in the river herring stocks, its habitats and fisheries, and the rationale for management efforts to solve these problems.

3.2 Fishery Status

The river herring fishery can be divided into two segments: commercial and recreational, with recreational occurring in Coastal, Joint and Inland Waters. These fisheries are entirely dependent on sexually mature fish, age 3 and older. Fisheries in Coastal Waters are under the regulatory jurisdiction of the Marine Fisheries Commission (MFC), while river herring fisheries in designated Inland Waters are under the Wildlife Resources Commission (WRC).

3.2.1 Commercial Fisheries

The North Carolina river herring fishery began in the mid-1700s, and has always been concentrated in the Albemarle Sound area. Since the late 1800s, the areas fished and gears utilized to harvest river herring have remained essentially unchanged. The extent of the river herring fisheries in both amounts of gear and harvest, however, has declined significantly. The fisheries in the Albemarle Sound area are now pursued as multi-species fisheries, which are not totally dependent on river herring. Prior to the early 1970s landings regularly exceeded 10 million pounds. Landings in the commercial fisheries have been depressed since the late 1980s, even considering the harvest limits imposed since 1995.

In 1995, a fishing season was implemented by MFC rule, which prohibited the take of blueback herring and alewife by any method from April 15 through January 1. This rule was adopted to allow more fish to escape fishing mortality and spawn. This rule remained in effect in 1995 and 1997. In 1996 and 1998, the rule was suspended only for the Chowan River pound net fishery, at which time the fishery operated on a total allowable catch (TAC), of 250,000 lbs. and 400,000 lbs., respectively. The MFC amended the rule in a temporary action for the 1999 harvest, granting the Fisheries Director proclamation authority, to take various actions and impose an annual quota of 450,000 lbs. for the entire management area.

The 2000 FMP, established an annual commercial quota in the Albemarle Sound (ASRHMA) and Chowan River (CRHMA) Herring Management Areas of 300,000 lbs. allocated as follows: (1) 200,000 lbs. to the Chowan River pound net fishery, (2) 67,000 lbs. to the Albemarle Sound area gill net fishery and (3) 33,000 lbs. allocated at the discretion of the Fisheries Director. Once the TAC was reached, various fisheries gear restrictions were implemented and harvest was not allowed from the respective gears.

The MFC implemented interim measures on river herring harvest in 2006. A 100,000 lbs. TAC was established for the Albemarle Sound area, with 65,000 lbs. allocated to the Chowan River pound net fishery, 33,000 lbs. to the Albemarle Sound area gill net fishery and 5,000 lbs. to fyke nets, pound nets outside the Chowan River management area and other gears. The preliminary landings for 2006 from the ASMA totaled 108,117 lbs and the state total was 109,042 lbs.

During 1999-2004, North Carolina accounted for 9-33% of the total river herring landings from the Atlantic coast, compared to 29-52% from 1995-1998. The Chowan River pound net fishery contributed 60.3-76.5% of North Carolina's annual river herring harvest during 1995-1999. Since 2000, the Chowan River pound net fishery contributed 41-66% of the State's total river herring harvest.

3.2.2 Recreational Fishery

The recreational fishery for river herring is probably best defined as that fishery in which river herring are targeted and used for personal consumption or for bait. The recreational river herring harvest is unknown.

Since 2000, a recreational limit of 25 blueback herring or alewife, in the aggregate, per person per day has been in effect in Joint and Coastal waters of North Carolina. In 2006, the MFC implemented interim measures on the recreational harvest, reducing the daily limit to 12 blueback herring or alewife in the aggregate, per person per day.

River herring could be sold from designated Inland Waters of the State, under the jurisdiction of the WRC, prior to 2000 and there was no limit on the amount of harvest. Since 2000, no sale of river herring has been allowed from Inland Waters. In 2003, the WRC adopted rules prohibiting the use of gill nets in Inland Waters of the State and implemented a 25 fish per day limit on river herring. Effective July 1, 2006, no river herring (alewife or blueback herring) greater than six inches in length may be taken or possessed from the Inland Waters of coastal rivers and their tributaries up to the first impoundment dam on the main course of the rivers. The first impoundment dams are Roanoke Rapids Dam on the Roanoke River, Rocky Mount Mill Dam on the Tar River, Milburnie Dam on the Neuse River, and Buckhorn Dam on the Cape Fear River.

3.3 Socioeconomic Status

River herring was the most economically important finfish harvested in North Carolina in the late 1800s. The commercial value of river herring in North Carolina peaked in 1985 at $846,000. The value then fell sharply to ~$67,000 in 1993 due to lower landings, but a rise in the average price per pound helped to temper the effect on revenues to fishermen. Since 2000, when the 300,000 lbs. TAC was implemented the inflated value has ranged from $65,723 to $127,206 but the price per pound has increased, ranging from $0.38 to $0.45.

The number of participants in the North Carolina commercial river herring fishery has declined from 265 in 1996 to 136 in 2004. The majority of river herring participants in each year have total annual ex-vessel landings values of less than $500 each. A recovered fishery of several million pounds, either as a food source or as bait, would produce more revenue to the fishermen.

Reliable economic data specific to the recreational river herring fishery is not available.

Fishing for river herring is a long-standing tradition in northeastern North Carolina. Currently, for most participants, the primary importance of the fisheries is social and cultural than it is economic.

3.4 Stock Status

A fish stock exhibiting low abundance or biomass is considered overfished. If the exploitation rate on a stock exceeds sustainable or target levels, then overfishing is occurring. The May 2005 River Herring Stock Assessments indicates that the Chowan River blueback herring and alewife stocks are overfished and that overfishing is occurring. This determination is based on an overall evaluation of the stocks and review of several available stock status indicators.

Fishing mortality rates on blueback herring have ranged from 0.98 in 1998 to 1.71 in 2003, with a corresponding exploitation rate ranging from 63 - 85% for the Chowan River. Alewife mortality rates from the Chowan River have ranged from 1.01 in 1998 to 1.86 in 2002, with corresponding exploitation rates ranging from 64 – 85%. Blueback herring recruitment has been low since 1989, only averaging 1.8 million fish per year but has only averaged 552,000 fish in the last five years. Any modest gains in blueback herring recruitment since the early 1980s supported catches over a short period of time and were quickly removed by high fishing mortality. Chowan River alewife recruitment has only averaged 587,000 fish since 1987 and in the last five years averaged 317,000 fish, a slight increase. As with blueback herring, any modest gains in alewife recruitment since 1996 supported catches over the short term and were quickly removed by high fishing mortality. Blueback herring spawning stock biomass (SSB) ranged between 4.43 and 14.5 million pounds and averaged 8.3 million pounds from 1972 through 1986. Continued blueback herring declines in recruitment through the 1990s further reduced SSB to a record low of 89,768 pounds in 2003. Alewife SSB varied from 1.1 million to 3.1 million pounds from 1971 to 1998, but then declined rapidly during the 1990s. From 1994 through 1999, alewife SSB averaged 22,953 pounds, with a record low of 10,862 pounds in 1995. Even though a slight increase in alewife SSB has been observed since 2000, the 2003 SSB value (92,442 pounds) was only 7.5% of the 1972 – 2003 average. The juvenile abundance indices for both species are well below the long-term average. Blueback herring spawning repetition has been 6% or below since 1986.

3.5 Environmental Factors

Considerable amounts of habitat important to river herring have been degraded or lost in North Carolina. There are still problems with non-point source run-off and some discharges in the state. In the Albemarle Sound area the overall water quality has improved since the late 1970s when fish kills and algae blooms were common. Habitat and water quality protection, conservation and restoration are essential to accomplish the goals and objectives of the FMP. Local spawning populations may have been eliminated in some streams, but restoration techniques can be applied once such streams are identified.

3.6 Management Actions

The purpose of this plan is to recommend management measures and research needs that will return the North Carolina blueback herring and alewife stocks to a viable level. Subject areas addressed in the management of North Carolina’s river herring fishery in this FMP are: (1) management required to restore the abundance of river herring; (2) establishing a monitoring program and stock recovery indicators; (3)

enhancing restoration of river herring through stocking programs; (4) impacts of predation on river herring by other species; (5) river herring bycatch in the Atlantic Ocean fisheries; (6) protection of critical habitat areas including identification of spawning and nursery area habitat; (7) water quality and habitat; and (8) socioeconomic factors.

During the development of the FMP by DMF and the River Herring FMP Advisory Committee (AC), subject areas were examined and options evaluated on how best to address the issues presented. In order to achieve the goals of the FMP, the MFC has selected the following management actions for each of the main areas:

1. Management strategies required to restore the abundance of river herring.

- A zero harvest statewide, but up to 7,500 lbs set aside for research at the Division Directors discretion and coupled with gear restrictions.

2. Monitoring program and stock recovery indicators

- Establishment and maintenance of an intensive monitoring and data collection program and emphasize the fact that without additional funds and personnel the recommendations cannot be accomplished. Support is also given to the four stock recovery indicators as trigger points for management action. All available stock recovery indicators must be met for the stock to be considered recovered.

- Conduct all sampling of the monitoring and data collection program.

    1. Spawning area survey
        - Conduct spawning area survey in all tributaries of the Albemarle Sound beginning with the Chowan River.
        - Expand spawning area survey to other systems of the state as money and personnel become available.
    2. Juvenile abundance survey
        - Continue to conduct the long-term alosines juvenile abundance seine survey in the Albemarle Sound area.
        - Expand the juvenile abundance survey to all tributaries of the Albemarle Sound area.
        - Expand the juvenile abundance survey to other areas of the state as money and personnel become available.

3. Pound net survey
    - Set/sample at least 6 pound nets in Chowan River system.
    - Expand pound net sets to other tributaries in the Albemarle Sound area.
    - Expand pound net sets to other areas of the state if spawning area and juvenile surveys identify significant spawning runs in these areas.

4. Independent gill net survey
    - Continue data collection from the Albemarle Sound Management Area independent gill net survey (IGNS), and expand survey into all tributaries of the Albemarle Sound for collection of river herring data.
    - Use IGNS in other areas of the state to collect river herring data and expand the surveys to include all tributaries.

- Utilize the following stock recovery indicators to evaluate stock status and assure that all available indicators are reached prior to removing harvest restrictions.

    1. Juvenile abundance- restoration target for blueback herring- achieve three-year moving average catch per unit of effort at least 60.

    2. Percent repeat spawners- Chowan River blueback herring stock should contain at least 10% repeat spawners (percent of spawning stock that have spawned at least once).

    3. Spawning stock biomass (SSB)- restoration target is to restore Chowan River blueback herring SSB to a Minimum Stock Size Threshold (MSST) of 4 million pounds.

    4. Recruitment- recruitment of age three blueback herring should be restored to a three-year moving average of at least 8 million fish.

- Continue the stock monitoring and data collection program for 5 years with no alterations in data collection or management strategies before reassessing stock status.

- Strongly support that money and personnel be identified to conduct the recommended sampling, as it is necessary in order to adequately monitor the status of river herring stocks in North Carolina.

3. Restoration/Stocking Programs

- Spawning and nursery area surveys be updated immediately and the best course of action be evaluated concerning river herring restoration programs.

4. Predation on River Herring by Other Species, Emphasis on Striped Bass

- Endorse additional research on predation.

- Consideration on development of an Albemarle Sound multi-species ecosystem management program and the science necessary to develop such a program.

5. River Herring Bycatch in the Atlantic Ocean Fisheries

- Endorse additional research coastwide to collect and assess river herring bycatch to a high level of precision from Atlantic mackerel, Atlantic herring and other pelagic fisheries and requests that NMFS allocate funds to conduct such studies.

6. Anadromous Spawning and Nursery Areas- Critical Habitat

- Advocate the adoption of anadromous spawning and nursery areas in the Albemarle Sound area for river herring identified by DMF into rules. In other coastal areas of the state where river herring spawning areas have been identified, rule adoption should also occur. Update anadromous spawning and nursery area surveys in the systems outside the Albemarle area.

- Advocate stronger enforcement of regulations protecting critical habitat in the management areas.

- Purchase land adjacent to critical habitat areas to ensure that these areas are protected.

- Advocate that coastal counties undertake the preparation and aggressive funding of open space preservation and conservation plans.

- Continue to make recommendations on all state, federal and local permits where applicable.

- Support implementation of habitat recommendations of the Coastal Habitat Protection Plans, the Albemarle-Pamlico Estuarine Study, and the Estuarine Shoreline Protection Stakeholders Report.

- Maintain, restore and improve habitat to increase growth, survival and reproduction of river herring.

7. Water Quality

- Work in coordination with other agencies to maintain, restore and improve water quality to increase growth, survival and reproduction of river herring. Priority activities identified include the establishment of buffer strips and conservation easements within each basin, and continue the refinement of best management practices on lands primarily for agriculture, silviculture and industrial and residential development.

- Support implementation of recommendations of DWQ basinwide water quality management plans, particularly measures that will reduce nutrient loading, sediment delivery and associated turbidity in all coastal watersheds.

8. Blockages of Historical Spawning Habitat

- Identify all man-made physical obstructions to river herring migrations, prioritize impediments for removal/replacement after identification.

9. Entrainment and Impingement of Eggs and Larvae

- The Division has no direct authority to regulate facilities that withdraw water from coastal rivers. However, the MFC recommend the following:

  1. Continue to give close attention to state and federal permit requests in which water withdrawal structures are involved.

  2. Monitor the progress of EPA's implementation of Section 316(b) rules, as these rules may apply to water withdrawal points in coastal rivers.

  3. In the absence of effective technology, require water users to curtail withdrawals during periods in which river herring eggs, fry and juveniles may be present.

4. Division of Water Quality and Division of Water Resources should be required to interface NPDES discharges and support whole watershed management.

4. INTRODUCTION

4.1 AUTHORITY FOR MANAGEMENT

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

Many different state laws (General Statutes – G.S.) provide the necessary authority for fishery management in North Carolina. General authority for stewardship of the marine and estuarine resources by the North Carolina Department of Environment and Natural Resources (NCDENR) is provided in G.S. 113-131. The Division of Marine Fisheries (DMF) is the arm of the Department, which carries out this responsibility. G.S. 113-136 provides enforcement authority for DMF enforcement officers. General Statute 113-163 authorizes research and statistical programs. The North Carolina Marine Fisheries Commission (MFC) is charged to "manage, restore, develop, cultivate, conserve, protect, and regulate the marine and estuarine resources of the State of North Carolina" (G.S. 143B-289.51). The MFC can regulate fishing times, areas, fishing gear, seasons, size limits, and quantities of fish harvested and possessed (G.S. 113-182 and 143B-289.52). General Statute 143B-289.52 allows the MFC to delegate authority to implement its regulations for fisheries "which may be affected by variable conditions" to the Director of DMF by issuing public notices called "proclamations". Thus, North Carolina has a very powerful and flexible legal basis for coastal fisheries management. The General Assembly has retained for itself the authority to establish commercial fishing licenses, but has delegated to the MFC authority to establish free permits for various commercial fishing gears and activities.

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

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

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

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

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

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

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

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

4.2 RECOMMENDED MANAGEMENT PROGRAM

4.2.1 Goals and Objectives

The goal of the 2006 North Carolina River Herring FMP is to restore and manage river herring (blueback herring and alewife) in North Carolina in a manner that is biologically, economically, and socially sound while protecting the resource, the habitat, and its users. The management plan for river herring will be adaptive and involve regular reviews and responses to new information about the current state of the resource, the habitat and its users. The development of the 2006 FMP is based on blueback herring as the indicator species for determining stock status due to this species’ predominance in the fishery.

To achieve these goals, it is recommended that the following objectives be met:

1. Identify and describe fishery and population attributes necessary to sustain long-term stock viability.

2. Restore river herring stocks to viable status.

3. Identify, protect, restore and enhance spawning and nursery area habitats.

4. Manage the stocks in a manner to sustain long-term stock viability, traditional harvest and forage uses, and prevent recruitment overfishing.

5. Initiate, enhance, and/or continue programs to collect and analyze biological, social, economic, fishery, and environmental data needed to effectively monitor and manage the river herring fishery.

6. Promote a program of education and public information to help the public understand the causes and nature of problems in the river herring stocks, its habitats and fisheries, and the rationale for management efforts to solve these problems.

4.3 DEFINITION OF MANAGEMENT UNIT

The management unit includes the two species of river herring (blueback herring, *Alosa aestivalis*, and alewife, *A. pseudoharengus*) and their fisheries throughout coastal North Carolina.

The management areas are defined as follows:

The Albemarle Sound River Herring Management Area (ASRHMA)- Albemarle Sound and all its Coastal, Joint and Inland water tributaries; Currituck Sound; Roanoke and Croatan sounds and all their Coastal, Joint and Inland water tributaries, including Oregon Inlet, north of a line from Roanoke Marshes Point 35° 48.3693’ N - 75° 43.7232’ W across to the north point of Eagles Nest Bay 35° 44.1710’ N - 75° 31.0520’ W (Figure 4.1).

The Chowan River Herring Management Area (CRHMA)- Northwest of a line from Black Walnut Point 35° 59.9267’ N - 76° 41.0313’ W to Reedy Point 36° 02.2140’ N - 76° 39.3240’ W, to the North Carolina/Virginia state line; including the Meherrin River (Figure 4.1).

River herring are distributed throughout the coastal waters of North Carolina, ascending many streams to their headwaters or until blocked by dams or other obstructions. As shown in Table 4.1, they have been harvested historically from virtually all coastal streams. Over the last 30 – 35 years; however, the fisheries have been overwhelmingly concentrated in the Albemarle Sound area. In addition, historical landings data indicate that the river herring fisheries have always been concentrated in the Albemarle Sound area, with minor fisheries in other coastal streams (NCDMF 2000). The DMF has conducted spawning and nursery area surveys and some age composition work for most of the coastal streams outside the Albemarle Sound area, but this work ended 15 – 23 years ago, varying with area, as federal aid funds were decreased (Table 4.2). Current data, other than landings data, simply do not exist for river herring outside the Albemarle Sound area. Finally, significant fishery management issues are well documented for the Albemarle Sound area, but not for other areas. For the reasons provided above, this FMP will primarily focus on the Albemarle Sound area and secondarily on the other areas of the state.

4.4 GENERAL PROBLEM(S) STATEMENT

The majority of the problems identified in this FMP are the same as those identified in the 2000 River Herring FMP. Few problem areas were resolved because dedicated funds and personnel were never provided to address these issues.

4.4.1 Stock Problems

A fish stock exhibiting low abundance or biomass is considered overfished; if the exploitation rate on a stock exceeds sustainable or target levels, then overfishing is also occurring. The May 2005 River Herring Stock Assessments (Grist 2005, Section 12.2, Appendix 2) indicates that the Chowan River blueback herring and alewife stocks are overfished and that overfishing is occurring. This determination is based on an overall evaluation of the stocks and review of several available stock status indicators. The overfished status of the Chowan River blueback herring stock agrees with that reported by Carmichael (1999). Crecco and Gibson (1990) conducted a stock assessment analysis in 1988 and found that the Chowan River blueback herring stock was over exploited and alewife were overfished.

Recruitment through much of the 1970’s and early 1980’s sustained the Chowan River stock of river herring in spite of very high fishing mortality. A succession of poor year-classes during the mid-1980’s could not support the high fishing mortality at that time, so subsequently the stock declined to historically low levels. Spawning stock biomass and recruitment of blueback herring and alewife declined dramatically during

Table 4.1. River herring landings and value by waterbody in North Carolina, 1962-2006.

	Albemarle Sound		Croatan Sound		Currituck Sound		Chowan River		Roanoke River		Tribs. to Albemarle S.		Pamlico Sound	
Year	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)
1962	3,262,600	32,626	20,000	200	25,000	250	10,786,000	107,860	122,000	1,220	6,600	66	16,200	162
1963	2,366,100	23,661	25,000	250	40,400	404	12,288,400	122,884	300,000	3,000	23,100	231	16,900	169
1964	1,920,500	19,205	35,000	350	22,300	223	4,948,900	50,760	565,000	5,650	26,800	268		
1965	1,827,700	19,976	15,000	150	10,000	100	10,944,200	112,080			12,000	120	3,200	33
1966	1,274,200	13,916			1,000	20	10,911,300	116,597	256,300	2,566	41,400	498	18,700	391
1967	322,100	5,427	5,000	50	11,700	121	18,016,100	309,992	38,000	746	27,700	475	33,900	467
1968	1,067,200	16,824	3,300	35	10,000	150	12,950,100	194,881	1,306,300	19,771	34,000	593	75,600	933
1969	769,000	13,415	19,300	193	12,000	180	17,536,100	266,614	1,286,100	19,293	10,200	181	2,000	20
1970	217,600	3,263			1,000	20	10,701,300	173,541	469,400	14,270	65,100	1,118		
1971	553,500	9,088					10,426,000	166,339	1,670,500	26,062	61,700	1,396	1,000	25
1972	297,551	6,480	2,670	53			10,594,117	182,052	335,488	7,393	7,317	167		
1973	472,153	13,327	4,590	137			7,350,578	196,212	92,056	3,571	5,132	216	149	7
1974	150,490	5,748			7,554	288	5,736,905	224,074	256,110	13,588	53,838	2,682		
1975	597,440	28,659					5,031,756	168,847	230,433	14,485	89,850	3,374		
1976	356,123	21,304			4,150	415	5,734,776	286,830	300,100	27,775	6,211	426		
1977	828,679	38,247					7,418,218	360,962	252,700	21,232	20,746	895	490	29
1978	491,372	24,688			3,950	208	5,615,113	239,227	383,199	15,328	76,418	5,454	30,697	1,465
1979	466,389	32,741	3,000	120	2,900	128	4,303,663	260,229	209,950	12,258	45,392	2,695	2,894	216
1980	680,476	51,882	*	*	4,850	420	5,382,954	379,206	71,773	6,911	20,323	1,615	5,263	527
1981	1,050,871	87,524	*	*	2,585	225	3,314,447	202,814	155,860	13,118	17,432	1,416	39,774	3,627
1982	1,558,873	144,751	*	*	22,787	2,597	7,459,968	515,545	240,540	25,725	49,956	4,629	4,565	429
1983	1,190,909	118,887	110,576	10,732	39,255	3,614	4,405,915	313,747	92,200	14,415	20,093	1,812	5,471	639
1984	1,791,289	193,857	*	*	9,100	1,258	4,561,503	382,919	65,672	8,495	49,815	5,315	*	*
1985	2,296,010	177,908	*	*	*	*	8,871,391	635,190	204,750	20,826	*	*	4,190	499
1986	689,297	94,764	*	*			5,767,874	517,945	244,994	26,519	14,860	1,937	3,780	424
1987	705,585	85,153	*	*			2,334,719	265,640	*	*	*	*		
1988	1,490,413	178,848	*	*			2,259,888	271,186	*	*	20,250	2,430	*	*
1989	554,878	69,157					908,145	110,795	*	*	*	*	*	*
1990	365,881	56,047	*	*			710,849	106,635	*	*	60,037	9,065	1,505	166
1991	352,458	28,361	*	*			1,202,535	87,799	*	*	*	*		
1992	217,918	22,161	*	*			1,135,340	113,655	255,772	25,578	*	*		
1993	111,749	10,308			117	15	801,115	56,806			*	*	25	3
1994	180,271	33,348	729	73	1,357	136	390,852	44,017	*	*	29,015	18,428	1,000	245
1995	97,137	34,277	1,723	344	640	160	280,681	73,482	2,858	715	47,723	20,111	3,923	1,022
1996	104,166	34,311	4,708	2,139	114	28	404,884	82,129	2,176	1,675	12,562	12,039	625	155
1997	109,876	46,927	9,436	5,321	159	59	201,928	67,454	*	*	4,766	5,075	518	302
1998	115,436	46,814	16,831	13,815	157	62	377,311	135,901	*	*	10,338	6,555	601	399
1999	85,086	33,928	21,101	22,884	98	35	332,466	119,247	*	*	3,305	3,167	280	100
2000	88,903	28,646	36,539	23,261	893	262	184,741	57,272	337	450	11,945	4,144	8,120	12,906
2001	49,678	21,081	24,085	9,159	1,485	632	201,717	76,707	*	*	14,162	6,244	15,172	5,992
2002	39,251	14,681	16,569	6,099	136	51	93,048	34,587	*	*	19,650	7,486	4,676	1,683
2003	67,175	29,631	6,552	4,039	1,535	675	84,591	37,220			23,178	10,203	15,100	6,865
2004	73,092	31,651	15,248	6,566	1,297	558	77,177	33,186	*	*	13,698	5,890	3,529	1,517
2005	63,350	32,515	17,495	8,944	*	*	157,087	81,196	*	*	11,844	6,055	*	*
2006	22,573		9,633		288		67,404		*	*	5,670		*	*

Table 4 (Continued)												
	Pamlico River		Neuse River		Cape Fear River		Atlantic Ocean		Other Areas		State Total	
Year	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)
1962	61,100	611	2,000	20	100	1			800	8	14,302,400	143,024
1963	27,700	277	4,000	40	4,500	45			3,500	35	15,099,600	150,996
1964	33,500	335	8,200	82	700	7					7,560,900	76,880
1965	13,400	139			300	3					12,825,800	132,601
1966	15,500	262	500	5	400	6					12,519,300	134,261
1967	30,300	425			300	4			900	9	18,486,000	317,716
1968	4,500	55	200	9	200	8			73,500	1,410	15,524,900	234,669
1969	1,500	56							125,500	3,765	19,761,700	303,717
1970	200	11			1,100	23			65,700	1,510	11,521,400	193,756
1971	100	2	400	10	1,200	50			7,500	150	12,721,900	203,122
1972											11,237,143	196,145
1973			1,240	49							7,925,898	213,519
1974	3,995	340	650	33							6,209,542	246,753
1975	250	15					2,338	121			5,952,067	215,501
1976											6,401,360	336,750
1977	2,980	238									8,523,813	421,603
1978	5,200	260			704	50			500	25	6,607,153	286,705
1979	64,444	3,397	1,130	56			19,388	1,939			5,119,150	313,779
1980	32,609	2,110					*	*	20,275	1,656	6,218,523	444,327
1981	10,049	1,482	*	*			143,232	5,252	*	*	4,753,723	316,850
1982	12,556	1,864	*	*			7,679	726	80,779	8,333	9,437,703	704,599
1983	3,813	528							*	*	5,868,332	464,389
1984	11,137	1,280					9,497	843	18,096	2,461	6,516,109	596,428
1985	7,308	731					*	*	164,629	10,752	11,548,278	845,906
1986	3,306	496					*	*	90,212	5,208	6,814,323	647,293
1987	2,288	297					19,279	1,000	133,104	15,972	3,194,975	368,062
1988	1,593	195					*	*	419,067	49,507	4,191,211	502,166
1989	934	105							27,120	3,785	1,491,077	183,842
1990	307	43					*	*	19,046	2,303	1,157,625	174,259
1991									20,385	2,112	1,575,378	118,272
1992							110,794	10,773	3,354	286	1,723,178	172,453
1993	*	*							3,229	362	916,235	67,494
1994	14	1	1,668	167			38,834	3,883	*	*	644,309	100,996
1995	*	*	64	15			19,174	4,793	62	16	453,984	134,934
1996	*	*	103	59			*	*	165	38	529,503	132,573
1997			185	278			5,568	1,949	2,374	1,317	334,809	128,682
1998	56	20	539	189					*	*	521,930	204,706
1999	*	*	*	*					1,158	1,514	443,494	180,874
2000	44	13	*	*			*	*	815	252	332,336	127,206
2001	*	*	45	81			45	17	373	142	306,761	120,053
2002	*	*	*	*			39	15	1,493	1,121	174,860	65,723
2003	*	*	773	464			*	*	814	358	199,716	89,456
2004	*	*	302	226			*	*	4,199	1,805	188,542	81,399
2005	*	*	*	*					245	125	250,021	128,834
2006									1,249		109,243	83,812

*Confidential landings; incorporated in "Other Areas".

Table 4.2. River herring research and monitoring work by the North Carolina Division of Marine Fisheries in the rivers and sound of eastern North Carolina.

			Type of work			
System	Years	Spawning areas	Juvenile abundance	Adult aging	Migration	Stock assessment
Albemarle Sound area	1971 – present	1972-80 1982-83 1987-88 1993 2001	1972 – present	1972 – present	1974 – 76	1996, 1998, 1999, 2005
Tar-Pamlico	1974-81	1975-76 1980	1974-81	1974-81	1975-76	
Neuse	1976-81	1977-79	1976-81	1976-81	1977-79	
White Oak	1973-75	1974-75	1974-75	1974-75		
New	1973-75	1974-75	1974-75	1974-75		
Cape Fear	1975-81	1976-81	1975-81	1976-81		

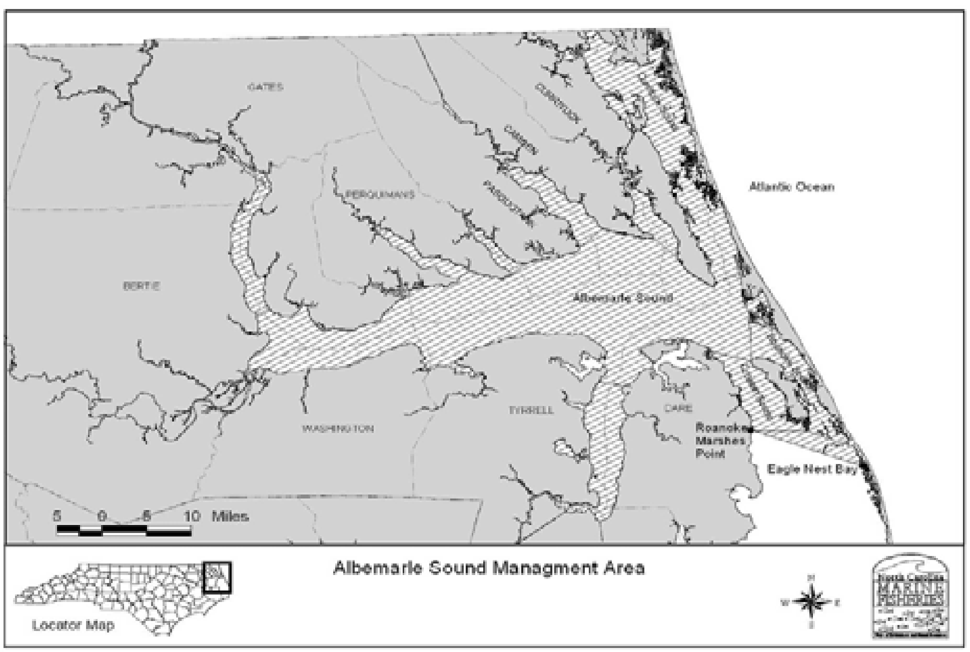


Figure 4.1. Albemarle Sound river herring management area.

the mid to late 1980's and has never recovered. Sustained high exploitation over the last 25 years has reduced the Spawning Stock Biomass (SSB) to the extent that current levels are insufficient to produce even moderate recruitment for either blueback herring or alewife. The stock is comprised of an inadequate number of spawners and too few repeat spawners. Landings in the commercial fisheries have been depressed since the late 1980's, even considering the harvest limits imposed since 1995.

4.4.2 Environmental Issue

Problems exist in the areas of physical habitat and water quality. Considerable habitats have been lost through wetland drainage, stream channelization and conversion to other uses. Some streams are blocked by dams (including beaver dams), storm debris, and other physical barriers. Migration and spawning may be affected by replacement of small road bridges with culverts. Oxygen-consuming wastes are discharged into a number of streams. Practices to control non-point discharges are inadequate. Nuisance algal blooms, fish kills and fish diseases have occurred over the years. There are also questions concerning the status of the forage base for river herring.

4.4.3 Insufficient Assessment Data

Data concerning the stocks are lacking in many areas. More complete data are needed on adults during the spawning migration run regardless of whether a fishing season is in place. Fishery independent data are deficient to non-existent. Very limited catch data exists on the recreational fishery; with no effort or biological data.

4.4.4 Inadequate Environmental Data

All fish stocks are basically dependent on environmental conditions for their survival. The key environmental conditions which control river herring behavior, survival, health and spawning success are unknown beyond a few measures, such as water temperature. There is no system in place to gather such environmental data.

4.4.5 Socioeconomic Data

Socioeconomic data to assess the cumulative effects of reduced stock availability and harvest restrictions on fishermen who have traditionally relied on the fishery for economic opportunity are lacking.

4.5 EXISTING PLANS, STATUTES, AND RULES

4.5.1 Interim Measures

The North Carolina Marine Fisheries Commission directed the Division in September 2005 to develop interim management measures for the 2006 River Herring season as a result of the poor conditions of the stocks. On November 17, 2005, the MFC approved the following measures for the 2006 river herring season: 100,000 pounds Total Allowable Catch (TAC) to the Albemarle Sound area commercial fishery, of which 65,000 pounds was allocated to the Chowan River pound net fishery, 30,000 pounds to the Albemarle Sound area gill net fishery and 5,000 pounds to be allocated at the discretion of the Fisheries Director (pound nets outside Chowan River, fyke nets, haul seines, etc). The statewide recreational river herring (blueback herring and alewife, in the aggregate) limit was set at 12 fish per person per day in the Coastal and Joint waters of the state.

4.5.2 Plans

An Atlantic States Marine Fisheries Commission (ASMFC) plan for shads and river herring was initially approved in 1985 (ASMFC 1985), but no restrictions were included. Amendment No. 1 to the Interstate Fishery Management Plan for Shads and River Herring (ASMFC 1999) was approved in 1998. It provides for restrictions on the American shad (*A. sapidissima*) fisheries in the ocean, but no specific regulatory recommendations relative to river herring. The plan includes greater biological monitoring and reporting requirements for river herring. Further, the ASMFC plan recommends that existing management regimes be maintained or strengthened. Plans of the regional fishery management councils under the federal Magnuson-Stevens Act do not directly affect the river herring fisheries. However, river herring may be taken as bycatch in the mid-Atlantic and New England area fisheries for Atlantic mackerel and Atlantic herring. There are Magnuson-Stevens Act FMPs for these fisheries, so there are indirect federal management effects on North Carolina's river herring fisheries. In addition, the South Atlantic Fishery Management Council's Habitat Plan for the South Atlantic Region (SAFMC 1998) specifically considers habitat needs for anadromous fishes, including both species of river herrings.

In February 2000, the North Carolina Fishery Management Plan- Albemarle Sound Area River Herring was approved by the MFC. The plan will be reviewed and updated at least every five years and this document is the first update.

4.5.3 Statutes (North Carolina General Statutes)

All management authority for North Carolina's river herring fishery is vested in the State of North Carolina. Since the stocks depend greatly on habitats found in both Coastal and Inland Waters and river herring fisheries occur in both areas, the North Carolina Marine Fisheries Commission and the North Carolina Wildlife Resources Commission will implement management actions in their respective jurisdictions pursuant to the recommendations contained in this plan. General authorities noted in Section 4.1 provide the MFC and WRC with regulatory powers to manage the fisheries.

Other statutes that affect herring fishing practices, rule making, agency jurisdiction and habitat protection and provide authority for the recommendations contained in this plan include:

G.S. 113-129.	Definitions relating to resources*
G.S. 113-131.	Resources belong to public; stewardship of conservation agencies; grant and delegation of powers; injunctive relief
G.S. 113-132.	Jurisdiction of fisheries agencies
G.S. 113-134.	Rules*
G.S. 113-181.	Duties and powers of Department
G.S. 113-182.	Regulation of fishing and fisheries*
G.S. 113-182.1.	Fishery Management Plans*
G.S. 113-221.	Rules; proclamations; emergency Commission meetings*
G.S. 113-224.	Cooperative agreements by Department
G.S. 113-268.	Injuring, destroying, stealing, or stealing from nets, seines, buoys, pots, etc.*
G.S. 143B-279.8.	Coastal Habitat Protection Plans*

Statutes marked with an asterisk are printed in North Carolina Fisheries Rules for Coastal Waters 2005. Text of all North Carolina statutes are available at www.ncga.state.nc.us/gascripts/Statutes/Statutes.asp

4.5.4 Marine Fisheries Commission Rules

- **Definitions (15A NCAC 3I .0101 (a), (b) (20) (C) (D)**

All definitions set out in G.S. 113, Subchapter IV apply to this Chapter. Critical habitat areas: The fragile estuarine and marine areas that support juvenile and adult populations of economically important seafood species, as well as forage species important in the food chain. Critical habitats include nursery areas, beds of submerged aquatic vegetation, shellfish producing areas, anadromous fish spawning and anadromous fish nursery areas, in all coastal fishing waters as determined through marine and estuarine survey sampling. Critical habitats are vital for portions, or the entire life cycle, including the early growth and development of important seafood species. Anadromous fish spawning areas are defined as those areas where evidence of spawning of anadromous fish has been documented by direct observation of spawning, capture of running ripe females, or capture of eggs or early larvae. Anadromous fish nursery areas are defined as those areas in the riverine and estuarine systems utilized by post-larval and later juvenile anadromous fish.

- **River Herring and Shad (15A NCAC 3M .0513 (a) (b) (c) (d))**

The Fisheries Director may, by proclamation, based on variability in environmental and local stock conditions, take any or all of the following actions in the blueback herring, alewife, American shad and hickory shad fisheries: (1) Specify size; (2) Specify season; (3) Specify area; (4) Specify quantity; (5) Specify means/methods; and (6) Require submission of statistical and biological data. The annual commercial quota (calendar year) for river herring in the Albemarle Sound and Chowan River Herring Management Area shall be 300,000 pounds to be allocated as follows: (1) 200,000 pounds to the pound net fishery for the Chowan River Herring Management Area; (2) 67,000 pounds to the Albemarle Sound Herring Management Area gill net fishery; and (3) 33,000 pounds to be allocated at the discretion of the Fisheries Director. For the purpose of this rule, the Albemarle Sound Herring Management Area and the Chowan River Herring Management Area are defined in 15A NCAC 3J .0209. It is unlawful to possess more than 25 blueback herring or alewife, in the aggregate, per person per day taken for recreational purposes.

- **Albemarle Sound/Chowan River Herring Management Areas (15A NCAC 3J .0209 (a) (b))**

The Albemarle Sound Herring Management Area is defined as Albemarle Sound and all its joint water tributaries; Currituck Sound; Roanoke and Croatan sounds and all their joint water tributaries, including Oregon Inlet, north of a line from Roanoke Marshes Point 35° 48.3693' N - 75° 43.7232' W across to the north point of Eagles Nest Bay 35° 44.1710' N - 75° 31.0520' W.

The Chowan River Herring Management Area is defined as that area northwest of a line from Black Walnut Point 35° 59.9267' N - 76° 41.0313' W to Reedy Point 36° 02.2140' N - 76° 39.3240' W, to the North Carolina/Virginia state line; including the Meherrin River.

Effective January 1, 2001, it is unlawful to use drift gill nets with a mesh length less than 3 inches from January 1 through May 15.

- **Mutilated Finfish (15A NCAC 3M .0101)**

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

- **Permit Conditions; Specific (15A NCAC 3O .0503 (b) (3))**

Albemarle Sound Management Area for River Herring Dealer Permit: It is unlawful to possess, buy, sell or offer for sale river herring taken from the following area without first obtaining an Albemarle Sound Management Area River Herring Dealer Permit: Albemarle Sound Management Area for River Herring is defined in 15A NCAC 3R .0201.

- **Fixed Or Stationary Nets (15A NCAC 3J .0101 (1), (2), (3), (4))**

It is unlawful to use or set fixed or stationary nets: (1) where nets constitutes a hazard to navigation; (2) so as to block more than two-thirds of a waterway; (3) in the middle third of any marked navigation channel; (4) in the channel third of any of the rivers tributary to Albemarle Sound.

- **Nets Or Net Stakes (15A NCAC 3J .0102 (1), (2), (3))**

It is unlawful to use nets or stakes: (1) within 150 yards of bridges across Roanoke and Alligator rivers; (2) within 300 yards of highway bridges across Albemarle, Croatan**,** Currituck, or Roanoke sounds or Chowan River; (3) if such stakes are of metallic material.

- **Gill Nets, Seines, Identification, Restriction (15A NCAC 3J .0103 (a)(1), (b), (d) (1))**

(a) It is unlawful to use a gill net with a mesh length less than 2 ½ inches. (b) The Fisheries Director may, by proclamation, restrict gill net areas, season, mesh size, means and methods, and number and length. (c) Specific gill net marking requirements; (d) Gill nets must be 200 yards from a pound net in use,

- **Pound Net Sets (15NCAC 3J .0107 (a) – (o))**

All initial, renewal or transfer applications for Pound Net Set Permits, and the operation of such pound net sets, shall comply with the general rules governing all permits in 15A NCAC 03O .0500. The procedures and requirements for obtaining permits are also found in 15A NCAC 03O .0500.

It is unlawful to use pound net sets in coastal fishing waters without the permittee’s identification being clearly printed on a sign no less than six inches square, securely attached to the outermost stake of each end of each set. For pound net sets in the Atlantic Ocean using anchors instead of stakes, the set must be identified with a yellow buoy, which shall be of solid foam or other solid buoyant material no less than five inches in diameter and no less than 11 inches in length. The permittee’s identification shall be clearly printed on the buoy. Such identification on signs or buoys must include the pound net set permit number and the permittee’s last name and initials.
It is unlawful to use pound net sets, or any part thereof, except for one location identification stake or identification buoy for pound nets used in the Atlantic Ocean at each end of proposed new locations, without first obtaining a Pound Net Set Permit from the Fisheries Director. The applicant must indicate on a base map provided by the Division the proposed set including an inset vicinity map showing the location of the proposed set with detail sufficient to permit on-site identification and location. The applicant must specify the type(s) of pound net set(s) requested and possess proper valid licenses and permits necessary to fish

those type(s) of net. A pound net set shall be deemed a flounder pound net set when the catch consists of 50 percent or more flounder by weight of the entire landed catch, excluding blue crabs. The type “other finfish pound net set” is for sciaenid (Atlantic croaker, red drum, weakfish, spotted seatrout, spot, for example) and other finfish, except flounder, herring, or shad, taken for human consumption. Following are the type(s) of pound net fisheries that may be specified: (1) Flounder pound net set; (2) Herring/shad pound net set; (3) Bait pound net set; (4) Shrimp pound net set; (5) Blue crab pound net set; (6) Other finfish pound net set.

For proposed new locations, the Fisheries Director shall issue a public notice of intent to consider issuance of a Pound Net Set Permit allowing for public comments for 20 days, and after the comment period, may hold public meetings to take comments on the proposed pound net set. If the Director does not approve or deny the application within 90 days of receipt of a complete and verified application, the application shall be deemed denied. The applicant shall be notified of such denial in writing. For new locations, transfers and renewals, the Fisheries Director may deny the permit application if the Director determines that granting the permit will be inconsistent with one or more of the following permitting criteria, as determined by the Fisheries Director: (1) The application must be in the name of an individual and shall not be granted to a corporation, partnership, organization or other entity; (2) The proposed pound net set, either alone or when considered cumulatively with other existing pound net sets in the area, will not interfere with public navigation or with existing, traditional uses of the area other than navigation, and will not violate 15A NCAC 03J .0101 and .0102; (3) The proposed pound net set will not interfere with the rights of any riparian or littoral landowner, including the construction or use of piers; (4) The proposed pound net set will not, by its proximate location, interfere with existing pound net sets in the area. Except in Chowan River as referenced in 15A NCAC 03J .0203, proposed new pound net set locations shall be a minimum of 1,000 yards as measured in a perpendicular direction from any point on a line following the permitted location of existing pound net sets; (5) The applicant has in the past complied with fisheries rules and laws and does not currently have any licenses or privileges under suspension or revocation. In addition, a history if habitual fisheries violations evidenced by eight or more convictions in ten years shall be grounds for denial of a pound net set permit; (6) The proposed pound net set is in the public interest; and (7) The applicant has in the past complied with all permit conditions, rules and laws related to pound nets.

Approval shall be conditional based upon the applicant’s continuing compliance with specific conditions contained on the Pound Net Set Permit and the conditions set out in Subparagraphs (1) through (7) of this Paragraph. The final decision to approve or deny the Pound Net Set Permit application may be appealed by the applicant by filing a petition for a contested case hearing, in writing, within 60 days from the date of mailing notice of such final decision to the applicant, with the Office of Administrative Hearings.

An application for renewal of an existing Pound Net Set Permit shall be filed not less than 30 days prior to the date of expiration of the existing permit, and shall not be processed unless filed by the permittee. The Fisheries Director shall review the renewal application under the criteria for issuance of a new Pound Net Set Permit, except that pound net sets approved prior to January 1, 2003 do not have to meet the 1,000 yard minimum distance requirement specified in Subparagraph (d)(4) of this Rule. The Fisheries Director may hold public meetings and may conduct such investigations necessary to determine if the permit should be renewed.

A Pound Net Set Permit, whether a new or renewal permit, shall expire one year from the date of issuance. The expiration date shall be stated on the permit.

Pound net sets, except herring/shad pound net sets in the Chowan River, shall be operational for a minimum period of 30 consecutive days during the permit period unless a season for the fishery for which the pound net set is permitted is ended earlier due to a quota being met. For purposes of this Rule, operational means with net attached to stakes or anchors for the lead and pound, including only a single pound in a multi-pound set, and a non-restricted opening leading into the pound such that the set is able to catch and hold fish. The permittee, including permittees of operational herring/shad pound net sets in the Chowan River, shall notify the Marine Patrol Communications Center by phone within 72 hours after the pound net set is operational. Notification shall include name of permittee, pound net set permit number, county where located, a specific location site, and how many pounds are in the set. It is unlawful to fail to notify the Marine Patrol Communications Center within 72 hours after the pound net set is operational or to make false notification when said pound net set is not operational. Failure to comply with this Paragraph shall be grounds for the Fisheries Director to revoke this and any other pound net set permits held by the permittee and for denial of any future pound net set permits.

It is unlawful to transfer a pound net set permit without a completed application for transfer being submitted to the Division of Marine Fisheries not less than 45 days before the date of the transfer. Such application shall be made by the proposed new permittee in writing and shall be accompanied by a copy of the current permittee's permit and an application for a pound net set permit in the new permittee's name. The Fisheries Director may hold a public meeting and may conduct such investigations necessary to determine if the permit should be transferred. The transferred permit shall expire on the same date as the initial permit. Upon death of the permittee, the permit may be transferred to the Administrator/Executor of the estate of the permittee if transferred within six months of the Administrator/ Executor's qualification under G.S. 28A. The Administrator/Executor must provide a copy of the deceased permittee's death certificate, a copy of the certificate of administration and a list of eligible immediate family members as defined in G.S. 113-168 to the Morehead City Office of the Division of Marine Fisheries. Once transferred to the Administrator/Executor, the Administrator/Executor may transfer the permit(s) to eligible family members of the deceased permittee. No transfer is effective until approved and processed by the Division.

Every pound net set in coastal fishing waters shall have yellow light reflective tape or yellow light reflective devices on each pound. The light reflective tape or yellow light reflective devices shall be affixed to a stake of at least three inches in diameter on any outside corner of each pound, shall cover a vertical distance of not less than 12 inches, and shall be visible from all directions. In addition, every pound net set shall have a marked navigational opening of at least 25 feet in width at the end of every third pound. Such opening shall be marked with yellow light reflective tape or yellow light reflective devices on each side of the opening. The yellow light reflective tape or yellow light reflective devices shall be affixed to a stake of at least three inches in diameter, shall cover a vertical distance of not less than 12 inches, and shall be visible from all directions. If a permittee notified of a violation under this

Paragraph fails or refuses to take corrective action sufficient to remedy the violation within 10 days of receiving notice of the violation, the Fisheries Director shall revoke the permit.

In Core Sound, it is unlawful to use pound net sets in the pound net sets prohibited areas designated in 15A NCAC 03R .0113 except that only those pound net set permits valid within the specified area as of March 1, 1994, may be renewed or transferred subject to the requirements of this Rule.
Escape Panels:

(1) The Fisheries Director may, by proclamation, require escape panels in pound net sets and may impose any or all of the following requirements or restrictions on the use of escape panels:
   (A) Specify size, number, and location.
   (B) Specify mesh length, but not more than six inches.
   (C) Specify time or season.
   (D) Specify areas.

(2) It is unlawful to use flounder pound net sets without four unobstructed escape panels in each pound south and east of a line beginning at a point 35° 57.3950' N - 76° 00.8166' W on Long Shoal Point; running easterly to a point 35° 56.7316' N - 75° 59.3000' W near Marker "5" in Alligator River; running northeasterly along the Intracoastal Waterway to a point 36° 09.3033' N - 75° 53.4916' W near Marker "171"at the mouth of North River; running northwesterly to a point 36° 09.9093' N - 75° 54.6601' W on Camden Point. The escape panels must be fastened to the bottom and corner ropes on each wall on the side and back of the pound opposite the heart. The escape panels must be a minimum mesh size of five and one-half inches, hung on the diamond, and must be at least six meshes high and eight meshes long.

Pound net sets are subject to inspection at all times.

Daily reporting may be a condition of the permit for pound net sets for fisheries under a quota.

It is unlawful to fail to remove all pound net stakes and associated gear within 30 days after expiration of the permit or notice by the Fisheries Director that an existing pound net set permit has been revoked or denied.

It is unlawful to abandon an existing pound net set without completely removing from the coastal waters all stakes and associated gear within 30 days.

- **Chowan River and Its Tributaries (NCAC 15A 3J .0203 (1), (2), (3), (4) (5))**

It is unlawful to: (1) anchor the lead line of any net closer than 50 feet from shore except in Meherrin River; (2) use pound nets in any tributary creek or within 150 yards of the mouth a tributary creek of the Chowan River; (3) to set a pound net within 200 yards parallel to any other pound net in Chowan River; (4) to use a seine within 1,000 yards of the mouth of any creek tributary to the Chowan River; (5) to set a trotline within 100 yards of a pound net from February 1 through May 31.

4.5.5 Wildlife Resources Commission Rules

Under WRC rules, river herring are considered as “nongame fish”. Nongame fish may be taken by “special devices” (bow nets, traps, etc) as provided in rule (Section NCAC 15A 10C), as well as by hook-and-line. No person shall take or possess during one day more than 25 river herring (alewife and blueback herring in the aggregate) that are greater than 6 inches in length from the Inland Waters of coastal rivers and their tributaries up to the first impoundment dam on the main course of the rivers. River herring greater than 6 inches in length may not be sold. Gill nets in Inland Waters are prohibited, except a few exceptions do exist in some areas.

4.5.6 Other States River Herring Rules and Regulations

See Section 12.3, Appendix 3 for a list of rules and regulations for blueback herring and alewife in other East Coast states.

5. GENERAL LIFE HISTORY

5.1 Introduction

The alewife and the blueback herring, collectively known as river herring, are anadromous members of the family Clupeidae (herrings and shads). “Anadromous” means they migrate from the ocean, enter coastal bays and sounds through inlets, and ascend into freshwater rivers and streams to spawn, traveling further upstream in wet years and remaining downstream in dry years. Surviving adults then return to the ocean after spawning. The young-of-the-year fish use rivers and estuaries as nursery grounds as they migrate downstream after hatching. After the juveniles leave the rivers and estuaries in the fall or early winter, they complete their development in the Atlantic Ocean, over the continental shelf off New England (Loesch 1987; Jenkins and Burkhead 1993). The two species occur geographically together from New Brunswick and Nova Scotia in Canada south to the northern coastal area of South Carolina. Blueback herring occur further south, to northern Florida. There are important life history differences between the two species (Loesch 1987). Alewives select slower-flowing areas for spawning, with blueback herring reported to select faster-flowing sites in areas where both species occur; however such areas generally do not exist in the FMP management area. In areas where both species occur, alewives generally spawn earlier. While fish are believed to return to the streams of their birth for spawning, both species readily colonize new streams or ponds and will reoccupy systems from which they have been extirpated (Loesch 1987). Both juveniles and adults respond negatively to light, in both riverine and offshore habitats, with alewives remaining deeper in the water column in both habitats (Klauda et al. 1991). Both species are important prey during all life stages for many other species of commercial and recreational importance. Both species have also been widely stocked in inland freshwater lakes and reservoirs where they live and reproduce entirely in freshwater and serve as prey for freshwater game fish.

In the collective population of river herring, the percentage of alewife and blueback herring present in major Albemarle Sound tributaries has varied, based on sampling of the commercial catch (Johnson et al. 1981). For example, percent composition of alewife ranged from 4 % in 1977 to 49 % in 1979, with alewife dominating the early catches in each year. From 1989 through 1992, the percentage of alewife ranged from 14.2 to 31.2% (Winslow and Rawls 1992). The same pattern of early dominance by alewife, with subsequent later dominance by blueback herring, is evident in weekly species composition samples taken during the 1980-92 spawning runs on the Chowan and Scuppernong rivers (Winslow et al. 1983; Winslow and Rawls 1992). The fraction of alewife in the commercial catch for those years ranged from 27 to 37%.

5.1.1 Alewife

The alewife has a grey to grey-green back and silvery sides. They range in size as adults from about 9 in (230 mm) to over 13 in (330 mm). Adult alewives were sampled offshore during National Marine Fisheries Service (NMFS) Atlantic Coast trawl surveys (Fay et al. 1983; Loesch 1987). The majority of catches occurred at depths less than 328 ft (100 m). Alewives were more abundant than blueback herring when all samples were combined. Alewives were most abundant at depths between 184 and 361 ft (56 and 110 m), deeper than blueback herring. Neves (1981) felt that the greenish dorsal coloration of the alewife is associated with the deeper vertical distribution of the species relative to blueback herring, given that a greenish coloration would provide better camouflage at those depths, since green wavelengths penetrate deeper than blue. Catches of the species in the ocean were confined to areas north of 40° north latitude in summer and fall. Winter catches were made between 40° and 43° north latitude, with spring catches distributed over the entire continental shelf.

Alewives which spawn in Albemarle Sound tributaries migrate from the northwest Atlantic Ocean, through Oregon Inlet and perhaps Hatteras Inlet, in late winter and early spring. Spawning surveys conducted by the DMF since the mid 1970s during March through May have documented spawning in many tributary streams of Albemarle Sound's major tributaries (Street et al. 1975; Johnson et al. 1977; Johnson et al. 1981; Winslow et al. 1983; Winslow et al. 1985; Winslow and Rawls 1992; Rawls 2001). Known historical anadromous fish spawning areas are depicted in Figures 5.1.1-5.1.3, which also delineates Essential Fish Habitat for the species. Table 5.1 summarizes the amount of documented anadromous fish spawning and use areas (by type of water body) relative to potential habitat. Potential habitat includes all streams in the coastal plain shown on 1:100,000 scale hydrologic maps below major impediments.

Although the alewife has been reported as ranging from Newfoundland south to South Carolina (Loesch 1987), surveys reported by Rulifson et al. (1982) in 1980 and repeated 12 years later (Rulifson 1994) indicated that the species now occurs in south Atlantic coastal rivers only in North Carolina. In North Carolina, populations were reported in the North, Pasquotank, Little, Perquimans, Yeopim, Chowan, Meherrin, Roanoke, Cashie, Scuppernong and Alligator rivers (all tributaries of Albemarle Sound); Lake Mattamuskeet and canals to the lake, Tar-Pamlico, Pungo, Neuse, and Trent rivers (tributaries to Pamlico Sound); New River; White Oak River; and Cape Fear, Northeast Cape Fear and Brunswick rivers. The status of these populations is presented in Table 4 of Rulifson (1994). All populations were listed as either "declining" or "status unknown" as of 1992.

Anadromous alewives may begin spawning as early as age three, with the majority reaching sexual maturity at age 4 or 5. Fecundity in females ranged from 60,000 to 100,000 eggs (Fay et al. 1983). Moser and Patrick (2000) reported a mean alewife fecundity estimate of 118,670 for the Albemarle area. Spawning populations are generally younger in the south.

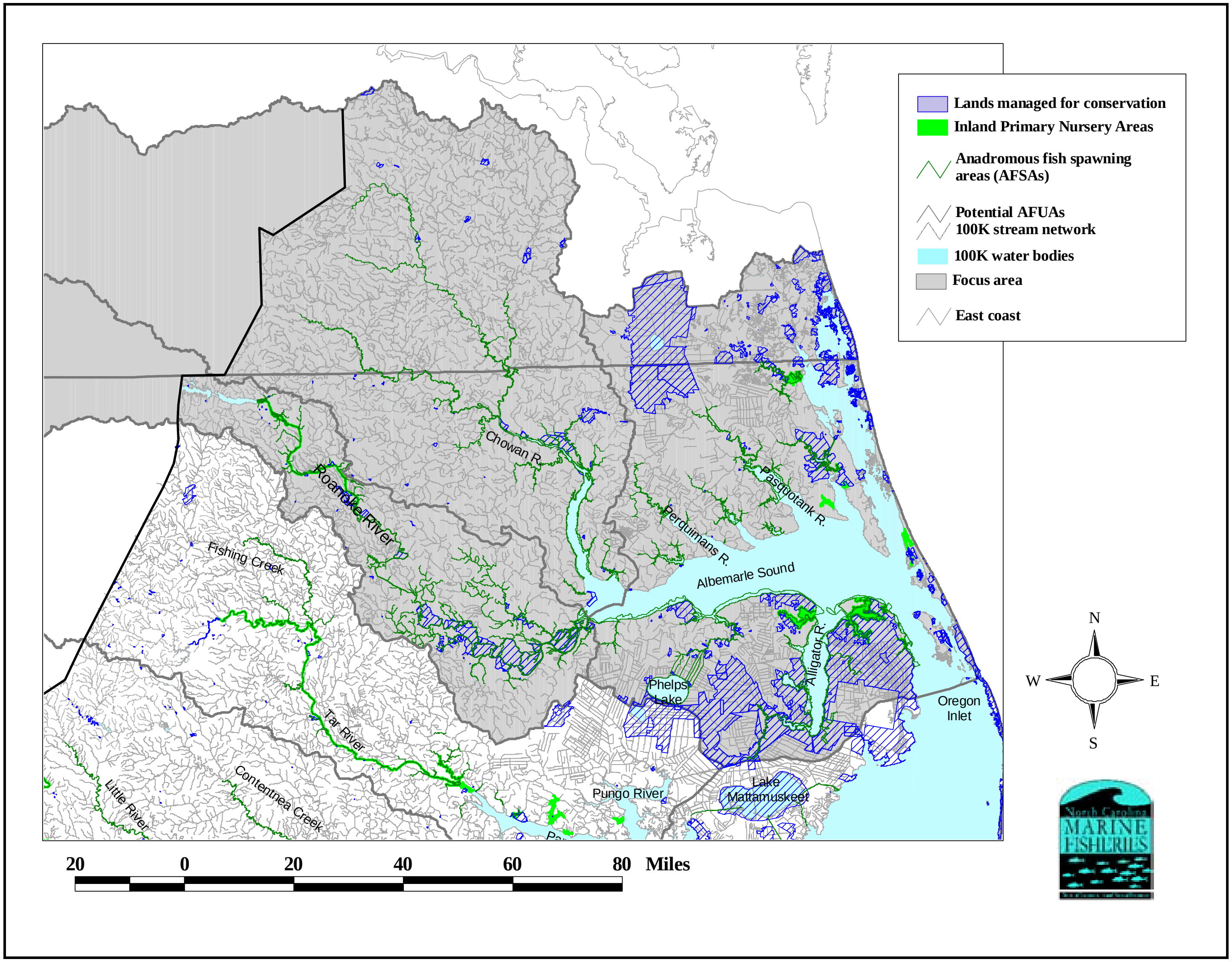


Figure 5.1.1. Anadromous fish spawning areas (as delineated by DMF, 2/20/06), lands managed for conservation (CGIA, 2002), and Inland Primary Nursery Areas (designated by WRC, 8/03) in the northern coastal plain of North Carolina.

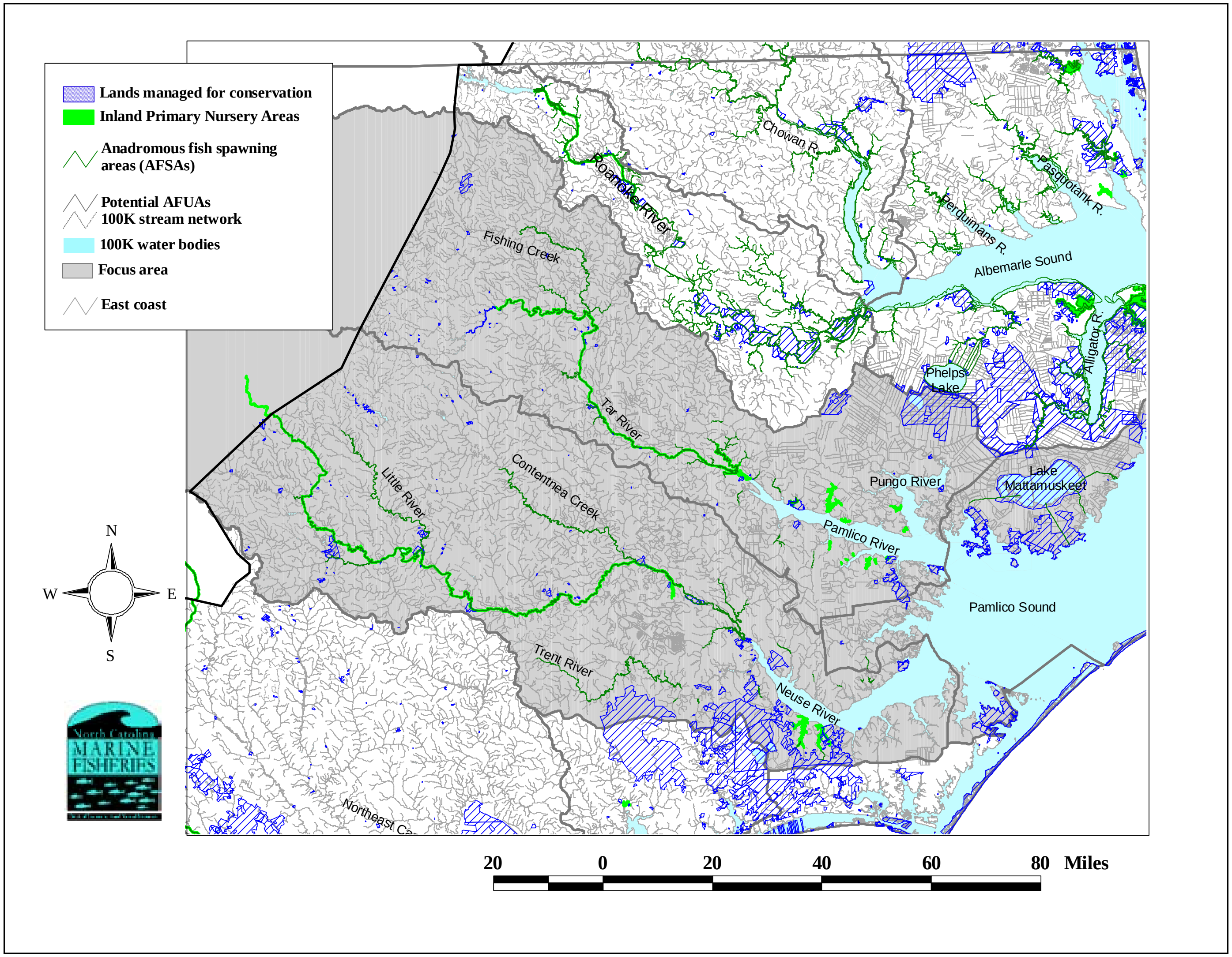


Figure 5.1.2. Anadromous fish spawning areas (as delineated by DMF, 2/20/06), lands managed for conservation (CGIA, 2002), and Inland Primary Nursery Areas (designated by WRC, 8/03) in the central coastal plain of North Carolina.

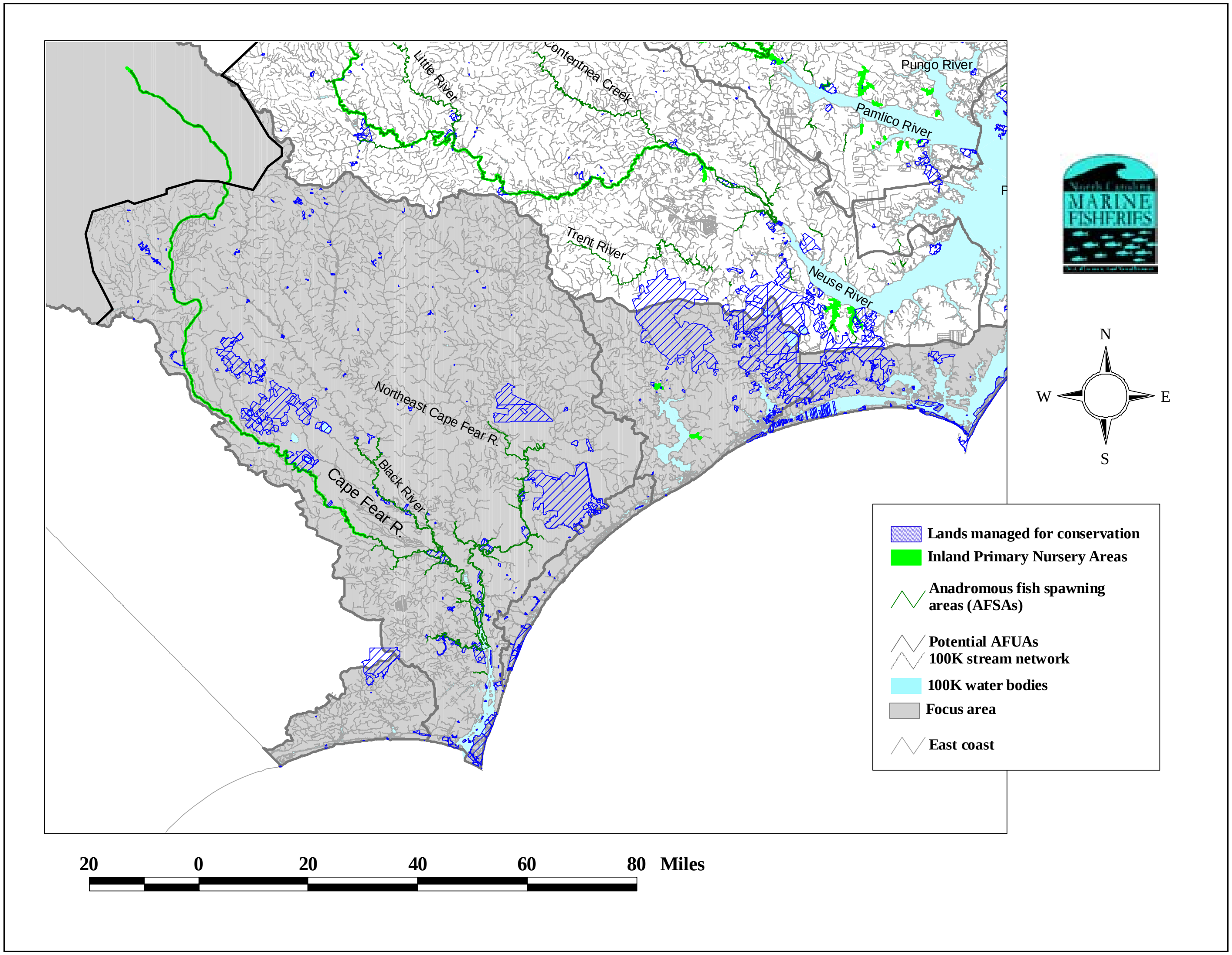


Figure 5.1.3. Anadromous fish spawning areas (as delineated by DMF, 2/20/06), lands managed for conservation (CGIA, 2002), and Inland Primary Nursery Areas (designated by WRC, 8/03) in the southern coastal plain of North Carolina.

Table 5.1. Amount of documented anadromous fish habitat relative to potential habitat in coastal North Carolina. See Figures 5.1.1-5.1.3 for reference.

MU	Hydrographic feature	ANADROMOUS FISH SPAWNING AND USE AREAS (mi)					
		Potential			Documented		
		NC	VA	Total	NC	VA	Total
Albemarle	Major rivers	8	48	56	8	0	8
	Lake shorelines	34	4	39	10	0	10
	Tributaries	3,150	995	4,145	247	0	247
	Coastal shorelines	1,241	76	1,317	516	0	516
Chowan	Major rivers	95	44	139	141	48	189
	Lake shorelines	0	0	0	0	0	0
	Tributaries	1,272	2,084	3,356	267	117	384
	Coastal shorelines	88	0	88	88	0	88
Roanoke	Major rivers	181	0	181	181	0	181
	Lake shorelines	0	0	0	0	0	0
	Tributaries	1,382	0	1,470	427	0	427
	Coastal shorelines	6	0	6	4	0	4
Albemarle watershed		7,459	3,251	10,797	1,889	165	2,054
Pamlico	Major rivers	0	0	0	0	0	0
	Lake shorelines	79	0	79	37	0	37
	Tributaries	852	0	852	42	0	42
	Coastal shorelines	664	0	664	14	0	14
Tar/Pamlico	Major rivers	83	0	83	86	0	86
	Lake shorelines	8	0	8	0	0	0
	Tributaries	3,936	0	3,936	188	0	188
	Coastal shorelines	550	0	550	79	0	79
Neuse	Major rivers	220	0	220	188	0	188
	Lake shorelines	14	0	14	0	0	0
	Tributaries	4,469	0	4,469	302	0	302
	Coastal shorelines	369	0	369	11	0	11
Core/Bogue	Major rivers	0	0	0	0	0	0
	Lake shorelines	0	0	0	0	0	0
	Tributaries	226	0	226	9	0	9
	Coastal shorelines	674	0	674	0	0	0
New/White Oak	Major rivers	0	0	0	0	0	0
	Lake shorelines	14	0	14	0	0	0
	Tributaries	793	0	793	64	0	64
	Coastal shorelines	347	0	347	82	0	82
Cape Fear	Major rivers	237	0	237	231	0	231
	Lake shorelines	10	0	10	0	0	0
	Tributaries	4,690	0	4,690	246	0	246
	Coastal shorelines	212	0	212	19	0	19
Pamlico and southern watersheds		18,446	0	18,446	1,598	0	1,598
TOTALS	Major rivers	824	91	916	835	48	883
	Lake Shorelines	158	4	163	47	0	47
	Tributaries	20,771	3,079	23,937	1,793	117	1,909
	Coastal shorelines	4,151	76	4,227	813	0	813
	All waterbodies	25,905	3,251	29,242	3,487	165	3,652

Females sampled from Albemarle Sound tributaries were primarily (94-97%) ages 4 through 6, with fish present up to ages 7 or 8 (Johnson et al. 1981). The historical average repeat spawning from 1972 through 1981 was 9.4% for alewife (see Section 5.3). Spawning occurs in the spring, earlier in the south and later in the north. Alewives generally spawn 3-4 weeks before blueback herring in areas where both species coexist. Alewives in North Carolina spawn at water temperatures of 55-61° F (12.9-16° C) (Tyus 1974; Winslow 1989; Winslow et al. 1983). Alewives use a wide variety of spawning sites, such as stream edges and flooded backwaters.

Alewife eggs hatch in approximately 50 to 360 hours, depending upon temperature (Fay et al. 1983). The alewife yolk-sac stage lasts from 2 to 5 days, with larval alewives ranging in size from 0.2 to 0.8 in (4.3 to 19.9 mm). Transformation to the juvenile stage occurs at about 0.8 in (20 mm). Juvenile alewives may initially exhibit upstream movement during periods of decreased flows and encroachment of saline waters (ASMFC 2004), later moving downstream as fall approaches. Emigration from Albemarle Sound occurs between September and November of the first year of life, and may be stimulated by heavy rainfall, high water, and/or sharp declines in water temperatures. However, high abundance of juveniles may trigger an early migration (e.g. summer) (Richkus 1975). Although an early migration has not been documented in North Carolina (Sara Winslow/DMF, personal communication 2005). Habitat requirements for critical early life history stages of the alewife as determined by Klauda et al. (1991) are presented in Table 5.2.

Alewives primarily consume zooplankton, although fish eggs, crustacean eggs, insects and insect eggs and shrimp, squid and small fishes may be eaten in some areas or by larger individuals (Jenkins and Burkhead 1993). Alewife is important prey for other species jointly managed by federal and state governments and the ASMFC, including bluefish, American eel, striped bass and weakfish. Age-1 striped bass, in particular, can feed heavily on Alosines during their fall emigration (Tuomikoski 2004). State managed freshwater species such as: largemouth bass, pumpkinseed, redfin pickerel, shiners, walleye, white bass, white perch and yellow perch also consume alewife (Loesch 1987).

5.1.2 Blueback Herring

Blueback herring have a blue to blue-green back and silver sides with a prominent dark spot on the shoulder. In contrast to the alewife, bluebacks have a black peritoneum lining the body cavity. They range in size from around 9 in (230 mm) at age three to around 12.3 in (313 mm) at age eight or nine. Catch data from NMFS ocean trawl surveys (Neves 1981) indicate that bluebacks spend most of their time offshore in water depths of less than 328 ft (100 m). North of Cape Hatteras, blueback herring were most abundant at depths between 89 and 180 ft (27 and 55 m). Catches of bluebacks in summer and fall were confined to the areas north of 40°– north latitude. Winter catches were made between 40° and 43° north latitude. Spring catches were distributed over the entire Continental Shelf portion of the study area (Fay et al. 1983).

Bluebacks have a broader range in the south Atlantic than alewife, occurring as far south as coastal rivers in Florida. Rulifson's recent (1994) survey indicated that the species occurs in the following North Carolina river systems: North, Pasquotank, Little, Perquimans, Yeopim, Chowan, Meherrin, Roanoke, Cashie, Scuppernong and Alligator rivers (all tributaries of Albemarle Sound); Tar-Pamlico, Pungo, Neuse, and Trent rivers (tributaries to Pamlico Sound); New River; White Oak River; and Cape Fear, North East Cape Fear and Brunswick rivers. Known historical anadromous spawning areas are depicted in Figures 5.1.1- 5.1.3, which also delineates Essential Fish Habitats for the species. Table 5.1 summarizes the amount of documented anadromous fish spawning and use areas (by type of water body) relative to potential habitat.

Blueback herring have been reported to spawn in the lower portions of the tributary rivers of estuaries along the east coast from Nova Scotia to the St. Johns River in Florida (Fay et al. 1983). Loesch (1987) noted that both species have the ability to ascend rivers far upstream although earlier studies suggested that alewife will ascend further upstream than bluebacks (Hildebrand 1963; Scott and Crossman 1973).

Table 5.2. Habitat requirements for the critical early life history stages of alewife, *Alosa pseudoharengus* (after Klauda et al. 1991). NIF indicates no information found.

Life Stage	**Zone**	**Temperature °C**	**Salinity %**	**Dissolved Oxygen mgL^{-1}**	**pH**	**Hardness mgL^{-1} $CaCO_3$**	**Alkalinity mgL^{-1} $CaCO_3$**	**Suspended Solids mgL^{-1}**	**Current Velocity cm^{s-1}**
Egg	substrate and water column	11-28 (suitable) 16-21 (optimum)	NIF* (suitable) 0-2 (optimum)	>5.0 (suitable) NIF (optimum)	5.0-8.5 (suitable) NIF (optimum)	NIF	NIF	<1000 (suitable) NIF (optimum)	NIF
Prolarva	water column	8-31 (suitable) 15-24 (optimum)	NIF (suitable) 0-3 (optimum)	>5.0 (suitable) NIF (optimum)	5.5-8.5 (suitable) NIF (optimum)	NIF	NIF	NIF	NIF
Postlarva	water column	14-28 (suitable) 20-26 (optimum)	NIF (suitable) 0-5 (optimum)	>5.0 (suitable) NIF (optimum)	NIF	NIF	NIF	NIF	NIF
Early juvenile	water column and near substrate	10-28 (suitable) 17-24 (optimum)	NIF (suitable) 0-5 (optimum)	>3.6 (suitable) NIF (optimum)	NIF	NIF	NIF	NIF	NIF

Bluebacks vary more than alewives in age of first spawning, although, their maturation rates are similar (Fay et al. 1983). Spawning populations in Albemarle Sound tributaries were dominated by ages 4-6 during the late 1970s and early 1980s (Johnson et al. 1981, Winslow et al. 1983). Fecundity of blueback herring females ranged from 45,800 eggs in a 9.4 in (238 mm) individual to 349,700 in a 12.2 in (310 mm) fish (Fay et al. 1983). Moser and Patrick (2000) reported a mean fecundity estimate of 150,901 eggs/female for blueback herring from the Albemarle area. In North Carolina, blueback herring begin spawning at warmer temperatures than alewives, with recorded spawning temperatures of 58-63° F (14.4-17° C) (Winslow 1989; Winslow et al. 1983). Bluebacks spawn in flooded backswamps, oxbows and along stream edges. Both species spawn in groups, scatter their eggs, and cease spawning when water temperatures rise above 81° F (27° C). Blueback herring eggs hatch in approximately 55 to 94 hours, depending upon the temperature. Yolk-sac larvae average 0.2 in (5.1 mm) at absorption and remain in that stage for 2-3 days. Larval blueback herring range from 0.2 to 0.6 in (4-15.9 mm) in length. Transformation to the juvenile stage is completed at about 0.8 in (20 mm) in length. Like juvenile alewife, juvenile blueback herring may initially exhibit upstream movement during the summer, followed by downstream movement beginning in October. Juveniles exhibit diel movement, moving toward the bottom during the day and toward the surface at night. Emigration from estuarine nursery areas in North Carolina occurs between September and November of their first year. Little information is available on the juveniles of the species once emigration to sea has occurred. Habitat requirements for critical early life stages of blueback herring as documented by Klauda et al. (1991) are presented in Table 5.3.

Blueback herring, like alewives, are primarily zooplankton feeders. Young-of-the year bluebacks consumed various species of copepods and cladocerans (Jenkins and Burkhead 1993). In the ocean, the species' diet consists of copepods, other plankton, pelagic shrimps, small fishes and fish fry. The food of adults is similar to that of juveniles and includes insects during the spawning migration (Jenkins and Burkhead 1993). The blueback herring is a small species, and as such, is important forage for other species. It is preyed upon by the same species that prey on alewife and other clupeid species, and constitutes an important link in estuarine and marine food webs between zooplankton and top predators.

Table 5.3. Habitat requirements for the critical early life history stages of blueback herring, *A. aestivalis* (after Klauda et al. 1991). NIF indicates no information found.

Life Stage	Zone	Temperature C	Salinity %	Dissolved Oxygen mgL^{-1}	pH	Hardness mgL^{-1} $CaCO_3$	Alkalinity mgL^{-1} $CaCO_3$	Suspended Solids mgL^{-1}	Current Velocity cm^{s-1}
Egg	substrate and water column	14-26 (suitable) 20-24 (optimum)	0-22 (suitable) 0-2 (optimum)	NIF* (suitable) NIF (optimum)	5.7-8.5 (suitable) 6.0-8.0 (optimum)	NIF	NIF	<1000 (suitable) NIF (optimum)	NIF
Prolarva	water column	14-26 (suitable) NIF (optimum)	0-22 (suitable) NIF (optimum)	>5.0 (suitable) NIF (optimum)	6.2-8.5 (suitable) 6.5-8.0 (optimum)	NIF	NIF	<500 (suitable) NIF (optimum)	NIF
Postlarva	water column	14-28 (suitable) NIF (optimum)	0-22 (suitable) NIF (optimum)	>5.0 (suitable) NIF (optimum)	NIF	NIF	NIF	NIF	NIF
Early juvenile	water column and near substrate	10-30 (suitable) 20-28 (optimum)	0-28 (suitable) 0-5 (optimum)	>4.0 (suitable) NIF (optimum)	NIF	NIF	NIF	NIF	NIF

5.2 Historical Abundance

In North Carolina, there are no long-term data available on river herring abundance. Historical abundance of river herring in Albemarle Sound, based on landings and effort data, was investigated by Hightower et al. (1996). Fisheries in the Albemarle Sound once harvested large numbers of river herring, but landings in recent years are substantially lower. Average yearly landings during the 90-year period of 1880 – 1970 were 11.9 million pounds (5.4 million kg). In contrast, landings in 1998 were only 4.2% of the historical average (519,289 lb; 235,548 kg; see Section 6). This comparison does not take into account the change in effort since a season was implemented in 1995. Hightower et al. (1996) noted that the estimate of maximum sustainable yield derived from their modeling the period 1845 – 1993 was 12.6 million lb (5.7 million kg), similar to the long-term average of reported landings. They stated that the only remaining question was whether habitat has been lost or degraded to such a degree that historical levels of harvest are no longer possible.

5.3 Present Stock Status

The DMF anadromous fish sampling program began in the Albemarle Sound area in 1972. Work began in the Tar-Pamlico, Neuse and Cape Fear systems during the mid-1970s. Sampling throughout the coastal area has been scaled back over the years due to reductions in federal funds supplied by the Anadromous Fish Conservation Act (P.L. 89-304). River herring research and monitoring work conducted by DMF are shown in Table 4.2, by system and year. Specific sampling methods are described in Street et al. (1975), Johnson et al. (1977; 1981), Winslow et al. (1983; 1985), Winslow (1989; 1995; 1998); Winslow and Rawls (1992) and Rawls (2001; 2004). The stock assessment analysis, "The Status of River Herring (Blueback Herring and Alewife) in the Chowan River, 1972 – 2004" (Grist 2005) is presented in Section 12.2, Appendix 2.

5.3.1 Fishing Mortality

Mortality rates were estimated by catch curve and catch at age analyses for blueback herring and alewife in the Chowan River. Total mortality for blueback herring based on the catch curve analyses averaged Z= 1.44 for the 1972 – 2003 period. By subtracting the assumed natural mortality rate of M= 0.5, fishing mortality is estimated at approximately F= 1.17 for blueback herring. Estimated fishing mortality from the catch at age model for blueback herring from 1972 through 1994 is 0.90, which is equivalent to an annual exploitation rate attributable to fishing of 59%. To account for the possibility that regulatory changes have had some impact on exploitation rates, F was estimated annually for 1995 – 2003. Except for 1995 and 1997, fishing mortality has ranged from 0.98 in 1998 to 1.91 in 2003, with a corresponding exploitation ranging from 63 – 85% for blueback herring.

Chowan River alewife annual catch curve analysis also suggested a high total mortality, averaging 1.48 from 1972 through 2003. Subtracting natural mortality, the estimated fishing mortality on alewife based on the catch curve analysis is 1.27. Estimated fishing mortality from 1972 – 1994 was 0.98 for alewife, with an annual exploitation rate attributable to fishing of 62%. Except 1995 and 1997, fishing mortality has ranged from 1.01 in 1998 to 1.86 in 2002 with corresponding exploitations ranging from 64% to 85%.

5.3.2 Recruitment

Blueback herring recruitment at age 3 averaged 28.9 million fish per year between 1972 and 1985; but since 1986, it has averaged 3.6 million fish and in the last five years, only 552,000 fish (Figure 5.2). Strong year classes in the late 1960s sustained the stock through the mid-1970s, when the poor 1975 – 1977 cohorts contributed to the decline in the late 1970s. Exceptional recruitment of the 1978 – 1981 cohorts, which averaged 38 million fish, allowed the stock to rebuild in the early 1980s, but from 1982 to 1986 combined with sustained high fishing mortality lead to a decline in overall stock abundance over the last 10 years. Recruitment has been low since 1989, only averaging 1.8 million fish a year. Moreover, any modest gains in blueback herring recruitment since the early 1980s supported catches over the short term and were quickly removed by high fishing mortality.

Chowan River alewife recruitment averaged 7.5 million age-3 fish a year between 1972 and 1986, but since 1987 it has only averaged around 587,000 fish, and in the last five years only 317,000 fish (Figure 5.3). Strong year classes of alewife in the late 1960s sustained the stock through the early 1970s, then poor 1972 and 1973 cohorts contributed to the decline in the mid-1970s. High recruitment of the 1978 to 1981 cohorts, averaging 9.5 million fish, allowed the stock

Figure 5.2. Blueback herring annual estimates of recruitment, 1972 to 2003.

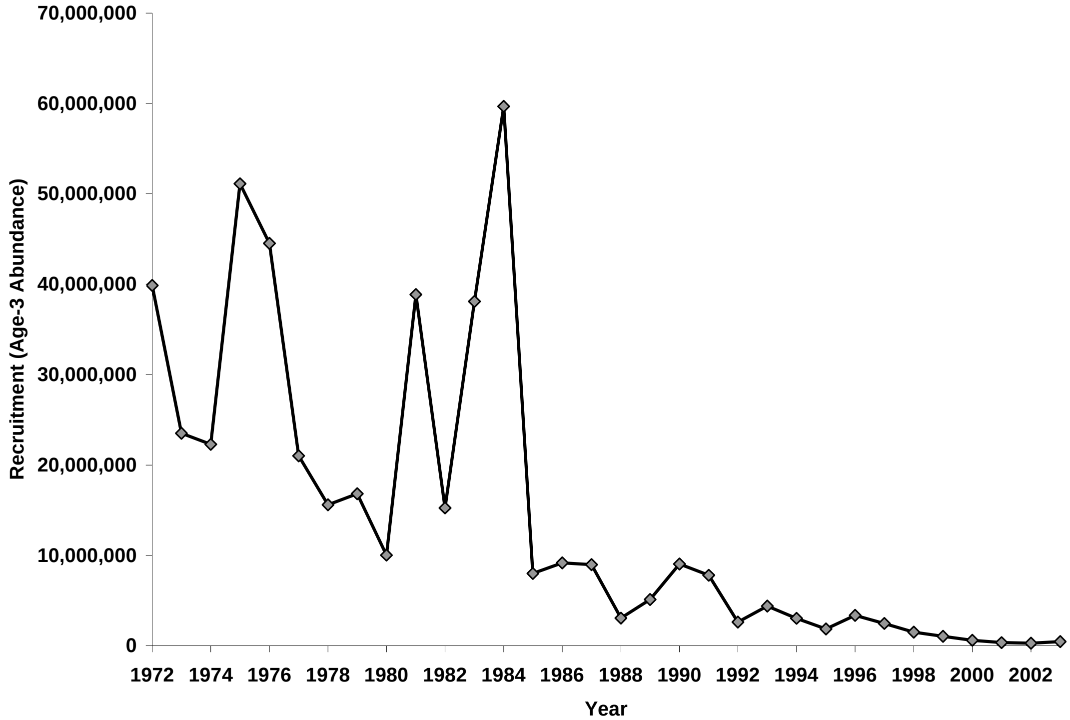


Figure 5.3. Alewife annual estimates of recruitment, 1972 to 2003.

to rebuild in the early 1980s. However, another series of poor cohorts from 1985 and 1986, and then extremely poor cohorts from 1989 through 1994, combined with sustained high fishing mortality lead to a drastic decline in overall stock abundance during the mid-1990s. A slight increase in alewife recruitment over the last five years, averaging 317,000 fish has occurred. However, any modest gains in alewife recruitment since 1996 has supported catches over the short term and were quickly removed by high fishing mortality. The 1996 cohort supported nearly 58% of the 2000 catch, nearly 53% of the 2001 catch, and over 21% of the 2002 catch.

5.3.3 Spawning Stock Biomass

Blueback herring spawning stock biomass (SSB) varied between 4.4 and 14.5 million pounds and averaged 8.3 million pounds from 1972 through 1986 (Figure 5.4). SSB then dropped to just 1.0 million pounds in 1994, corresponding to a decline in recruitment (Table 5.4). Continued blueback herring declines in recruitment through the 1990s further reduced SSB to a record low of 89,678 pounds in 2003.

Alewife SSB varied from 1.1 million pounds to 3.1 million pounds from 1971 to 1988, but then declined rapidly during the early 1990s. From 1994 through 1999, alewife SSB averaged 22,953 pounds, with a record low of 10,862 pounds in 1995 (Figure 5.5). This dramatic drop in alewife SSB corresponds with historically low recruitment values in the early 1990s (Table 5.5). A slight increase in alewife SSB has been observed since 2000, however, the 2003 SSB value (92,442 pounds) was only 7.5% of the 1972 – 2003 average.

5.3.4 Juvenile Indices

The DMF began nursery area sampling for juvenile blueback herring and alewife in the Albemarle Sound area in 1972. This survey was designed to index annual relative abundance of juvenile blueback herring and alewife. Thirty-four stations were established in the western Albemarle Sound area and sampled with trawls and seines. The Carolina wing trawl was adopted as the standard trawl in place of the Cobb trawls in June 1974 (Johnson et al. 1977), and the seines continued. The 34 stations (23 trawls and 11 seines) were sampled monthly during June-October. During September, an additional 43 stations (28 trawls and 15 seines) were sampled throughout the Albemarle Sound area to determine distribution and nursery areas

Figure 5.4. Blueback herring annual estimates of spawning stock biomass, 1972 to 2003.

Figure 5.5. Alewife annual estimates of spawning stock biomass, 1972 to 2003.

Table 5.4. Blueback herring spawning stock biomass and recruitment by cohort based on catch at age analysis.

Year	SSB (lb)	Recruits by cohort (est. numbers at age-3)
1969		39,865,477
1970		23,506,889
1971		22,284,834
1972	14,522,222	51,118,274
1973	11,425,556	44,515,997
1974	8,548,280	21,013,218
1975	7,911,119	15,591,527
1976	9,911,718	16,829,710
1977	10,459,987	10,028,049
1978	8,022,784	38,857,247
1979	5,635,462	15,254,203
1980	4,417,303	38,099,778
1981	4,709,277	59,696,182
1982	6,008,350	7,987,989
1983	6,779,751	9,165,666
1984	8,723,894	8,969,447
1985	10,231,393	3,049,336
1986	7,313,002	5,103,808
1987	3,862,501	9,036,148
1988	2,559,345	7,797,123
1989	1,698,050	2,628,602
1990	1,497,323	4,380,587
1991	1,837,518	3,030,564
1992	1,822,752	1,864,735
1993	1,379,160	3,366,597
1994	1,072,525	2,476,938
1995	896,214	1,517,985
1996	838,699	1,055,377
1997	741,427	622,571
1998	815,045	343,726
1999	537,244	273,119
2000	283,041	467,359
2001	190,190	
2002	99,797	
2003	89,678	

Table 5.5. Alewife spawning stock biomass and recruitment by cohort based on catch at age analysis.

Year	SSB (lb)	Recruits by cohort (est. numbers at age-3)
1969		5,806,398
1970		6,792,805
1971		10,243,653
1972	3,027,835	1,524,166
1973	2,024,871	1,027,837
1974	2,099,253	10,412,192
1975	2,169,714	12,893,819
1976	1,300,120	6,485,611
1977	950,638	4,224,186
1978	2,208,861	14,429,980
1979	3,067,599	6,312,971
1980	2,417,636	6,863,865
1981	2,090,113	13,661,915
1982	2,759,259	5,047,520
1983	2,618,448	6,187,074
1984	2,398,657	3,179,568
1985	2,835,526	595,544
1986	2,368,913	448,161
1987	1,630,842	2,483,113
1988	1,111,173	1,176,496
1989	476,350	25,082
1990	289,931	18,843
1991	449,585	38,198
1992	398,218	36,853
1993	142,058	41,260
1994	22,772	66,988
1995	10,862	137,422
1996	11,246	436,220
1997	14,802	356,773
1998	25,596	102,284
1999	52,443	475,838
2000	101,751	214,737
2001	111,738	
2002	86,407	
2003	92,442	

of anadromous species.

Seine stations were sampled with a 60 ft bag seine with ¼ inch mesh bag, with a single haul considered one catch-per-unit-of-effort (CPUE). The Carolina wing trawl had a headrope length of 26 ft, containing webbing which ranged from 4 inch stretched mesh in the wings to 1/8 inch mesh tail bag. The trawl was pulled for 10 minutes, and was considered one CPUE. Samples were sorted to species, and up to 30 individuals of each alosine species present were measured to the nearest millimeter fork length (mm, FL), and all others were counted.

Based on catch consistency the seine proved to be the best sampling gear for blueback herring, and the wing trawl was the best for alewife. Due to a further reduction in federal aid funds, trawl sampling was dropped at the end of June 1984. Sampling with seines at the 11 cores stations has continued during June-October each year (Figure 5.6). During September, an additional 13 seine stations are sampled throughout the Albemarle Sound area (Figure 5.6) to determine distribution and migration.

The juvenile abundance indices (JAI) for blueback herring and alewife have fluctuated over the years in the Albemarle Sound area (Figure 5.7 and 5.8). The highest CPUE recorded for blueback herring was in 1973 (362.9 fish/seine); the lowest was in 1994 (0 fish/seine), part of a very low CPUE trend during 1986-2005 (Figure 5.7). The thirty-four year average CPUE for blueback herring is 59.9, dropping from 70.4 long-term average as reported in the 2000 River Herring FMP. The average CPUE for alewife during the 1972-2005 period is 2.3 fish/seine compared to the 2.5 fish/seine reported in 2000. In 1980, a CPUE of 12.4 fish/seine was recorded for alewife; other years were much below that level (Figure 5.8).

A recommendation of the 2000 River Herring FMP was to expand the seine survey in the western Albemarle Sound area to determine if the core nursery areas were no longer being utilized and/or if juvenile production was being overlooked. Five additional seine stations were added in 1999 and have been sampled monthly during June-October (Figure 5.6). The CPUE from these stations for blueback herring and alewife are shown in Figure 5.9. The blueback herring CPUE at these stations has increased the past two years, however for both years over 76% of the total catch was caught at one station on a single sampling day.

Annual sampling to determine the relative abundance of young-of-the-year (YOY) striped bass has been conducted at seven sampling locations (Hassler stations, Figure 5.10), in the western Albemarle Sound area since 1955. Dr. W.W. Hassler (North Carolina State University) conducted the sampling program from 1955 through 1987, through various funding sources (Hassler et al. 1981; 1982, Hassler and Taylor 1986). The DMF has conducted the sampling since 1988 (Henry et al. 1992; Taylor and Hardy 1993,1994; Trowell and Winslow 1997, 1998; Dilday and Winslow 2002; Winslow 2005). These sampling efforts also provide long-term data for blueback herring and alewife juvenile abundance.

An 18 ft semi-balloon trawl, constructed of 1.5 inch stretched mesh webbing in the body and 0.5 inch stretched mesh in the cod end is utilized. Sampling occurs annually during mid-July through October. Each trawl sample is pulled for 15 minutes, and considered one CPUE. Samples are sorted to species, counted and measured to the nearest millimeter fork length (mm, FL).

The CPUE for blueback herring taken at the Hassler (YOY striped bass) stations is shown in Figure 5.11. The 1996 (107.8), 1997 (90.5) and 2004 (60.0) CPUEs were the highest since 1962, but the 1994, 1995, 1998, 1999, and 2002 CPUEs were less than 0.2. Figure 5.12. shows the CPUEs for alewife from the Hassler stations. The alewife CPUE in 1996 was 3.0, the first time it had been above one since 1984. In 1997, 1998, 1999, and 2000 the CPUE dropped to 0.7, 0.05, and 0.87 respectively. The 2001 through 2004 alewife CPUE's increased, ranging from 1.3 to 8.6 but dropped in 2005 to 0.64 (Figure 5.12).

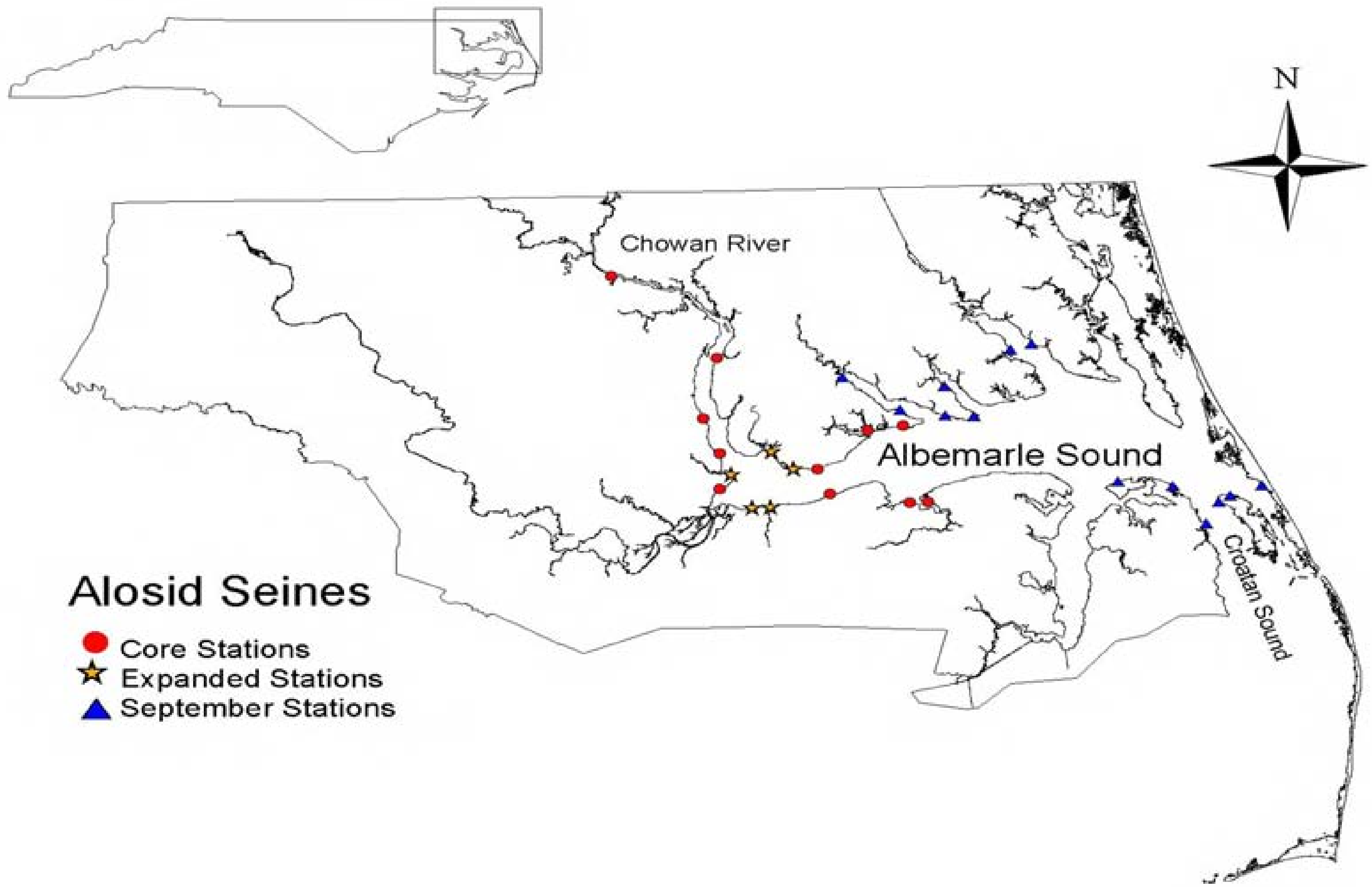


Figure 5.6. River herring nursery area sampling sites in the Albemarle Sound area, NC, 1972-2006.

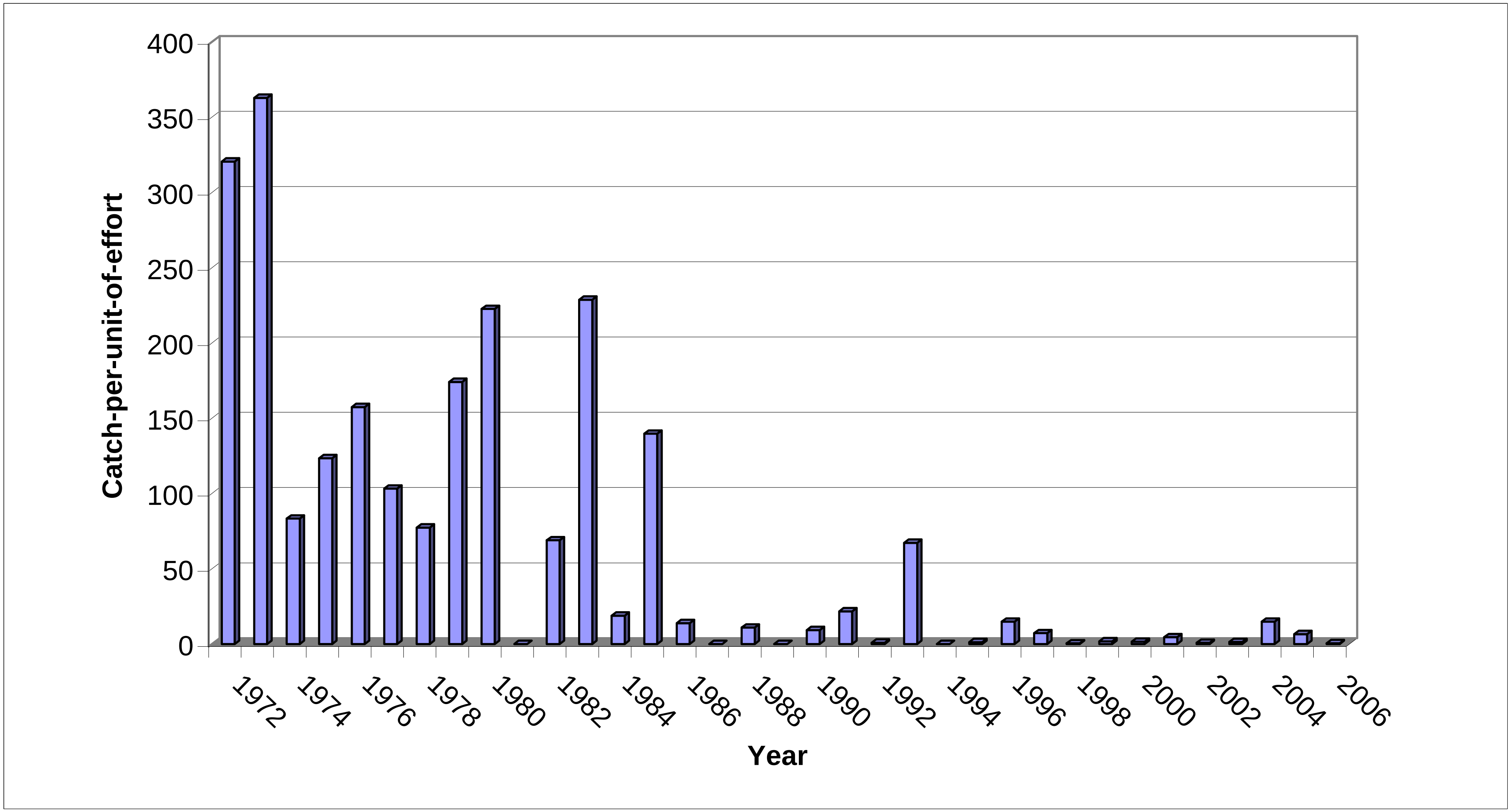


Figure 5.7. Juvenile abundance index by seine for blueback herring 1972-2006 year classes, from the Albemarle Sound area, NC.

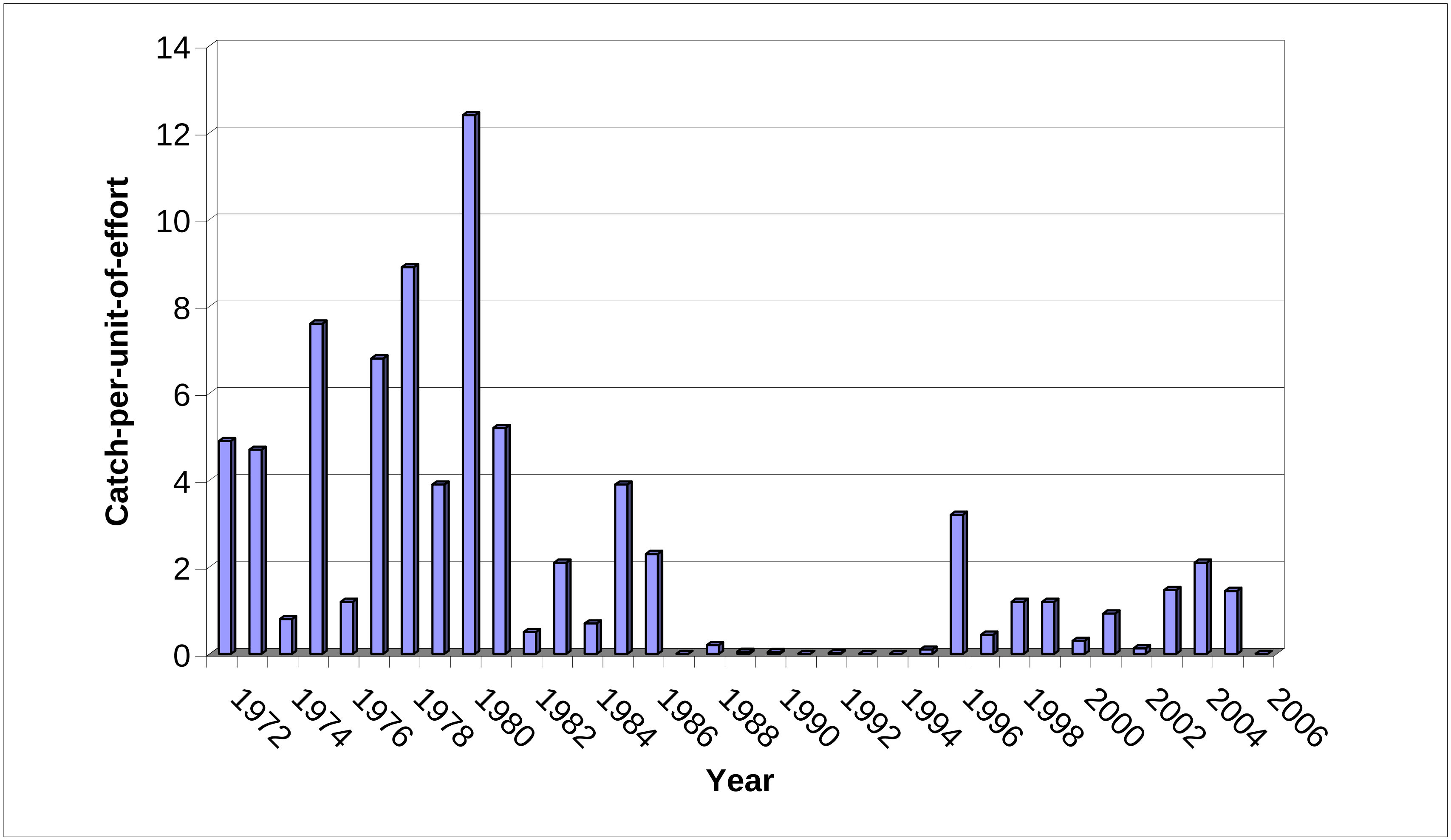


Figure 5.8. Juvenile abundance index by seine for alewife 1972-2006 year classes, from the Albemarle Sound area, NC.

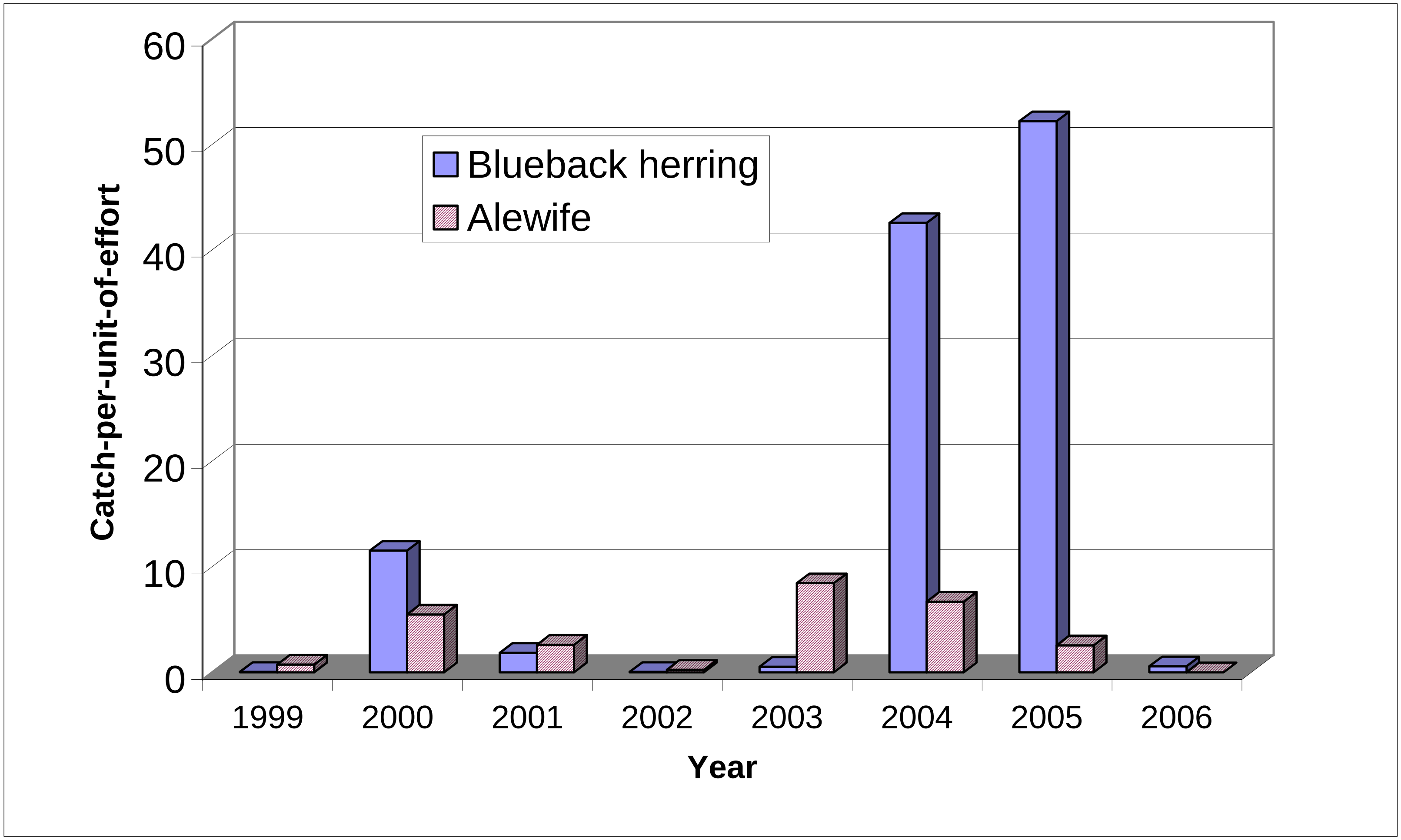


Figure 5.9. Catch per unit of effort for blueback herring and alewife from five additional seine stations added in western Albemarle Sound area, 1999-2006.

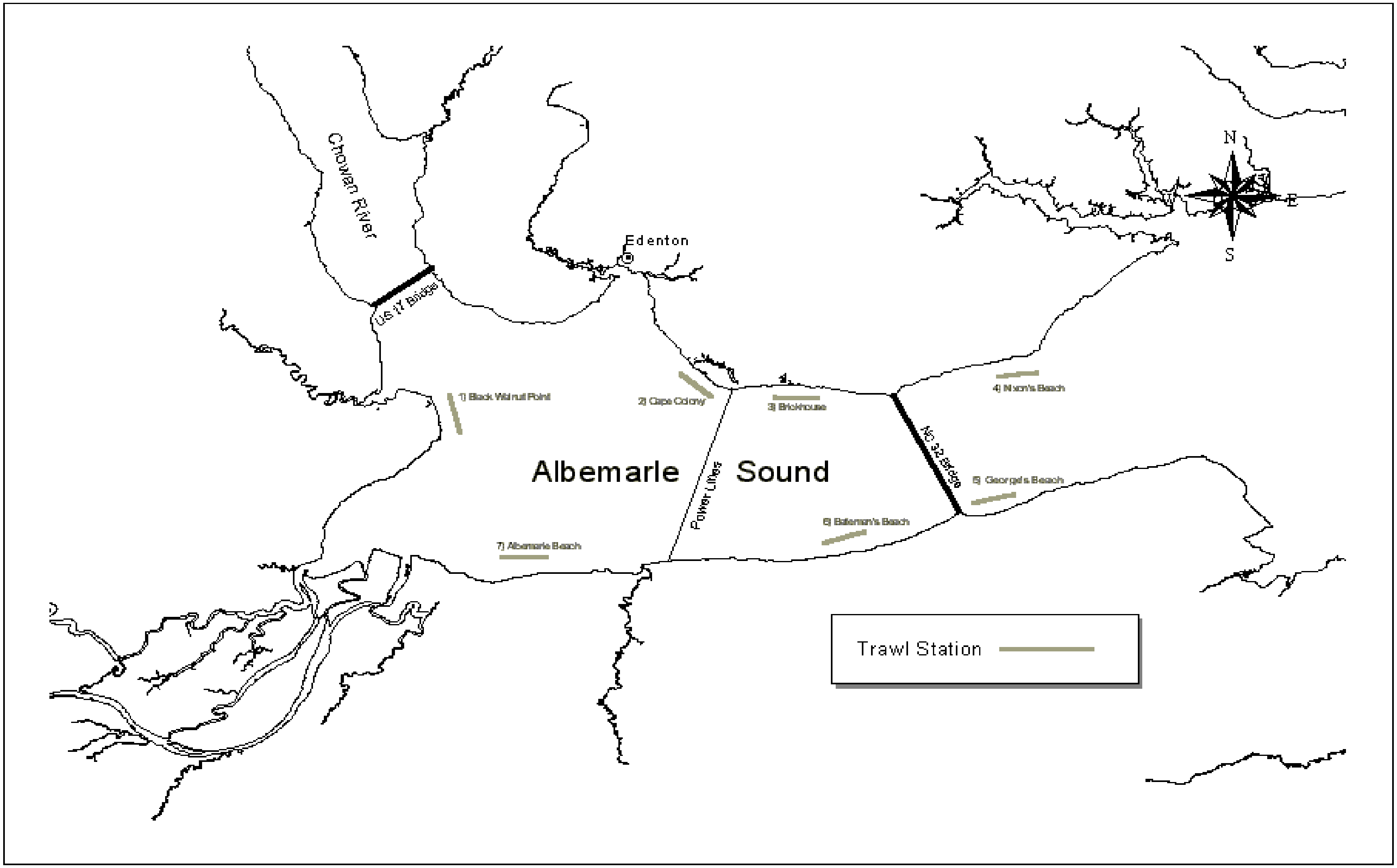


Figure 5.10. Trawl station locations (Hassler stations) sampled in the western Albemarle Sound area, NC, 1955-2006. (Dr. W.W. Hassler conducted sampling from 1955-1987; DMF sampling 1988-2006)

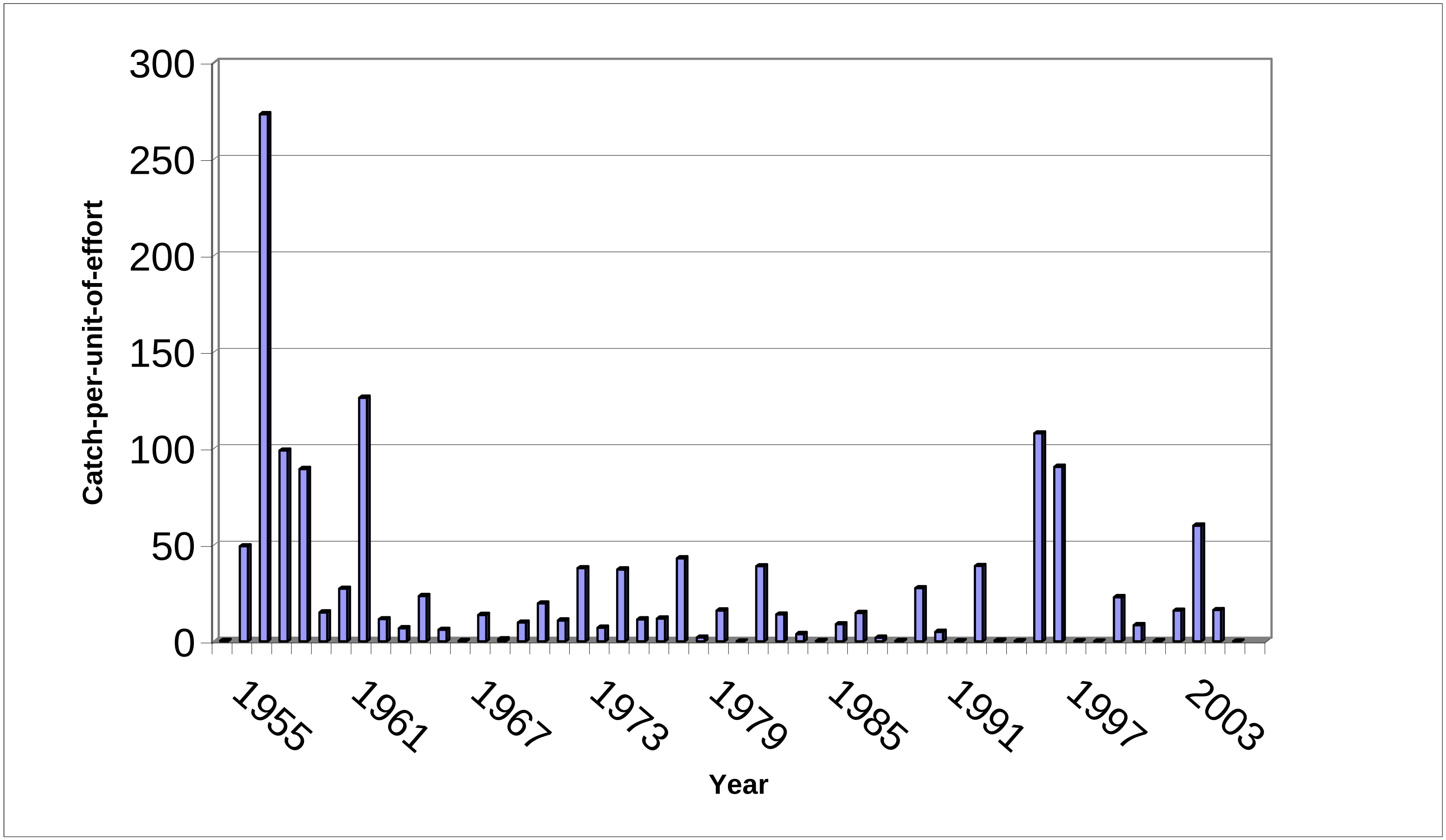


Figure 5.11. Catch-per-unit-of-effort of juvenile blueback herring from Hassler trawl stations, western Albemarle Sound, NC, 1955-2006.

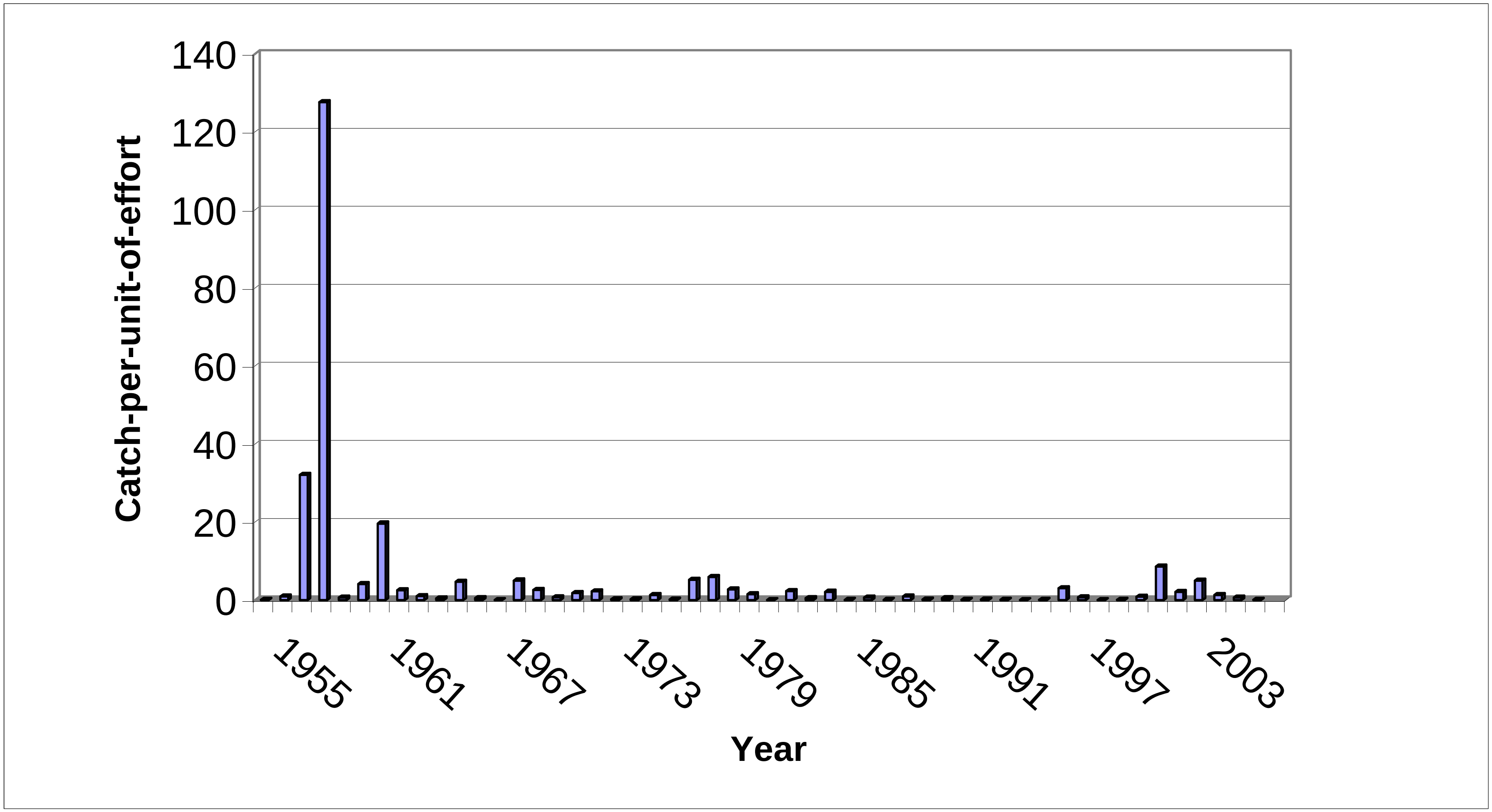


Figure 5.12. Catch-per-unit-of-effort of juvenile alewife from Hassler trawl stations, western Albemarle Sound area, NC, 1955-2006.

5.3.5 Independent Gill Net Survey

The Division has been conducting an Independent Gill Net Survey throughout the Albemarle Sound area since October 1990 and the zones are shown in Figure 5.13 (Winslow 2005). Blueback herring and alewife catch rates have been collected annually, 1991 – 2005, with 2.5 and 3.0 inch stretched mesh (ISM) gill nets. The total number caught by species, mesh size and year are shown in Figure 5.14. The catch rates of blueback herring in the 2.5 ISM gill nets have continued to decline since 2000, and alewife catches have declined since 2001 (Figure 5.14). Alewife catch rates in the 3 ISM gill nets have remained fairly constant since 2002 (Figure 5.14). A slight increase in the blueback herring catch rate was observed in 2003 but again declined in 2004 and 2005 (Figure 5.14).

5.3.6 Pound Net Catch Effort

Fishing effort (i.e. number of pound nets) in the Chowan River and Albemarle Sound area pound net fishery has declined since the early 1970s. In the Albemarle Sound area during 1971-1975, the number of pound nets ranged from 645 to 727 nets (Street and Davis 1976). Chowan River pound net fishing effort has declined each year since 1987 (Figure 5.15). The average number of pound nets set each week in 1977 was 529, compared to 451 in 1987. Prior to seasonal restrictions implemented in 1995, effort had decreased to 147 nets in 1994. Aerial flights were made weekly during spring 1995 through 1999 and the average number of nets ranged from 61 (1995) to 92 (1997). The average number of pound nets set in the Chowan River from 1999 (60) through 2004 (31) has continued to decline.

The Albemarle Sound area pound net fishery CPUE was determined from 1971 through 1975. The CPUE was 18,614 lbs. per net in 1971, declining to 8,040 lbs. in 1975. No data were available for 1976. The CPUE has been determined for the Chowan River pound net fishery since 1977 (Figure 5.16). In 1977, the CPUE was 14,895 lb per net, declining to 5,189 lbs. in 1987, and only 2,632 lbs. per net in 1994, the all time low prior to seasonal and harvest restrictions (Figure 5.16). In 1994, DMF began a new harvest data collection system through the trip ticket program, which may affect comparisons with former years. Since the 2000 FMP,

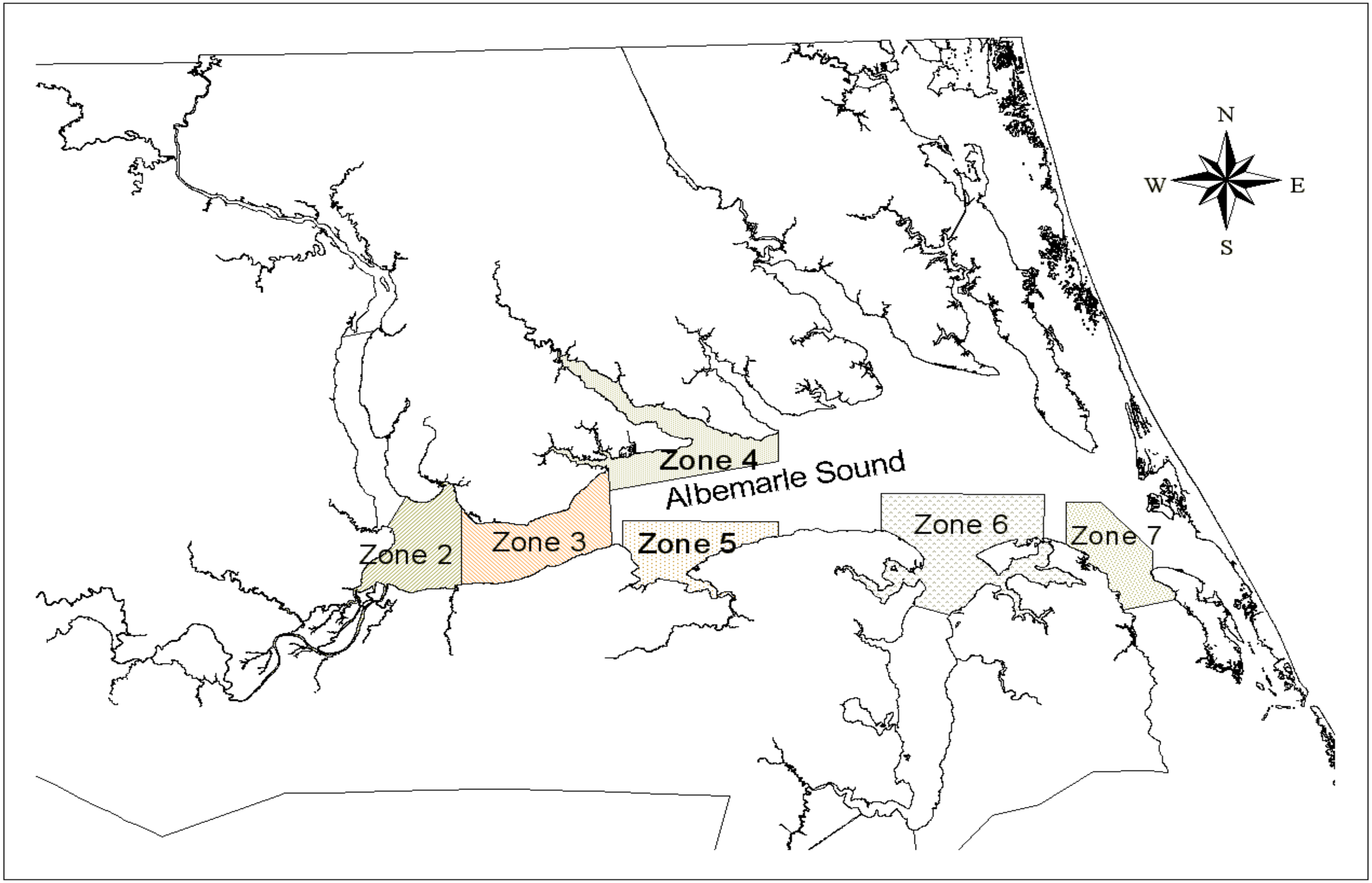
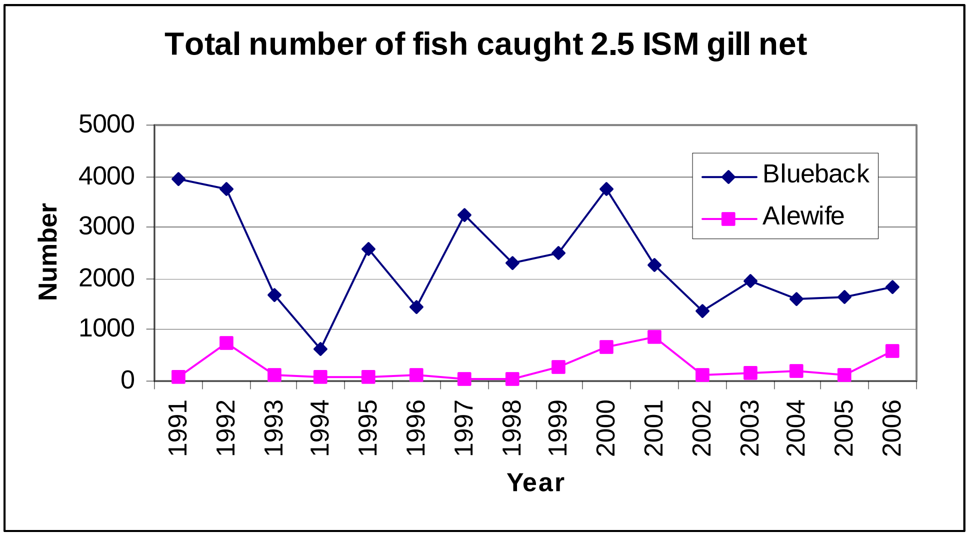


Figure 5.13. Location of sample zones for DMF independent gill net survey, Albemarle Sound area, 1990 – 2006.



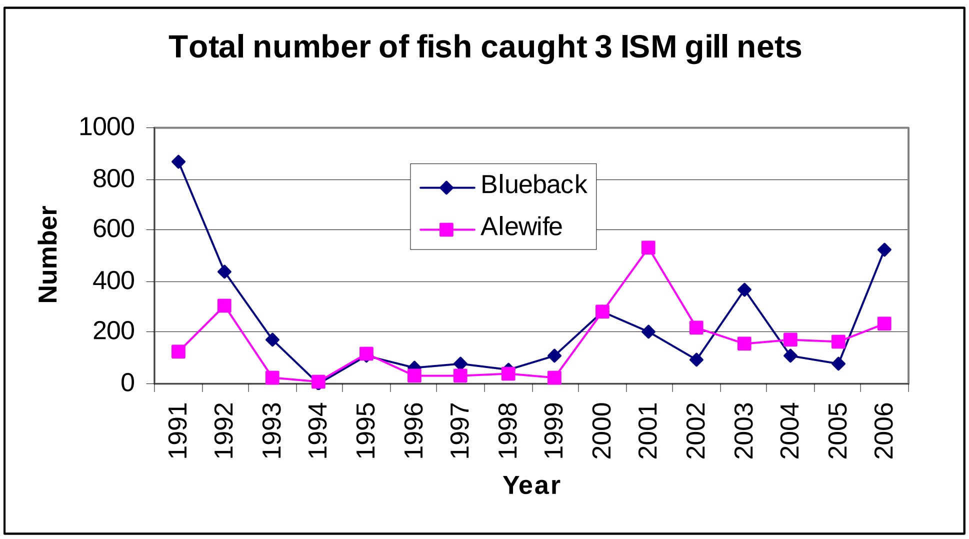


Figure 5.14. Blueback herring and alewife catch rates from the DMF independent gill net survey, Albemarle Sound area, 1991 – 2006.

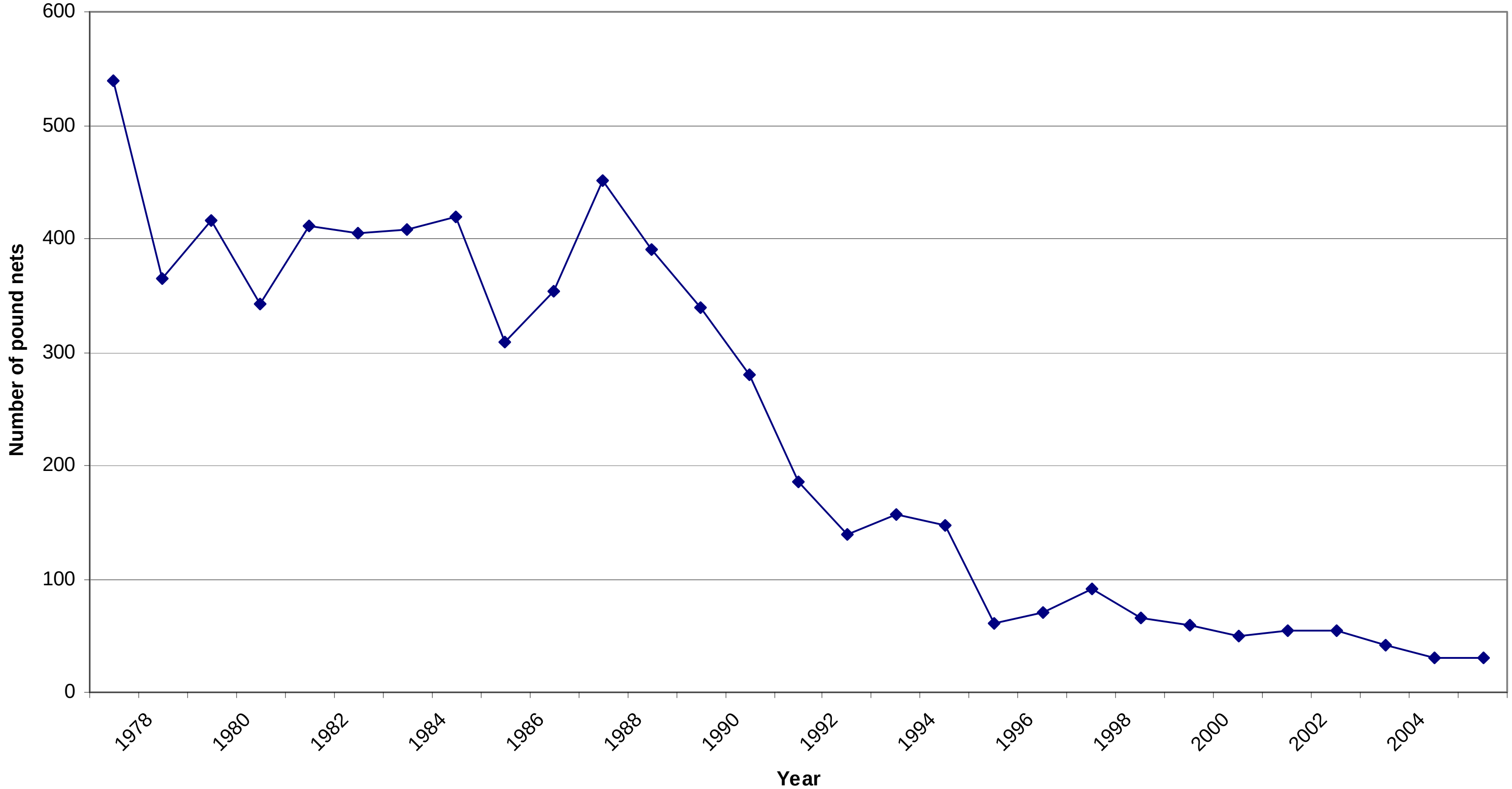


Figure 5.15. Mean number of river herring pound nets set in the Chowan River, NC, 1972-2005.

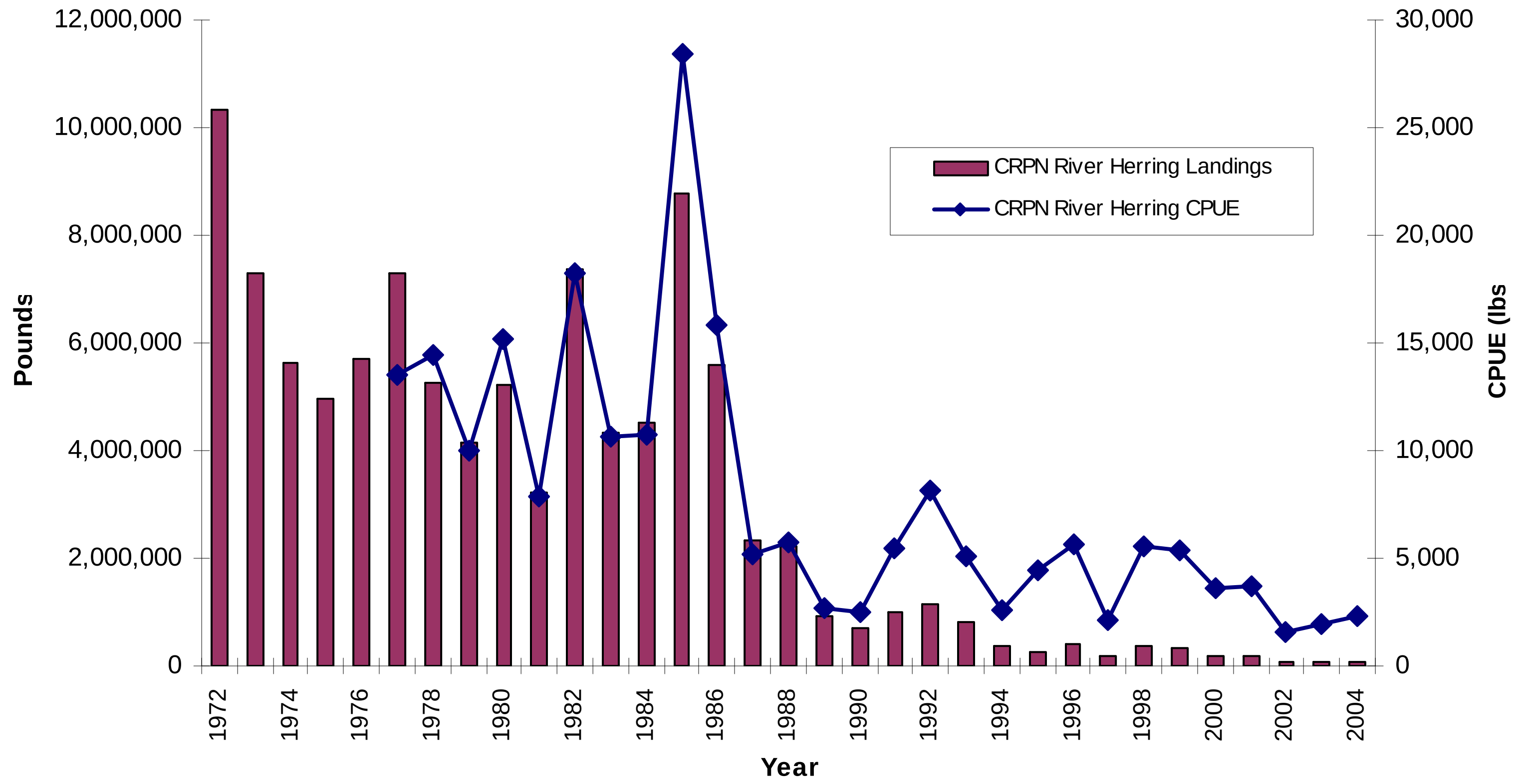


Figure 5.16. River herring pound net landings and catch-per-unit-of effort, Chowan River, NC, 1972-2004.

when a total allowable catch (TAC) was implemented, the CPUE has ranged from 1,590 lbs. (2002) to 3,663 lbs. (2001) (Figure 5.16).

5.3.7 Age Composition/Mean Size at Age - Pound Nets

The age structure of fish taken in the commercial river herring harvest (pound nets) in the Albemarle Sound area has been characterized since 1972. The Chowan River pound net fishery has been sampled annually, while pound net fisheries in the Alligator and Scuppernong rivers were sampled until 1993 and discontinued when funding levels were reduced. From the 1970s to the early 1990s, sampling was conducted at up to six fishhouses on a weekly basis. Throughout the years, unculled pound net samples of at least 30 individuals each of blueback herring and alewife were obtained at least weekly during the spring. The DMF always targeted for unculled pound net catches, but unculled catches were not always possible in recent years. If unculled samples were not available, culled samples were taken at the fishhouses. Size, age and sex composition of the harvest was determined from these samples. During 1989 and 1999, samples were obtained from three cooperating Chowan River pound net fishermen. Samples of up to 30 fish from each fisherman were obtained, up to three times per week during the season, and after the season, into the second week of May. From 2000 through 2005, samples were obtained weekly from up to three fishhouses until the season closed.

The commercial harvest of both species has been dominated by 3-5 year-old fish since pound net sampling began in 1972. The percent of blueback herring repeat spawners in the pound net harvest averaged 14.8% during 1972-1982. From 1983 through 1989, the percentage of repeat spawners declined significantly, ranging from 0.6% to 6.1% (Table 5.6). During the 1990s, blueback herring spawning repetition remained low, ranging from 1.2% (1994) to 4.7% (1993) (Table 5.6). During 2000 through 2003, a slight increase in the percentage was observed but declined again in 2004 (2.9%) and remains well below the historical average (Table 5.6).

The percentage of alewife repeat spawners has also decreased since the 1970s (Table 5.7), with a mean of 9.4% from 1972 through 1981. From 1988-1999, no or very small samples of alewife were obtained annually from the Chowan River pound net fishery, due to scarcity in the harvest. During 2001-2004, alewife samples were obtained from the pound net fishery and an increase in the percentage of repeat spawners was observed (Table 5.7).

Concern arises with the continued decrease of repeat spawners, due to the loss of spawning potential in the stocks. The older fish that have spawned more than once are much more fecund.

Data from pound nets for both species and sexes show a general decline of 1-2 inches in the mean length at age since 1972. Slight increases may have occurred in a couple of years but then would decrease the following year. Blueback herring mean size at age is presented in Figure 5.17. Alewife mean size at age from the Chowan River pound net fishery is shown in Figure 5.18. No alewife samples were obtained from the fishery during 1996 through 1999. Kornegay (1978) indicated an overlap of size of river herring, ages 4 through 6, which is the expected natural variation in size. The cause for this decrease in size is unknown, but may be an indicator of stock problems.

5.3.8 Age Composition/Mean Size at Age - Commercial Gill Nets

The DMF began sampling the commercial gill net fishery for river herring in 1999. Since that time the sampling area has expanded throughout the Albemarle and Croatan sound areas. Sampling this fishery was a recommendation of the 2000 FMP. Size, age and sex composition data are collected weekly from up to five fishhouses during the open season. The majority of the samples come from the eastern Albemarle and Croatan sounds, where the center of the fishery is located. Due to the timing of the harvest alewife are the predominant species and essentially account for the total gill net harvest.

Females make up the majority of the catch accounting for 64.3 – 81.1% of the samples from 1999-2004. Keefe (2003) reported females accounted for 95% of the catch during his Fishery Resource Grant- “Assessment Data from the River Herring Gill Net Fishery, 2001, in the Albemarle Sound area”. Targeting females has an adverse impact on the strongest of populations, much less a population that is overfished and where overfishing is occurring. The alewife gill net harvest was dominated by 4-6 year old fish, of both sexes from 1999 through

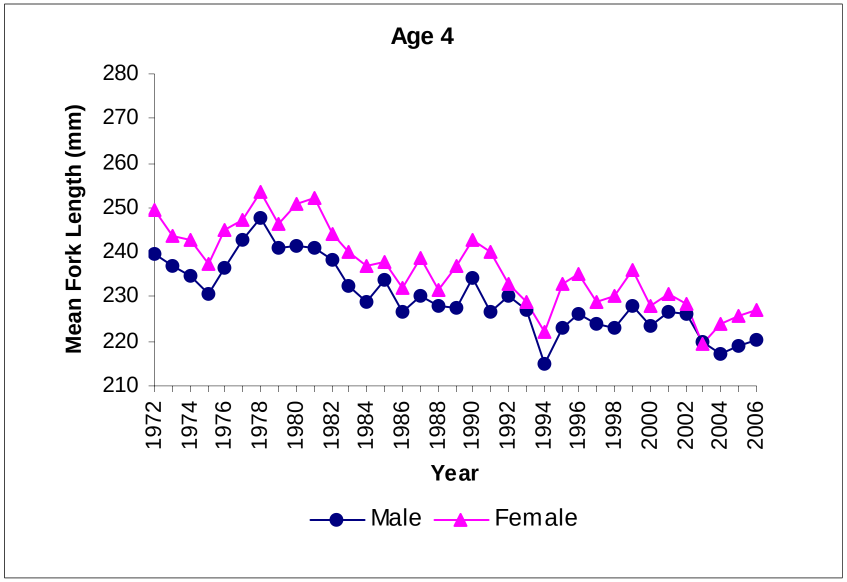
Table 5.6. Percentage of blueback herring repeat spawners (spawned two or more times) and maximum number of spawning marks from the Chowan River pound net fishery, 1972-2006.

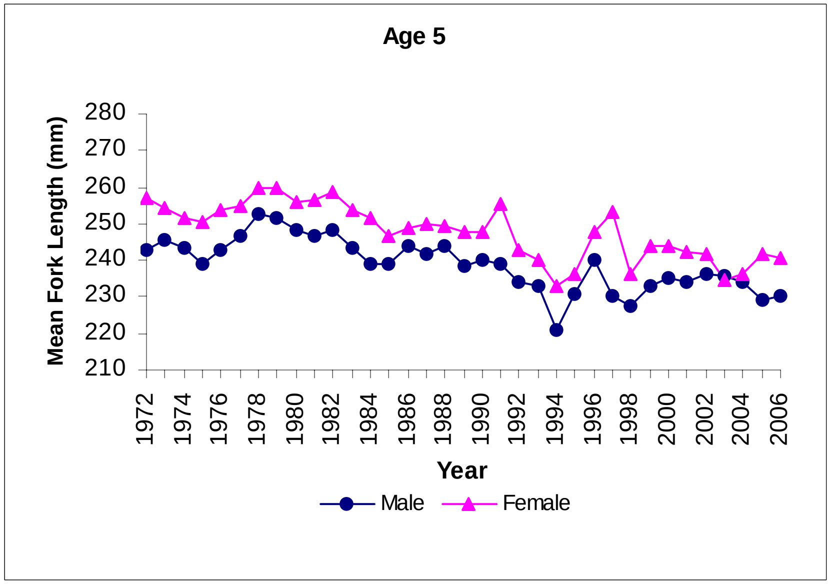
Year	Percent male	Percent female	Percent sexes combined	Maximum number of spawning marks
1972	19.5	24.1	21.1	4
1973	17.8	19.8	18.3	4
1974	13.5	22.0	16.4	3
1975	3.5	4.3	3.9	2
1976	2.5	10.6	5.3	3
1977	4.6	10.7	7.3	3
1978	5.6	9.1	7.1	3
1979	19.0	22.3	20.1	4
1980	17.5	31.6	24.6	4
1981	13.1	19.5	16.2	4
1982	15.0	12.5	13.9	4
1983	2.0	0.9	1.6	3
1984	0.4	2.1	1.3	2
1985	2.4	4.8	3.3	2
1986	2.8	10.0	6.1	2
1987	3.9	2.5	3.3	2
1988	1.2	3.6	2.0	2
1989	0.9	0.0	0.6	2
1990	2.7	2.2	2.5	2
1991	0.0	10.0	4.2	3
1992	5.3	0.9	3.7	2
1993	3.5	7.1	4.7	2
1994	0.0	3.2	1.2	2
1995	0.0	4.1	1.6	2
1996	3.4	2.0	2.8	2
1997	2.8	2.6	2.7	2
1998	2.3	3.0	2.7	2
1999	2.9	2.4	2.6	2
2000	3.5	14.1	6.0	3
2001	2.1	4.3	3.1	2
2002	4.4	4.9	4.7	2
2003	5.8	6.3	5.9	2
2004	4.2	1.1	2.9	2
2005	0	3.6	2.1	2
2006	0	0	0	-

Table 5.7. Percentage of alewife repeat spawners (spawned two or more times) and maximum number of spawning marks from the Chowan River pound net fishery, 1972-2006.

Year	Percent male	Percent female	Percent sexes combined	Maximum number of spawning marks
1972	8.2	25.9	15.9	5
1973	11.0	15.6	13.2	4
1974	2.7	7.8	4.6	4
1975	6.5	13.4	9.3	2
1976	11.1	18.2	14.4	3
1977	2.9	7.2	4.1	3
1978	4.8	5.3	4.9	3
1979	3.0	4.0	3.3	2
1980	11.4	16.9	13.7	4
1981	7.8	12.5	9.7	3
1982	0.0	1.5	0.5	2
1983	1.9	3.8	2.5	2
1984	7.8	11.8	10.2	2
1985	0.0	0.0	0.0	0
1986*	0.0	0.0	0.0	0
1987	0.0	2.0	0.7	2
1988*	1.7	4.2	2.5	2
1989*	0.0	0.0	0.0	0
1990	No sample obtained			
1991*	0.0	11.1	5.7	2
1992*	6.9	21.0	12.5	3
1993	No sample obtained			
1994	No sample obtained			
1995	No sample obtained			
1996	No sample obtained			
1997	No sample obtained			
1998	No sample obtained			
1999	No sample obtained			
2000	0.0	2.9	1.1	2
2001	4.1	5.8	5.0	2
2002	21.2	6.7	14.8	2
2003	4.8	6.2	5.4	2
2004	4.3	17.7	10.4	3
2005	4.3	20.0	12.6	2
2006	0	7.0	3.1	2

*Sample size very small





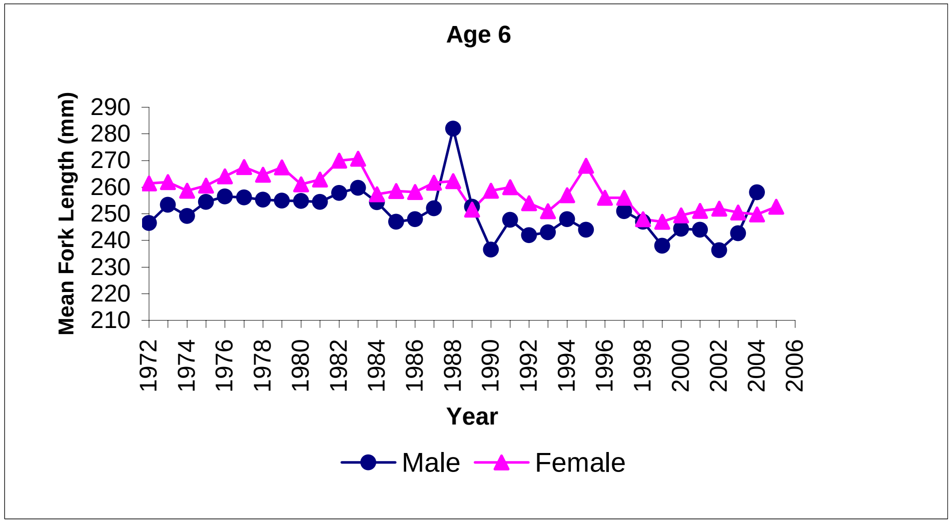


Figure 5.17. Mean length at age of blueback herring from the Chowan River pound net fishery, 1972-2006.

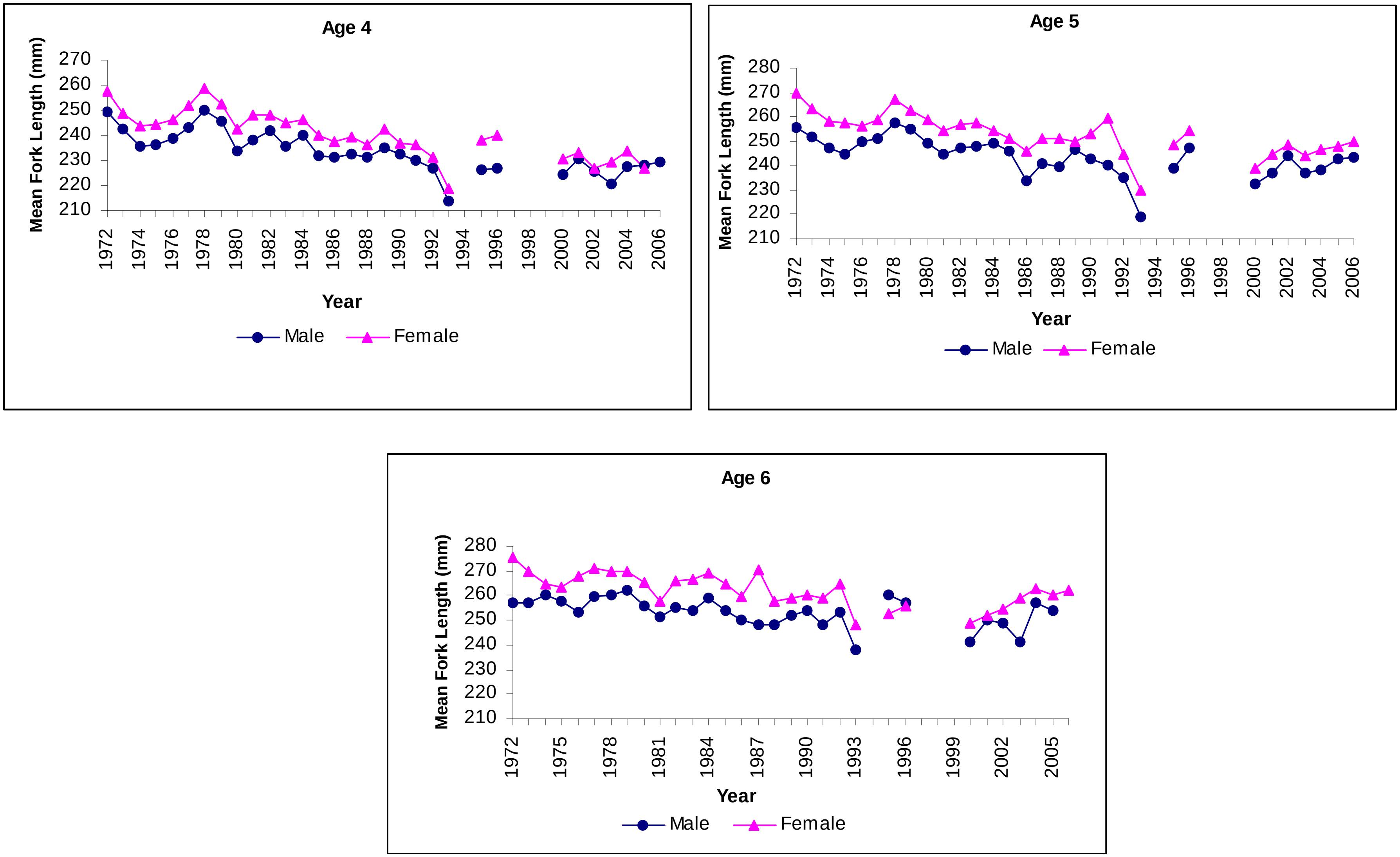


Figure 5.18. Mean length at age of alewife from the Chowan River pound net fishery, 1972-2006.

and the age of the fish relate back to the 1996 (JAI = 3.2), 1998 (JAI = 1.2) and 1999 (JAI =1.2) year class production. As a result of this fishery targeting larger females the percentage of virgin fish (2002- 35.9%; 2000- 70.9%) is lower than that found in pound nets (Table 5.8).

The mean size at age for alewife from the commercial gill net fishery is presented in Figure 5.19. In general the mean size of age 4 fish, has increased for both sexes from that found in 1999. The mean size of alewife 5 years old declined from 1999 to 2000 but has increased since (Figure 5.19). The mean size of age 6 fish has increased each year since sampling began in 1999.

6. STATUS OF THE FISHERIES

6.1 Introduction

The river herring fishery can be divided into two sections: the commercial fishery and the recreational fishery. The two fisheries co-exist in both in Coastal and Joint Waters. Only the recreational fishery occurs in Inland Waters. These fisheries are entirely dependent on sexually mature fish, age 3 and older. Although some of the gears used are employed by both fisheries, they are treated separately because the fisheries are regulated by two separate commissions. Fisheries in Coastal Waters are under the jurisdiction of the MFC, while herring fisheries in designated Inland Waters are under the WRC. The different jurisdictional areas are described in North Carolina Fisheries Rules for Coastal Waters, 2005, Subchapter 3Q – Jurisdiction of Agencies: Classification of Waters (NCDENR 2005).

6.2 Commercial Fishery

6.2.1 Historical

River herring have been subjected to intensive exploitation since colonial times along the Atlantic coast. The Albemarle Sound area has always been the center of the North Carolina fishery. In North Carolina, river herring were among the first fish to be exploited commercially because their oily flesh allowed them to be salt-preserved, without ice or refrigeration.

Table 5.8. Percentage of alewife repeat spawners (spawned two or more times) and maximum number of spawning marks from the Albemarle Sound area gill net fishery, 1999-2004.

Year	Percent male	Percent female	Percent sexes combined	Maximum number of spawning marks
1999		41.2	31.1	2
2000	4.9	4.9	2.1	2
2001	12.7	4	7.2	2
2002	35.9	25.3	30.0	3
2003	27.7	14.3	19.1	3
2004	6.7	18.7	14.7	3

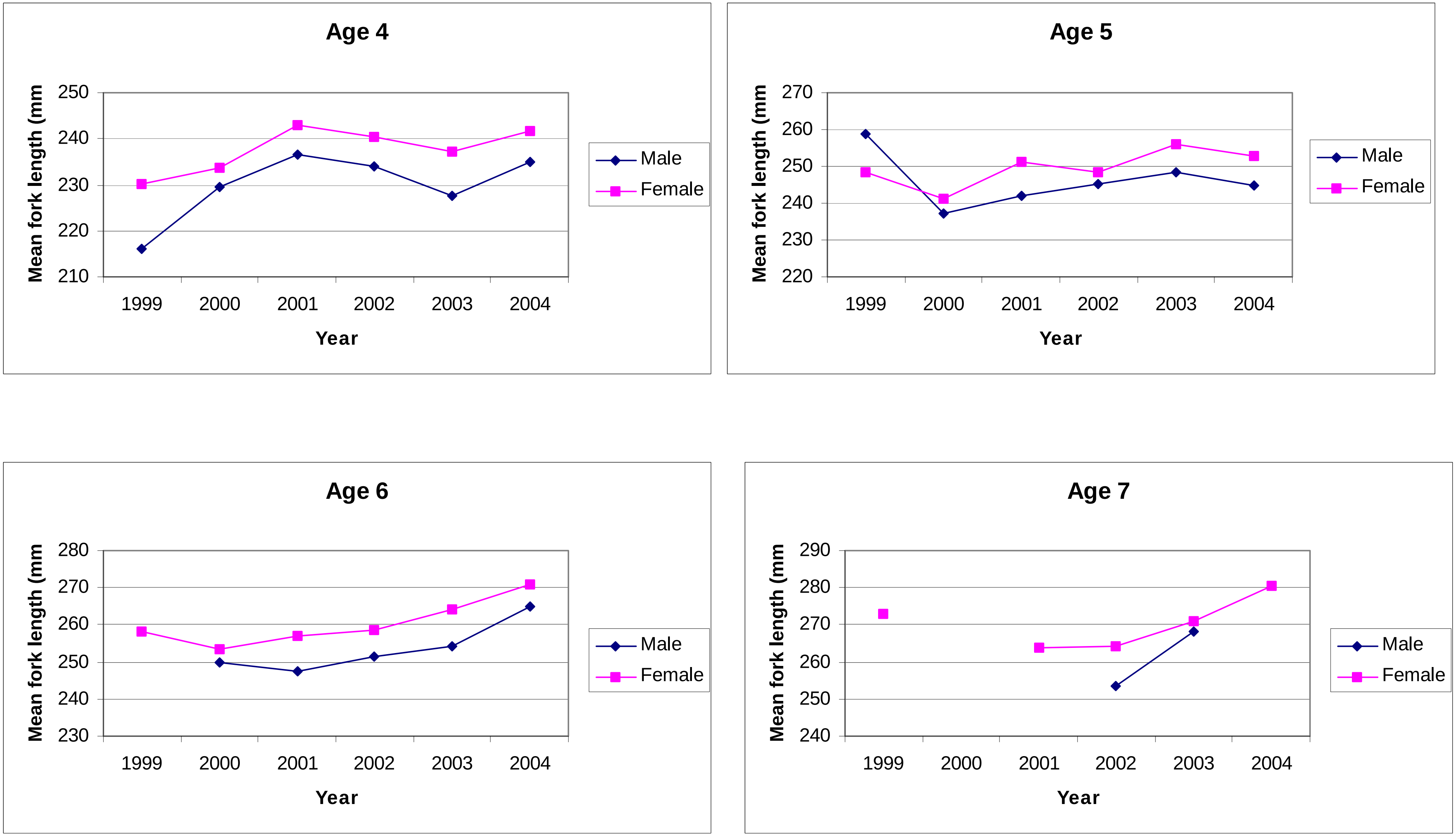


Figure 5.19. Mean length at age of alewife from the Albemarle Sound area commercial gill net fishery, 1999-2004.

Fishing served largely subsistence, rather than commercial, purposes in colonial times. During the late colonial and antebellum periods, planters in the Edenton area developed major fisheries for spawning American shad and river herring in the Chowan and Albemarle Sound. Only during the post-bellum period, with improved transportation and the availability of ice were markets created for fresh fish and shellfish, allowing independent watermen to emerge (Taylor 1992). A more detailed description of the historical fisheries in the Albemarle Sound area is found in the 2000 River Herring FMP (Section 6.2.1).

The use of pound nets revolutionized fishing in North Carolina, especially in the Albemarle Sound (Taylor 1992). Chestnut and Davis (1975) reported that 2,767 pound nets were set in North Carolina in 1927. Since the 1960s, the majority of the river herring pound nets have been set in the rivers, and the leads seldom exceeded 200 yards in length (Walburg and Nichols 1967). The Chowan River has been the center of the river herring pound net fishery, and from the late 1970s to the late 1980s the number of river herring pound nets ranged from 421 to 615 nets annually, with the amount of pound nets declining from 348 in 1989 to 175 in 1994.

Gill nets, anchor and drift, have historically been utilized in the river herring fishery. The amount of gill net effort in the fishery prior to 1994 is unknown. During the 1970s, the gill net harvest of river herring accounted for approximately 15% of the total Albemarle Sound area harvest. However, from 1987 to 1994, the proportion of gill net landings increased to 24-40% of the total river herring harvest from the Albemarle Sound area. This increase may have been due to a directed fishery for roe fish. In 1986, approximately 6 million pounds were harvested in pound nets and 900,000 pounds from gill nets. During 1988, pound nets landed 2.3 million pounds and gill nets 1.5 million pounds. In contrast, 1994 totals of 425,000 pounds from pound nets and 175,000 pounds from gill nets was harvested.

Several other types of commercial gears have been used in the river herring fishery: fyke nets, fish wheels and dip nets. These gears have contributed very little to the total harvest in the Albemarle area. From 1915 through 1965, various regulations were enacted for the Albemarle Sound river herring fishery (seasons, area closures, gear restrictions).

The Albemarle Sound area accounted for 66-100% of the state's river herring harvest from 1889 to 1994. Between 1962 and 1994, the Chowan River pound net fishery contributed 43-97% of the state's total river herring landings. Annual landings by gear are shown in Table 6.1 for 1972-2004 and in Table 4.1 by waterbody for 1962-2004. From 1950 to 1994, North Carolina accounted for 13.6-84.5% of the river herring landings of the Atlantic coast states.

Since the late 1800s, the areas fished and gears used to harvest river herring have remained essentially unchanged. The extent of the river herring fisheries in both the amount of gear and harvest, however, has declined significantly. The fisheries in the Albemarle Sound area are now pursued as multi-species fisheries, which are not totally dependent on river herring.

6.2.2 Current North Carolina Fishery

In 1995, a fishing season was implemented by MFC rule (DEHNR 1997, 15A NCAC 3M.0513), that prohibited taking blueback herring, alewife, American shad and hickory shad by any method from April 15 through January 1. This rule was adopted to allow more fish to escape fishing mortality and spawn. The rule remained in effect in 1995 and 1997. In 1996, the rule was suspended only for the Chowan River pound net fishery, extending the season for ten days. Once the season was extended, the fishery operated on a 250,000 pound total allowable catch (TAC). During 1998, the rule was again suspended, and the season was extended for an additional 15 days for the Chowan River pound net fishery, which operated on a 400,000 pound TAC for the entire season.

The MFC amended the river herring rule (15A NCAC 3M.0513) in a temporary action for the 1999 harvest season. The temporary rule gave the Fisheries Director proclamation authority, based on variability in environmental and local stock conditions, to take various actions and impose an annual quota for river herring in the Albemarle Sound River Herring Management Area of 450,000 pounds.

The 2000 River Herring Fishery Management Plan established a 300,000 pound TAC for the Albemarle Sound and Chowan River Herring Management Areas. Of that total the Chowan River pound net fishery was allocated 200,000 pounds, the Albemarle area gill net fishery received 67,000 pounds and 33,000 pounds was left to the discretion of the Fisheries Director utilized for pound nets outside the Chowan River management area, fyke nets and haul seines.

During 1995-1998, North Carolina accounted for 29-52% of the total river herring landings from the Atlantic coast. From 1999-2004, the State contributed 9-33% of the Atlantic coast river herring harvest. Landings from the Albemarle Sound area accounted for 91.6-99.8% of the state's total river herring landings during 1995-2004. The Chowan River pound net fishery contributed 60.3-76.5% of North Carolina's annual river herring harvest during 1995-1999. Since 2000, the Chowan River pound net fishery contributed 41-66% of the state's total river herring harvest. Since 1988, regulations enacted for striped bass conservation (gill net mesh size restrictions, yardage restrictions, area closures) have impacted river herring harvest in the Albemarle Sound area. Even with these regulations, the river herring gill net fishery has accounted for a greater proportion of the overall harvest from 1995 - 1999 (21.2-38.1%) (Table 6.1). Since the 67,000 pound TAC was implemented in 2000, gill nets have accounted for 24.4-39.5% of the annual river herring landings in the Albemarle area (Table 6.1).

During 1995-1999, the number of pound nets set in the Chowan River ranged from 68 to 102. The number of pound nets set in the Chowan River from 2000-2005, ranged from 36-63. In 1999, just 14 Chowan River pound net fishermen participated in the fishery while only nine participated in 2005. Since the 200,000 pound TAC was implemented in 2000, the Chowan pound net fishery has only reached the TAC once (2001).

For all finfish, the total number of participants in the Albemarle Sound area from January to May 1994-2004, have remained fairly constant, while the total number of trips for the same period has increased since 1994 (Table 6.2). The number of participants harvesting river herring in the Albemarle area has declined from 239 in 1996 to 117 in 2004 (Table 6.2). The total number of trips harvesting river herring in the ASMA have also decreased since 1994 (Table 6.2). The pound net fishery has seen the greatest drop in the number of participants but since 1995 the number of trips has increased (Table 6.2).

Table 6.1. River herring landings and percentage by gear from North Carolina, 1972-2006.

	Pound Net		Float & Sink Gill Nets		Drift Gill Net		Haul Seine		Trawl		Other Gears		
Year	Pounds	% Total Landings	Pounds	% Total Landings	Pounds	% Total Landings	Pounds	% Total Landings	Pounds	% Total Landings	Pounds	% Total Landings	Total Pounds
1962	12,443,100	87.0	1,682,300	11.8	24,700	0.2	151,500	1.1			800	0.0	14,302,400
1963	12,941,200	85.7	1,798,900	11.9	43,000	0.3	301,200	2.0			15,300	0.1	15,099,600
1964	5,883,300	77.8	1,069,100	14.1	76,500	1.0	532,000	7.0					7,560,900
1965	9,077,200	70.8	3,229,700	25.2	1,700	0.0	514,000	4.0			3,200	0.0	12,825,800
1966	12,414,000	99.2	103,000	0.8	200	0.0	1,000	0.0			1,100	0.0	12,519,300
1967	18,395,100	99.5	46,200	0.2	6,100	0.0	36,000	0.2			2,600	0.0	18,486,000
1968	13,597,600	87.6	914,100	5.9	85,000	0.5	854,700	5.5			73,500	0.5	15,524,900
1969	17,905,100	90.6	717,600	3.6	55,100	0.3	1,003,400	5.1			80,500	0.4	19,761,700
1970	10,873,100	94.4	13,200	0.1	18,600	0.2	581,800	5.0			34,700	0.3	11,521,400
1971	11,657,400	91.6	38,700	0.3	39,300	0.3	979,000	7.7			7,500	0.1	12,721,900
1972	10,868,387	96.7	1,863	0.0	46,248	0.4	320,645	2.9					11,237,143
1973	7,741,724	97.7	1,389	0.0	17,740	0.2	165,045	2.1					7,925,898
1974	5,866,038	94.5	31,277	0.5	49,000	0.8	263,227	4.2					6,209,542
1975	5,480,095	92.1	116,828	2.0	227,674	3.8	127,470	2.1					5,952,067
1976	6,106,419	95.4	122,553	1.9	111,900	1.7	60,488	0.9					6,401,360
1977	8,112,192	95.2	97,570	1.1	181,700	2.1	132,351	1.6					8,523,813
1978	5,487,100	83.0	876,009	13.3	146,669	2.2	96,875	1.5			500	0.0	6,607,153
1979	4,256,323	83.1	574,227	11.2	173,950	3.4	95,198	1.9	19,452	0.4			5,119,150
1980	5,354,430	86.1	757,576	12.2	56,898	0.9	46,513	0.7	*	*	3,106	0	6,218,523
1981	3,452,189	72.6	1,053,593	22.2	63,820	1.3	35,389	0.7	141,232	3.0	*	*	4,753,723
1982	7,720,694	81.8	1,649,488	17.5	37,000	0.4	20,721	0.2	7,679	0.1	*	*	9,437,703
1983	4,491,831	76.5	1,313,731	22.4	29,000	0.5	30,970	0.5			2,800	0.0	5,868,332
1984	4,591,016	70.5	1,866,635	28.6	36,632	0.6	6,452	0.1	9,497	0.1	5,877	0.1	6,516,109
1985	10,658,014	92.3	815,364	7.1	73,500	0.6	*	*			*	*	11,548,278
1986	5,895,596	86.5	822,377	12.1	56,100	0.8			*	*	*	*	6,814,323
1987	2,411,710	75.5	764,602	23.9			*	*	*	*	*	*	3,194,975
1988	2,307,436	55.1	1,864,258	44.5					*	*	*	*	4,191,211
1989	928,759	62.3	562,308	37.7					*	*	10	0.0	1,491,077
1990	782,356	67.6	364,196	31.5					*	*	*	*	1,157,625
1991	1,042,110	66.1	533,268	33.9									1,575,378
1992	1,392,104	80.8	225,794	13.1					*	*	*	*	1,723,178
1993	804,380	87.8	111,628	12.2			101	0.0			*	*	916,235
1994	423,644	65.8	173,568	26.9	4,130	0.6	181	0.0	*	*	42,785	6.6	644,309
1995	274,191	60.4	156,137	34.4	*	*	21	0.0	*	*	23,635	5	453,984
1996	406,411	76.8	119,305	22.5	1,278	0.2	10	0.0			2,499	0.5	529,503
1997	201,793	60.3	123,333	36.8	2,781	0.8	4	0.0	*	*	6,897	2.1	334,809
1998	374,700	71.8	143,267	27.4	2,284	0.4			*	*	1,680	0.3	521,930
1999	336,934	76.0	102,065	23.0	2,165	0.5	*	*			2,331	0.5	443,494
2000	230,890	69.5	91,768	27.6	376	0.1	*	*			9,302	2.8	332,336
2001	210,283	68.5	86,209	28.1	*	*	*	*			10,269	3	306,761
2002	92,668	53.0	71,644	41.0	322	0.2	*	*	*	*	10,226	6	174,860
2003	97,603	48.9	82,127	41.1	*	*	3,846	1.9			16,140	8.1	199,716
2004	90,154	47.8	75,928	40.0	*	*	5,395	2.9			17,064	9.0	188,541
2005	159,386	63.7	74,727	29.9	*	*	*	*			15,908	6.4	250,021
2006	66,071	60.6	36,520	33.5	*	*	*	*			6,451	5.9	109,042

*Denotes confidential landings; these are incorporated into "Other Gears".

Table 6.2. Number of participants, number of trips, pounds and value for all species and river herring from the Albemarle Sound Management Area, January – May, 1994-2006.

	All Finfish Species						River Herring			
Year	Gear	Number of Participants**	Number of Trips	Pounds	Value ($)		Number of Participants**	Number of Trips	Pounds	Value ($)
1994	Gill Net (Drift)	15	76	5,143	4,535		5	62	2,790	3,625
	Gill Net (Float & Sink)	354	5,847	1,089,946	529,865		166	2,358	171,639	47,999
	Gill Net (Runaround)	9	16	7,476	2,021		*	*	*	*
	Pound Net	56	1,343	780,519	137,887		40	929	423,627	44,328
	Other Gears	224	1,509	265,196	83,909		21	148	4,305	568
	Total:	**480**	**8,791**	**2,148,280**	**758,217**		**202**	**3,497**	**602,361**	**$96,520**
1995	Gill Net (Drift)	3	33	3133	784		3	33	3126	782
	Gill Net (Float & Sink)	479	7,387	832,921	468,856		181	2,291	152,027	56,484
	Gill Net (Runaround)	4	19	1,458	980					
	Pound Net	39	726	578,160	140,481		32	376	274,189	71,459
	Other Gears	246	1672	298,166	107,781		17	94	1,417	363
	Total:	**593**	**9,837**	**1,713,838**	**718,882**		**204**	**2,794**	**430,759**	**$129,087**
1996	Gill Net (Drift)	5	13	1,332	1,548		4	12	1,268	1,515
	Gill Net (Float & Sink)	422	6,749	1,056,348	519,090		211	2,621	118,425	49,672
	Gill Net (Runaround)	*	*	*	*					
	Pound Net	43	831	746,045	141,638		35	365	406,396	78,605
	Other Gears	285	1599	270,385	145,419		19	105	2,501	2,525
	Total:	**572**	**9,192**	**2,074,110**	**807,695**		**239**	**3,103**	**528,590**	**$132,317**
1997	Gill Net (Drift)	11	64	3,142	3,249		7	59	2,598	2,965
	Gill Net (Float & Sink)	394	7,245	1,023,127	627,206		184	2,046	122,798	56,418
	Gill Net (Runaround)	5	8	3,087	1,513					
	Pound Net	34	836	479,181	141,436		25	388	201,792	66,172
	Other Gears	231	1703	268,767	174,977		18	108	1,191	540
	Total:	**527**	**9,856**	**1,777,304**	**948,381**		**213**	**2,601**	**328,379**	**$126,096**
1998	Gill Net (Drift)	3	17	2,743	1,236		3	17	2,284	1,131
	Gill Net (Float & Sink)	366	6,709	1,150,800	693,890		190	2,220	142,066	67,828
	Gill Net (Runaround)	7	13	980	525		*	*	*	*
	Pound Net	27	684	588,357	194,080		22	417	374,700	134,488
	Other Gears	212	1555	233,210	133,068		19	97	1,679	642
	Total:	**482**	**8,978**	**1,976,090**	**1,022,799**		**206**	**2,751**	**520,728**	**$204,089**

*Denotes confidential landings; these are incorporated into "Other Gears".

**Number of participants is not additive across gears, because an individual participant can use more than one gear type.

Table 6.2. (Continued)

Year	Gear	All Finfish Species: Number of Participants	Number of Trips	Pounds	Value ($)		River Herring: Number of Participants	Number of Trips	Pounds	Value ($)
1999	Gill Net (Drift)	7	33	2,391	2,001		7	33	2,165	1,917
	Gill Net (Float & Sink)	407	8,836	1,392,511	798,703		164	2,083	101,677	56,963
	Gill Net (Runaround)	7	12	3,396	1,808					
	Pound Net	30	844	597,141	211,159		24	527	336,934	120,873
	Other Gears	244	1955	303,248	158,352		17	137	2,331	987
	Total:	**524**	**11,680**	**2,298,687**	**1,172,023**		**190**	**2,780**	**443,106**	**$180,740**
2000	Gill Net (Drift)	*	*	*	*		*	*	*	*
	Gill Net (Float & Sink)	385	9,227	1,317,009	690,848		164	1,563	83,038	32,446
	Gill Net (Runaround)	13	49	16,804	7,180		*	*	*	*
	Pound Net	36	925	546,539	165,430		30	559	230,701	78,299
	Other Gears	169	1329	371,393	208,594		23	205	9,614	3,288
	Total:	**469**	**11,530**	**2,251,745**	**1,072,052**		**189**	**2,327**	**323,353**	**$114,033**
2001	Gill Net (Drift)									
	Gill Net (Float & Sink)	405	10,284	1,268,732	702,184		115	790	70,957	29,206
	Gill Net (Runaround)	15	75	14,002	6,416		5	7	115	157
	Pound Net	31	742	521,368	156,145		23	421	210,283	80,422
	Other Gears	201	1384	253,738	156,529		25	136	10,127	4,173
	Total:	**502**	**12,485**	**2,057,840**	**1,021,274**		**143**	**1,354**	**291,483**	**$113,957**
2002	Gill Net (Drift)	5	11	687	185		*	*	*	*
	Gill Net (Float & Sink)	391	8,747	1,213,274	681,883		109	1,139	65,789	24,547
	Gill Net (Runaround)	13	41	10,788	4,860		*	*	*	*
	Pound Net	37	960	465,811	130,648		24	580	92,668	34,503
	Other Gears	201	1469	179,181	100,278		18	117	10,324	3,913
	Total:	**474**	**11,228**	**1,869,741**	**917,854**		**132**	**1,836**	**168,781**	**$62,964**
2003	Gill Net (Drift)	3	3	684	312					
	Gill Net (Float & Sink)	396	9,008	1,943,532	1,051,071		135	1,175	65,757	30,172
	Gill Net (Runaround)	8	15	8,376	3,623		*	*	*	*
	Pound Net	29	706	388,500	143,678		19	468	97,603	42,950
	Other Gears	226	1556	297,776	170,953		37	252	19,670	8,647
	Total:	**487**	**11,288**	**2,638,868**	**1,369,637**		**156**	**1,895**	**183,030**	**$81,769**

Table 6.2. (Continued)										
	All Finfish Species						River Herring			
Year	Gear	Number of Participants	Number of Trips	Pounds	Value ($)		Number of Participants	Number of Trips	Pounds	Value ($)
2004	Gill Net (Drift)	*	*	*	*		*	*	*	*
	Gill Net (Float & Sink)	359	8,180	1,339,116	781,307		98	716	72,321	31,113
	Gill Net (Runaround)	9	20	5,756	2,253					
	Pound Net	26	590	257,027	71,850		15	416	90,154	38,766
	Other Gears	188	1327	213,398	150,835		35	297	22,130	9,732
	Total:	**440**	**10,117**	**1,815,297**	**1,006,245**		**117**	**1,429**	**184,605**	**79,611**
2005	Gill Net (Drift)	19	210	171,544	31,956		9	91	2,526	1,291
	Gill Net (Float & Sink)	359	7,294	1,238,714	832,667		119	1,1134	74,532	38,127
	Gill Net (Runaround)	15	33	16,257	5,762		*	*	*	*
	Pound Net	22	525	288,021	117,600		15	393	159,386	82,371
	Other Gears	115	841	201,427	123,502		23	149	13,255	6,880
	Total:	**411**	**8,902**	**1,915,963**	**1,111,487**		**137**	**1,770**	**249,776**	**128,709**
2006	Gill Net (Drift)	12	57	7,655	6,701		4	13	324	166
	Gill Net (Float & Sink)	281	6,465	915,604	723,846		73	533	35,599	18,024
	Gill Net (Runaround)	9	17	5,319	2,181		*	*	*	*
	Pound Net	18	534	216,117	91,203		13	317	66,071	33,776
	Other Gears	92	815	188,739	100,148		5	83	6,123	3,130
	Total:	**325**	**7,886**	**1,333,433**	**924,079**		**85**	**947**	**108,117**	**55,096**
*Denotes confidential landings; these are incorporated into "Other Gears".				Pound Net						
**Number of participants is not additive across gears, because an individual participant can use more than one gear type.										

River herring were historically, and continue to be used for human consumption. The filets are generally processed and salted, while the roe is used, either fresh or canned. During 1995-1999, the percentage of the river herring harvest used for bait ranged from 6.2-38.8%. Since 2000, 2% or less of the total river herring harvest has been sold as bait.

6.2.3 Ocean Fishery

Substantial oceanic landings of river herring were reported by foreign fishing fleets operating in United States coastal waters between 1967 and 1972. In 1969, the peak year, total reported landings of river herring in the foreign fishery were 10,950 metric tons (24 million pounds). Foreign fleets harvested primarily fish that were less than 7.5 inches long and mostly immature (Street and Davis 1976). This level of fishing pressure on sub-adult river herring was probably a major factor contributing to the declines in commercial landings of river herring along the Atlantic coast seen in the mid-1970s.

Since 1977, the foreign fishery for river herring within the U.S. Exclusive Economic Zone (200 mile limit) has been restricted by federal rules under the authority of the Magnuson-Stevens Act. No directed foreign fishing for river herring has been allowed since the passage of the Magnuson-Stevens Act. The annual allocation of river herring landings to the foreign fisheries between 1977 and 1980 was 1.1 million pounds. Since 1981, the total annual allocation has been limited to 100 metric tons (220,460 lb), less than 2% of the total US river herring harvest in a typical year prior to that period. However, because the foreign trawl fishery and the joint-venture fishery for Atlantic mackerel take mostly immature river herring as bycatch, the potential for over harvesting effects on river herring stocks still exists. Even though foreign fishing pressure on river herring stocks in offshore waters has been reduced for 28 years, the population has not recovered anywhere along the Atlantic Coast.

The ASMFC Interstate Fishery Management Plan for Shad and River Herring (1985) expressed the concern of resource managers with the bycatch of river herring in the oceanic Atlantic mackerel fishery. This fishery is composed of a joint venture fishery and a directed fishery by foreign vessels. Bycatch of river herring was variable from year to year and averaged 105,727 pounds between 1980 and 1989 and appeared to be increasing (Harris and Rulifson

1989). Bycatch limits for river herring in the offshore mackerel fishery are currently set at 220,264 pounds. Data from NMFS indicates that river herring catches in the Atlantic mackerel fishery were at least 600 pounds during 1996 and 11,570 pounds during 1997 (MAFMC 1998). In the early 1990s river herring accounted for 5-10% of the catch in the Atlantic mackerel fishery. Since that time the migration patterns of Atlantic mackerel have shifted further offshore, outside the area used by river herring, eliminating this bycatch (J. Rhule, NC Rep. MAFMC, personal communication).

The NMFS has been conducting an observer program in the Atlantic herring fishery since 1994 (NEFMC 2005). Observer trips occur from Cape Cod north and are divided between the purse seine, mid-water trawl and pair trawl fisheries. From 1994 through 2004, no river herring bycatch was observed in the purse seine fishery, 69,741 pounds in the mid-water trawl fishery and 45,024 pounds in the pair trawl fishery. The Maine Department of Marine Resources established an observer program in the Atlantic herring fishery in 1997 and reported that the fishery relative to river herring was a clean fishery. The bycatch estimates of river herring have ranged from 404-7,319 pounds. From 2000-2002, a Canadian observer program was conducted in the mid-water trawl fishery on George’s Bank, with 2,000 pounds of river herring bycatch (NEFMC 2005).

The ASMFC Shad and River Herring Technical Committee (October 2005) at the request of the Management Board is taking steps to gather and analyze existing bycatch data collected by NMFS and anecdotal reports of river herring observed in markets as “bait” along Atlantic Coast states. The Technical Committee made a request to the ASMFC Shad and River Herring Management Board to intercede with NMFS or the appropriate fishery management councils to prioritize the alosines for bycatch monitoring, either in the on-board observer program or a shore based program. Better data for bycatch of shad and river herring in the Atlantic herring, Atlantic mackerel and other pelagic fisheries is crucial to understanding sources of mortality for these important fishes.

Commercial ocean harvest of river herring occurs as bycatch in other fisheries of various types: gill net, otter trawl and menhaden purse seine. During 1980-1998, the majority of the river herring harvest (in river and ocean) was taken in North Carolina (67%), Maine (15%) and Virginia (13%). From 1999-2004, North Carolina accounted for only 9-32.8% of the total Atlantic coast landings of river herring. Maine accounted for 50.4-73% of the coastwide river herring landings from 1999-2004. Beach haul seines and trawls accounted for the major portions of the North Carolina's Atlantic Ocean landings during 1962-2004 (Table 4.1 and 6.1). Between 1975 and 2004, Atlantic Ocean river herring landings from North Carolina have ranged from 0 to 143,232 pounds, with an average during the period of 21,371 pounds.

6.3 Recreational Fishery

The recreational fishery for river herring is probably best defined as that fishery in which river herring are targeted and used for personal consumption, (i.e., not sold). In those waters designated by the MFC and WRC as Coastal and Joint Waters, fishery managers assume that most herring harvested will be sold. In designated Inland Waters, the assumptions is made that most herring harvested will be used for personal consumption; however, prior to 2000 a portion of these could be sold, as allowed by WRC rules. In 2003, the WRC adopted rules prohibiting the use of gill nets in most Inland Waters of the state, which eliminated the river herring fishery in Inland Waters with gill nets. The WRC in 2003, also implemented a 25 per person per day limit. Several variations of dip nets (called "special fishing devices" when used in Inland Waters) are the primary gears used to recreationally harvest river herring although gill nets have also been used. Because river herring do not readily take bait or artificial lures, the hook and line fishery in coastal North Carolina is likely inconsequential. However, over the last several years, the harvest of river herring with "Sabiki" rigs for bait in the striped bass fishery has greatly increased.

Historically, river herring have been taken for personal consumption in every major North Carolina coastal river system. An analysis of river herring harvest by Baker (1968) indicated the majority of herring harvested by special device licensees in 1967-1968 occurred in the Chowan and Roanoke river basins. River herring were also harvested in other river basins, but American shad and hickory shad (*Alosa mediocris*) were of more importance to fishermen in those areas. Coastwide, Baker (1968) estimated that special device licensees harvested 2.9 million pounds of river herring some of which were sold. The recreational component of this total, however, is unknown. Although these fish were taken by fishermen licensed by WRC at that time, changes in designations of Coastal/Joint/Inland Waters, changes in jurisdictional responsibilities between DMF and WRC, and the unknown proportion of these fish which were harvested with the intent of sale precludes an estimate of the historical level of river herring harvest for personal consumption.

Currently, the extent of river herring harvest for personal consumption in coastal North Carolina is unknown. According to Wildlife Enforcement Officers who patrol the Inland Waters of the Cape Fear, Neuse, and Tar-Pamlico river basins, very few (usually none) special device licensees specifically targeting river herring are encountered in these areas, principally due to the low numbers or absence of these species. Special device licensees targeting river herring are still encountered in small tributaries of the Roanoke and Chowan rivers during the spring months, and an active recreational herring fishery persists in tributaries to the Meherrin River. Recreational river herring fishermen are still found at small bridge crossings over tributaries to other Albemarle Sound river systems such as the Pasquotank, Perquimans, Yeopim and Scuppernong rivers. Low effort directed at river herring harvest in these areas is likely indicative of low river herring abundance.

From 1992 through 2000, sales of WRC special fishing device licenses increased in the Chowan River basin from 94 to 436 (Figure 6.1). Since 2000, the number of licenses sold has declined to 295 in 2003/2004 but is still twice that sold from 1992 through 1996. This increase in sales has been most evident in Chowan, Gates, and Bertie counties since 1995. These increases in license sales occurred after implementation of the initial April 15 river herring season closure by the MFC in 1995. The number of special device licenses continued to increase until gill nets were prohibited in Inland Waters (2003), no sale provision adopted (2000) and the 25 fish possession limit (2003). Since that time the number of licenses have dropped slightly but still are higher than in the early 1990s. The WRC, however, will be implementing a moratorium in all Inland Waters of coastal rivers and their tributaries on possession of river herring larger than 6 inches long, effective July 1, 2006.

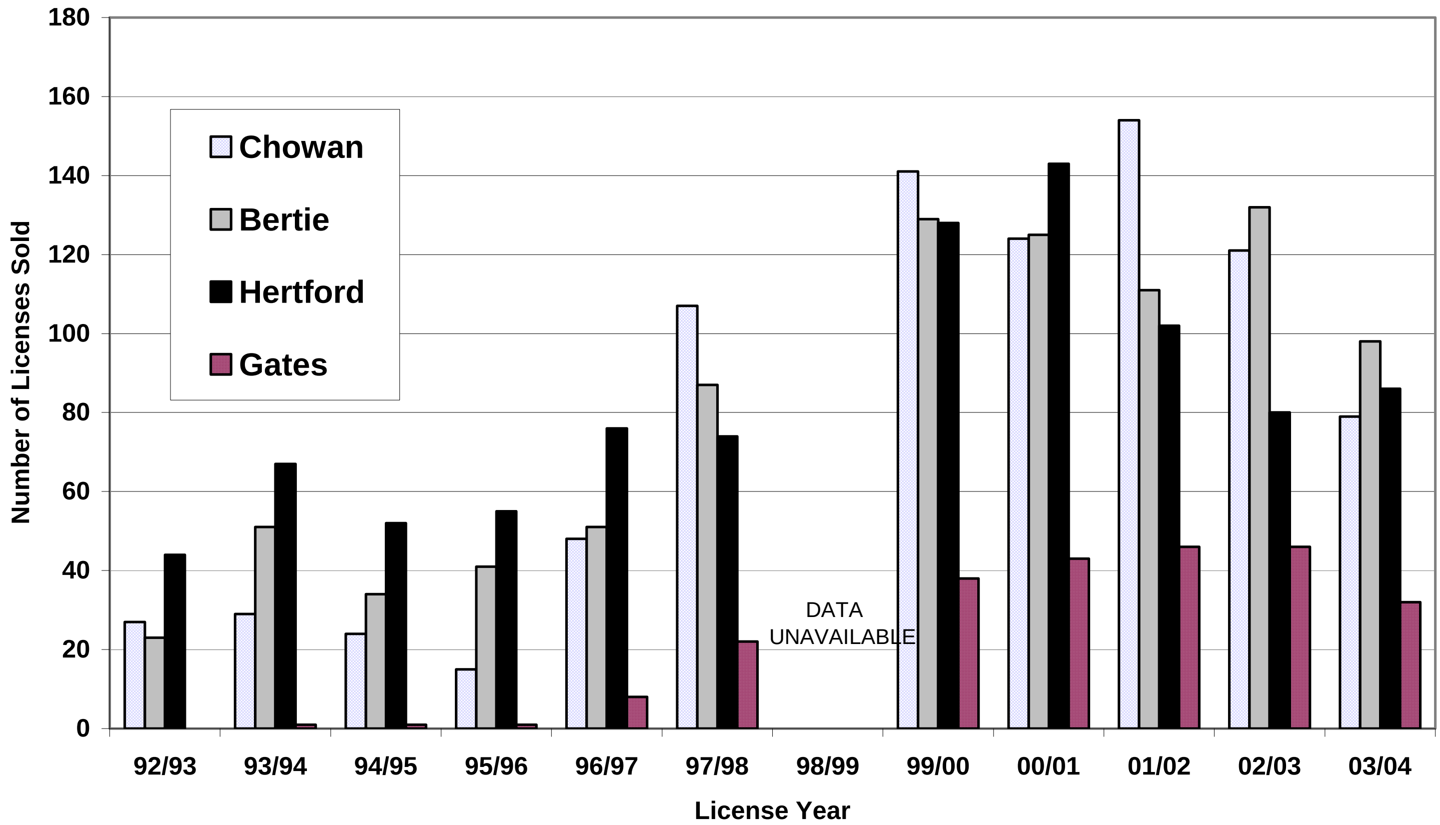


Figure 6.1. Sales of NCWRC special fishing device licenses (non-commercial) in counties bordering Chowan River.

The MFC rules adopted as a result of the 2000 FMP, established a limit of 25 blueback herring or alewife, in the aggregate, per person per day taken for recreational purposes in the Coastal and Joint waters of the state. Also on January 1, 2001, it became unlawful to use a drift gill net with a mesh length less than three inches (stretched mesh) from January 1 through May 15 in the Albemarle Sound/Chowan River Herring Management Areas (Figure 4.1).

A recreational drift net river herring fishery has existed on the Roanoke River for many years. This fishery has never been fully assessed by DMF or WRC. The DMF initiated a pilot drift net creel survey in 1999 to characterize this fishery for development of future monitoring strategies and to provide managers with weekly reports of recreational drift net activity (participation, catch rates, species composition, net sizes, etc). Sampling was conducted in the lower river area including Williamston, Jamesville, and Plymouth. Interviews were conducted three days per week, for a total of 21 sampling days in 1999. Catches of river herring ranged from 20 to 300 fish per vessel with a mean of 106. Drift duration ranged from 1 to 5 hours with a mean of 2.2 hours. A total of 2,764 river herring were observed in the survey. Because there was no estimate of total effort, total catch cannot be estimated. Through the survey, the county of residence of the fishermen was determined. Martin, Edgecombe, Greene and Pitt counties accounted for the majority of the fishermen.

In 2004, Vogelsong et al. (2004) conducted a Recreational Commercial Gear License (RCGL)- Herring Drift Netters Survey in the Roanoke River. The survey was conducted from February 1 through April 11, 2004 with 45 drift netters being sampled and a catch estimate for the season of 5,386 pounds. The average number of herring caught per day for the season ranged from 0-20+, with a mean of 14.4 fish. The number of drifts per day ranged from 1-9, with a mean of 3.4. Based on the survey, 46% were catching fish for personal consumption and 54% for bait for striped bass fishing.

The DMF has established a monthly RCGL survey but due to the low response rates during the river herring season the estimates of pounds and trips are unreliable. Very few RCGL holders participate in the herring fishery. The harvest estimates from 2002-2004 for the state have ranged from 8,988 through 29,415 pounds.

6.4 Social Significance

As noted previously, fishing for river herring each spring is a long-standing tradition in eastern North Carolina, socially as well as economically. Generations of local residents have pulled seines, set small gill nets, and drifted gill nets on the Chowan, Roanoke, Tar, Neuse and other rivers to catch river herring for fish fry events. These events often served to raise money for a church or civic organization. This tradition is in jeopardy because the stock has declined to such a low level. The social values of river herring should be considered as the stock recovers through implementation of this plan.

6. FISHERY ECONOMICS

7.1 Commercial Fishery

7.1.1 Ex-vessel Value and Price

River herring was the most economically important finfish harvested in North Carolina in the late 1800's (Chestnut and Davis 1975). It was not until 1918 before menhaden became more economically viable than river herring. Figure 7.1 shows the "inflated" ex-vessel value (the actual amount paid dockside to the fishermen) and the ex-vessel value of the landings "deflated" (normalized) for all years to the value of a dollar in 1972. Deflated values are calculated to provide a dollar value that is comparable across all years. There are no comparable deflated figures prior to 1918 because the US government did not start calculating the consumer price index (CPI) until that year.

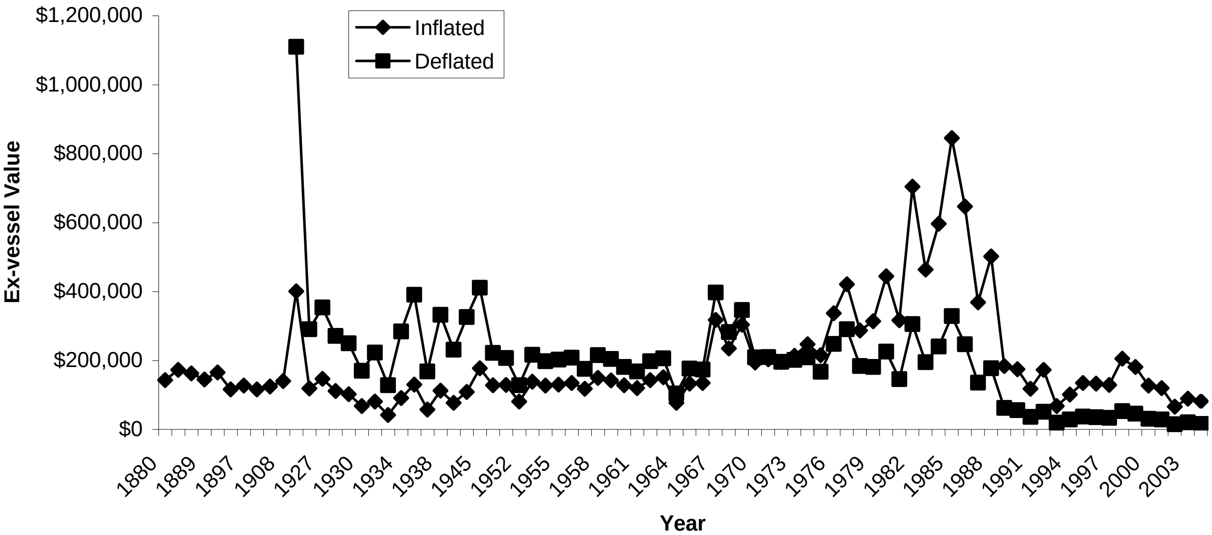


Figure 7.1 Commercial ex-vessel value of river herring landings, North Carolina, 1880 – 2004. (NC DMF Trip Ticket Program)

Prior to 1952, the annual deflated ex-vessel value of river herring fluctuated from a high of $1,110,053 in 1918 to a low of $128,146 in 1932. Deflated landings values remained fairly constant from 1953 until about 1963 ranging in value from approximately $168,000 to $216,000. Average annual landings values began to increase significantly in 1967 and declined sharply beginning in 1989 when the deflated value of landings was $61,973. Since then the trend has been toward decreasing annual value with the deflated value of landings in 2004 at $18,012.

Inflated values (the actual ex-vessel price paid to the fisherman) show the same trend. In 1988, the ex-vessel value was $502,166 and by 2004 the total ex-vessel value paid for all river herring landed in North Carolina was $81,399.

A survey is conducted periodically by the DMF to obtain price estimates from dealers for fish they have purchased from fishermen. The data from the survey are used to determine an average annual price for each market grade. River herring landings and total market value are currently at historic lows. During the peak of the economic value of the fishery in the 1980's, value was at roughly $.10 per pound. Table 7.1 summarizes the inflated and deflated annual values and price per pound for river herring.

The fishermen sell river herring to the dealers primarily as whole fish by the pound. They are occasionally sold individually, or just the roe may be sold. The price per pound of river herring roe is customarily much higher than the whole fish price per pound. However, relatively few pounds of river herring roe are sold each year. Figure 7.2 shows average annual price per pound paid to fishermen. The numbers reflect the actual price per pound paid and the price per pound normalized, or deflated to the value of one dollar in 1972. With the exception of 1968 when landings were low, the average price per pound never exceeded $.05 per pound prior to 1978 for either the actual or deflated prices. It was 1995 before the deflated price per pound exceeded $.05. Since 1995, the deflated price per pound has never exceeded $.10 per pound.

7.1.2 Gear

The advent of the North Carolina Trip Ticket system in 1994 allowed the DMF to track landings by individual trips taken by fishermen for the first time. Price estimates derived from the surveyed dealers do not take gear type or time of year into account.

However, since the river herring fishery is highly seasonal, it is likely that prices fluctuate greatly based on supply and demand. As river herring return from the ocean to spawn, higher prices may be received early in the season from gill nets fished in the eastern part of the Albemarle Sound Management Area. Pound net fishermen in the Chowan River may receive lower prices per pound as river herring are landed upstream later in the season. 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 river herring either using gill nets or pound nets. More gill net trips landed river herring in each year compared to pound nets. This is due primarily to how the two gears are fished. Gill net landed river herring tend

Table 7.1. Inflated and deflated ex-vessel and price per pound of river herring landings, North Carolina, 1880 – 2004. (NC DMF Trip Ticket Program)

Year	Inflated Value	Deflated Value	Inflated Price Per Pound	Deflated Price Per Pound	Year	Inflated Value	Deflated Value	Inflated Price Per Pound	Deflated Price Per Pound
1880	$143,000		$0.01		1965	$132,601	$175,959	$0.01	$0.01
1887	$173,000		$0.01		1966	$134,261	$173,213	$0.01	$0.01
1888	$162,000		$0.01		1967	$317,716	$397,621	$0.02	$0.02
1889	$145,000		$0.01		1968	$234,669	$281,873	$0.02	$0.02
1890	$165,000		$0.01		1969	$303,717	$345,923	$0.02	$0.02
1896	$116,000		$0.01		1970	$193,756	$208,737	$0.02	$0.02
1897	$127,000		$0.01		1971	$203,122	$209,642	$0.02	$0.02
1902	$116,000		$0.01		1972	$196,145	$196,145	$0.02	$0.02
1904	$124,000		$0.01		1973	$213,519	$201,016	$0.03	$0.03
1908	$140,000		$0.01		1974	$246,753	$209,215	$0.04	$0.03
1918	$401,000	$1,110,053	$0.02	$0.06	1975	$215,501	$167,434	$0.04	$0.03
1923	$119,000	$290,889	$0.01	$0.03	1976	$336,750	$247,384	$0.05	$0.04
1927	$147,000	$353,138	$0.01	$0.03	1977	$421,603	$290,809	$0.05	$0.03
1928	$111,000	$271,333	$0.01	$0.03	1978	$286,705	$183,808	$0.04	$0.03
1929	$102,000	$249,333	$0.01	$0.02	1979	$313,779	$180,661	$0.06	$0.04
1930	$68,000	$170,204	$0.01	$0.02	1980	$444,327	$225,399	$0.07	$0.04
1931	$81,000	$222,750	$0.01	$0.03	1981	$316,850	$145,702	$0.07	$0.03
1932	$42,000	$128,146	$0.01	$0.02	1982	$704,599	$305,205	$0.07	$0.03
1934	$91,000	$283,866	$0.01	$0.02	1983	$464,389	$194,894	$0.08	$0.03
1936	$130,000	$390,935	$0.01	$0.03	1984	$596,428	$239,949	$0.09	$0.04
1937	$58,000	$168,361	$0.01	$0.03	1985	$845,906	$328,614	$0.07	$0.03
1938	$112,000	$332,028	$0.01	$0.03	1986	$647,293	$246,869	$0.09	$0.04
1939	$77,000	$231,554	$0.01	$0.03	1987	$368,062	$135,431	$0.12	$0.04
1940	$109,000	$325,443	$0.01	$0.04	1988	$502,166	$177,435	$0.12	$0.04
1945	$177,000	$411,033	$0.02	$0.05	1989	$183,842	$61,973	$0.12	$0.04
1950	$128,000	$222,008	$0.02	$0.03	1990	$174,259	$55,731	$0.15	$0.05
1951	$129,000	$207,392	$0.01	$0.02	1991	$118,272	$36,298	$0.08	$0.02
1952	$81,000	$127,766	$0.01	$0.02	1992	$172,453	$51,379	$0.10	$0.03
1953	$138,000	$216,045	$0.01	$0.02	1993	$67,494	$19,524	$0.07	$0.02
1954	$127,000	$197,346	$0.01	$0.02	1994	$100,996	$28,486	$0.16	$0.04
1955	$130,000	$202,761	$0.01	$0.02	1995	$134,934	$37,009	$0.30	$0.08
1956	$135,000	$207,463	$0.01	$0.02	1996	$132,573	$35,319	$0.25	$0.07
1957	$118,000	$175,530	$0.01	$0.01	1997	$128,682	$33,514	$0.38	$0.10
1958	$149,000	$215,509	$0.01	$0.01	1998	$204,706	$52,495	$0.39	$0.10
1959	$142,000	$203,973	$0.01	$0.01	1999	$180,874	$45,381	$0.41	$0.10
1960	$128,000	$180,757	$0.01	$0.01	2000	$127,206	$30,878	$0.38	$0.09
1961	$120,000	$167,759	$0.01	$0.01	2001	$120,053	$28,335	$0.39	$0.09
1962	$143,024	$197,960	$0.01	$0.01	2002	$65,723	$15,271	$0.38	$0.09
1963	$150,996	$205,725	$0.01	$0.01	2003	$89,456	$20,322	$0.45	$0.10
1964	$76,880	$103,664	$0.01	$0.01	2004	$81,399	$18,012	$0.43	$0.10

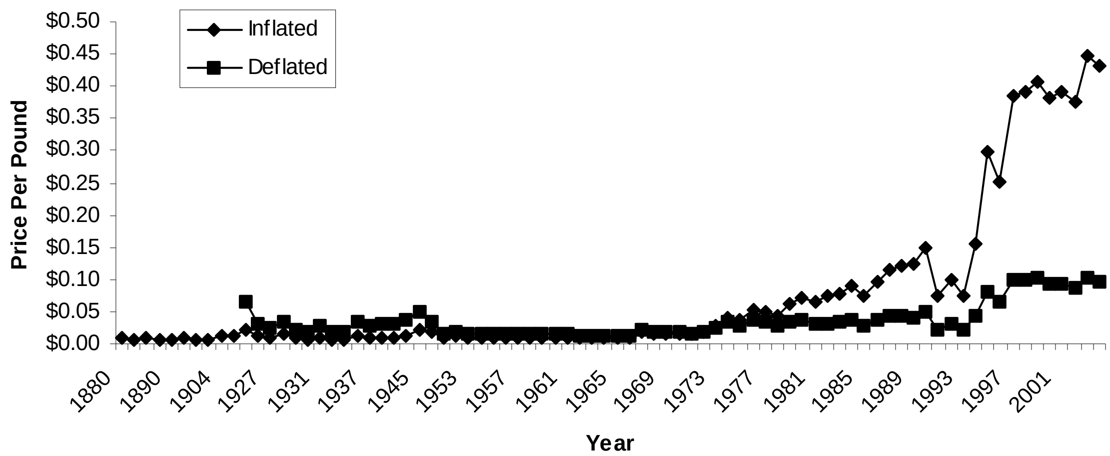


Figure 7.2. Commercial ex-vessel price per pound for river herring landings, North Carolina, 1880 – 2004. (Chestnut and Davis 1975; NC DMF Trip Ticket Program)

Table 7.2. Trips, ex-vessel value, and average price per pound for gill net and pound net trips for river herring, North Carolina, 1994 – 2004. (NC DMF Trip Ticket Program)

	Gill Nets			Pound Nets		
Year	Trips	Ex-Vessel Value	Price Per Pound	Trips	Ex-Vessel Value	Price Per Pound
1994	2,842	$52,282	$0.29	1,025	$44,330	$0.10
1995	2,606	$58,335	$0.37	445	$71,459	$0.26
1996	2,856	$51,439	$0.43	450	$78,609	$0.19
1997	2,398	$59,971	$0.48	442	$66,173	$0.33
1998	2,486	$69,576	$0.48	470	$134,488	$0.36
1999	2,406	$59,015	$0.57	596	$120,873	$0.36
2000	1,729	$45,683	$0.50	608	$78,677	$0.34
2001	941	$35,459	$0.41	422	$80,422	$0.38
2002	1,344	$27,356	$0.38	582	$34,503	$0.37
2003	1,378	$37,767	$0.46	471	$42,950	$0.44
2004	802	$32,912	$0.43	416	$38,766	$0.43

to bring a higher price per pound for two main reasons: 1) individual gill net trips typically bring in fewer pounds per trip; and 2) the river herring gill net season starts earlier than the pound net fishery. With lower amounts of river herring typically available during the gill net season, demand for the product drives the price up. In each year other than 1994, the total annual ex-vessel value from pound nets is higher than from gill nets partially due to management measures that went into place beginning in 1995.

The number of trips taken each year was greatly influenced by the length of the season. The gill net season closed much earlier in 2001 than in other years, resulting in fewer trips taken. The average ex-vessel value of a gill net trip in 2004 was $41.04. For pound nets, the average ex-vessel value per trip in 2004 was $93.19.

7.1.3 Waterbodies

Traditionally, pound nets in the Chowan River land the greatest portion of the river herring catch each year. Gill nets land more river herring primarily from the eastern parts of the Albemarle Sound Management Area. Figure 7.3 shows the annual ex-vessel value of river herring from the Albemarle Sound, Chowan River, and all other state water bodies. From 1962 to 1986, the ex-vessel value for landings from the Chowan River showed variability from one year to the next; however, in those years there was an overall increasing trend in the values of landings. Since 1991, only three years have seen total annual ex-vessel landings values greater than $100,000. The years of 2002 to 2004 showed the lowest annual ex-vessel values with the total value of landings from the Chowan River in each year being less than $40,000.

The ex-vessel value of river herring landed from the Albemarle Sound remained fairly constant from 1962 to 1979, with most year’s value at less than $30,000. The Albemarle Sound fishery saw increased landings value throughout most years in the 1980’s with landings values at or near $100,000 per year from 1982 to 1988. In 1990, the ex-vessel value of landings began to drop and have remained roughly in the range of $20,000 to $40,000 each year.

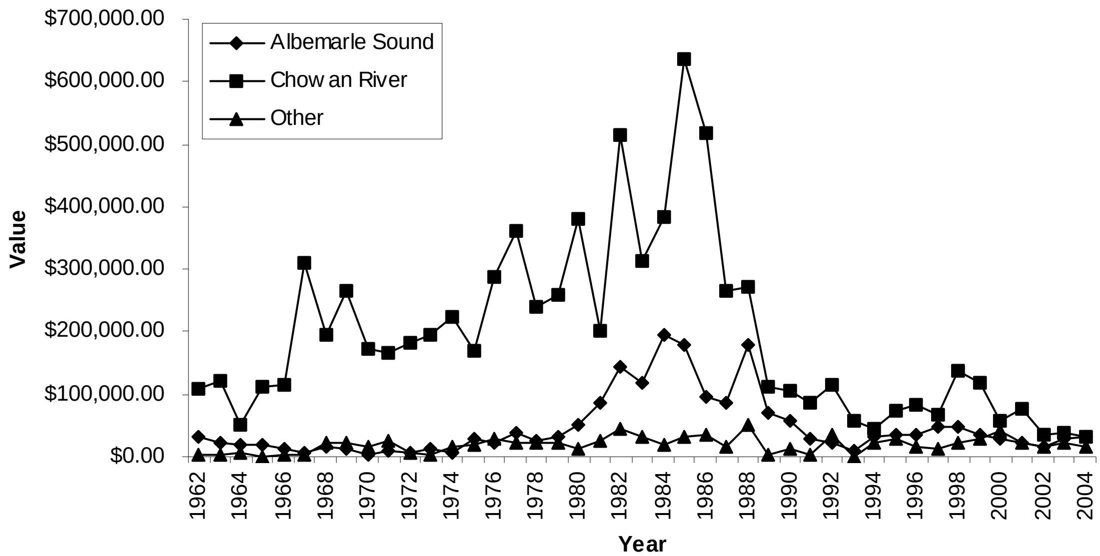


Figure 7.3. Annual ex-vessel landings value (inflated) for river herring from selected water bodies, North Carolina, 1962 – 2004. (NC DMF Trip Ticket Program)

Ex-vessel values from all other state water bodies have remained fairly constant across all years from 1962 to 2004 at roughly $10,000 to $30,000 per year. Only one year, 1988, saw landings values greater than $50,000.

The average price per pound received by fishermen for river herring showed an increasing trend from 1962 to 1990 going from $.01 per pound in 1962 to $.15 per pound in 1990 (Figure 7.4). In 1990 as the pounds of river herring landed decreased, the price per pound showed a decrease as well. However, by 1995 the price began to increase dramatically and reached at least $.40 per pound since 2001.

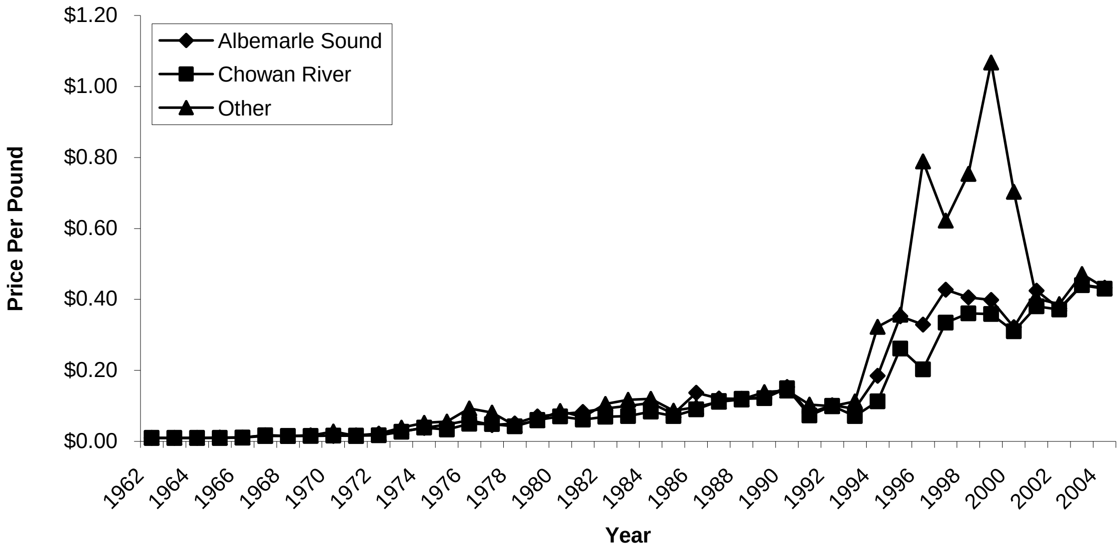


Figure 7.4. Annual average price per pound (inflated) for river herring from selected water bodies, North Carolina, 1962 – 2004. (NC DMF Trip Ticket Program)

7.1.4 Participants

The North Carolina trip ticket program enables managers to monitor fishing activity at the trip level, including giving an indication of how many persons are participating in the fishery. By 1994 the amount of fishing activity for river herring had already been greatly reduced from its original historic highs. Table 7.3 shows a decreasing trend in participation with a high in 1996 of 265 fishermen to 146 participants in 2002. In 2003, there was an increase in participants to 181, but the number of participants dropped to a new low of 136 participants in 2004. The majority of river herring participants in each year have total annual ex-vessel landings values of less than $500 each. Few fishermen in any year have annual ex-vessel landings values of more than $5,000. Two years, 1998 and 1999 saw the greatest number of fishermen earning more than $5,000 with 14 and 10, respectively.

Data from trip tickets indicate that fishermen who land river herring are also likely to land other species. Table 7.4 shows the percent of total ex-vessel value comprised by river herring just on trips where river herring were landed for fishermen with commercial landings from 1994 to 2004.

Table 7.3. Number of participants and annual ex-vessel landings value for river herring, North Carolina, 1994 – 2004. (NC DMF Trip Ticket Program)

Annual Ex-Vessel Value	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
< $25	121	125	144	114	107	100	91	45	54	56	42
$25 - $100	17	28	41	42	39	37	30	34	31	37	23
$100.01 - $500	44	32	40	30	32	30	42	36	29	48	36
$500.01 - $1,000	22	18	12	10	17	7	27	14	16	16	14
$1,000.01 - $5,000	28	24	22	31	14	20	13	13	16	20	21
> $5,000	*	5	6	4	14	10	7	9	*	4	*
Total Participants	232	232	265	231	223	204	210	151	146	181	136

* Denotes confidential data. Values added to previous category.

Table 7.4. Percent of total fishing income of fishermen from the North Carolina river herring fishery, 1994 – 2004. (NC Trip Ticket Program).

	Number of Participants per Year										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
< 5%	122	101	148	113	102	103	70	38	57	48	24
5 - 10%	19	28	29	23	31	26	34	20	12	30	20
10 – 15%	17	17	16	13	13	17	18	13	8	18	12
15 – 20%	9	10	8	9	12	6	9	8	6	14	11
20 – 30%	11	16	13	9	13	10	25	17	14	17	18
30 – 40%	6	20	10	10	6	7	16	18	9	14	14
40 – 50%	10	10	6	12	4	4	6	5	8	16	7
50- 60%	4	11	4	12	9	3	4	8	6	7	5
60 – 70%	8	5	7	5	7	8	11	6	9	4	10
70 – 80%	6	3	8	7	6	4	6	5	7	2	5
60 – 90%	4	5	8	9	11	8	6	7	2	6	5
90 - 100%	16	6	8	9	9	8	5	6	8	5	5
	232	232	265	231	223	204	210	151	146	181	136

Fishermen, especially gill net fishermen, typically catch and sell multiple species from a single trip. River herring accounted for less than 50% of the catch by value for the majority of these fishermen. Most fishermen with river herring landings do not rely on these fish for a major portion of their fishing income during the herring season as approximately 50% of the fishermen derive 20% or less of their total fishing income from river herring. However, the importance of river herring to many of these fishermen is that the fishery occurs primarily in winter and early spring, a time of year when there are few other opportunities for them to make a living as a commercial fisherman. Approximately 17% of the fishermen who participated in the river herring fishery from 1994 to 2004 derived more than 50% of their fishing income from river herring during the season. Those who relied most heavily on river herring for more than 50% of their fishing income during the 2004 season earned an average of $1,804 just from river herring.

The primary gears used for catching river herring are gill nets and pound nets. Species most typically landed from gill nets along with river herring include catfishes (*Ameiurus spp. & Ictalurus spp.)*, southern flounder (*Paralichthys lethostigma*), jumping mullet (*Mugil spp.*), perches (*Morone americana & Perca flavescens)*, and striped bass (*Morone saxatilis*). Species landed with river herring from pound nets include catfishes, shad (*Alosa spp.*), perches, and striped bass.

Figure 7.5 shows the number of participants for each year from 1994 to 2004 who fished for river herring using different gear types. The majority of fishermen who land river herring in each of the years used gill nets. While fewer fishermen used pound nets to land herring, the numbers of fish they land resulted in higher overall ex-vessel values than river herring landed in gill nets.

Table 7.5 shows the number of dealers statewide who reported landings of river herring on trip tickets between 1994 and 2004. In 1994 and 1996, 55 dealers statewide reported landings of river herring. By 2002 the number had declined to 35 dealers, but climbed back up to 42 dealers in 2003. However, the number of dealers in 2004 dropped to a new low of 34.

Between 1994 and 1999 about half of all dealers reported annual river herring landings values of less than $1,000 per year. In most years about 10% of dealers reported river herring landings valued at more than $10,000. Fewer than 6 dealers each year reported landings of more than $10,000.

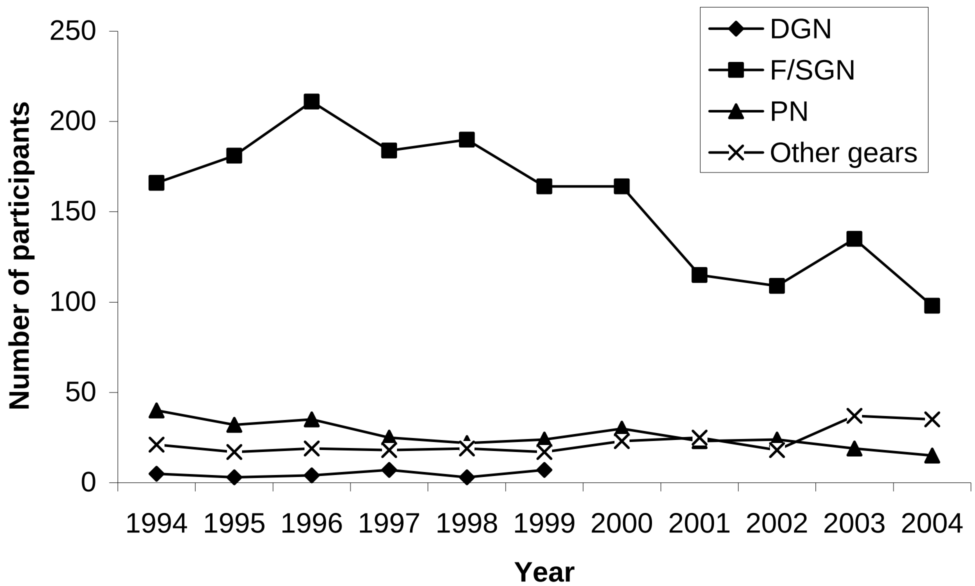


Figure 7.5. Participants in the river herring fishery by gear usage, North Carolina, 1994 – 2004. (North Carolina Trip Ticket Program) (DGN- drift gill net, F/SGN- float and sink gill net, PN- pound net)

Table 7.5. Number of dealers and annual ex-vessel landings value for river herring, North Carolina, 1994 – 2004. (NC DMF Trip Ticket Program)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
< $100	25	24	27	25	18	18	19	15	12	12	12
$100.01 - $5000	9	8	11	10	8	6	9	5	8	9	7
$500.01 - $1,000	5	*	4	*	6	4	4	4	*	5	*
$1,000.01 - $5,000	12	9	7	12	9	9	11	11	15	13	8
$5,000.01 - $10,000	*	*	3	4	*	0	*	*	*	*	7
> $10,000	4	5	3	*	3	4	3	3	*	3	*
Total	55	46	55	51	44	41	46	38	35	42	34

* Denotes confidential data. Values added to previous category.

Dare County consistently has the greatest number of dealers reporting landings of river herring on trip tickets, although the trend there is towards fewer dealers (Table 7.6). Chowan and Pasquotank are the only two other counties consistently reporting landings of river herring from 1994 to 2004. Many other counties have dealers reporting river herring on trip tickets. The location of the dealer's county is not necessarily an indication that the fish were caught there. It is an indication of where the fish were landed. Other counties where dealers reported river herring landings at least one year between 1994 and 2004 include: Beaufort, Bertie, Brunswick, Camden, Carteret, Craven, Currituck, Hertford, Martin, Onslow, Pamlico, Perquimans, Pitt, Tyrrell, and Washington. Many of these additional counties had only one or two dealers reporting river herring landings and many had no dealers reporting landings in some years.

Table 7.6. Number of dealers reporting river herring purchases by county, North Carolina, 1994 – 2004. (NC DMF Trip Ticket Program)

County	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Chowan	9	4	3	3	3	3	3	3	3	3	3
Dare	11	12	14	13	11	9	9	9	10	7	7
Pasquotank	3	3	5	4	4	3	3	3	3	3	3
Other Counties	32	27	33	31	26	26	31	23	19	29	21
Total	55	46	55	51	44	41	46	38	35	42	33

7.1.5 Processing

Processed river herring products historically have included fresh whole fish, frozen bait, salt herring fillets, salt headless dressed fish, and roe (fish eggs), canned and fresh. Unprocessed river herring also are used as bait.

There has been an overall decline in river herring processing activities in North Carolina since 1970 (Table 7.7). The number of processing plants fluctuated between three and seven between 1970 and 1982. Since 1982, the trend has been towards a decreasing number of plants processing river herring. Processing activities fell during these years in relation to a sharp decline in landings and due to the lower demand for the product. Beginning in 1998, there has only been one plant in North Carolina processing river herring. NOAA Fisheries reports that the one current operation processes extremely small amounts (Peter Fricke, NOAA Fisheries, personal communication).

The value of river herring processed products increased steadily from $341,384 in 1970 to a peak of almost $1.5 million in 1984 and has decreased ever since. Within a decade, processed product value declined more than 1700% from about $1 million in 1985 to less than $55,000 in 1994.

Table 7.7. Employment and processed value for river herring processors, North Carolina, 1970 – 2004. (NOAA Fisheries)

Year	No. Plants	Seasonal Employment	Yearly Employment	Processed Value
1970	5	134	130	$341,384
1971	5	137	137	$825,858
1972	4	137	137	$535,186
1973	5	98	98	$687,066
1974	5	91	91	$1,331,862
1975	5	126	113	$1,299,315
1976	5	105	92	$1,029,151
1977	6	112	104	$601,511
1978	5	110	101	$361,706
1979	4	93	75	$419,177
1980	3	92	75	$515,186
1981	3	69	44	$481,133
1982	7	142	118	$1,044,529
1983	5	99	71	$1,427,178
1984	4	88	60	$1,461,946
1985	6	118	98	$1,027,221
1986	5	120	97	$758,536
1987	5	120	95	$257,207
1988	5	103	85	$428,742
1989	5	86	73	$145,336
1990	3	62	59	$85,526
1991	3	60	56	$103,496
1992	3	61	58	$102,189
1993	3	62	60	$121,600
1994	3	69	66	$54,750
1995	2	76	76	*
1996	2	76	76	*
1997	2	72	72	*
1998	1	*	*	*
1999	1	*	*	*
2000	1	*	*	*
2001	1	*	*	*
2002	1	*	*	*
2003	1	*	*	*
2004	1	*	*	*

* Denotes confidential data

During the years 1970 to 1997, the processing sector provided full-time and seasonal employment in several communities; however, employment by the river herring processors declined greatly during these years. The decline is related to the decreased availability of raw product.

River herring processing employment and processed value data are confidential since 1997 because there is only one processor left in North Carolina (see Table 7.7). According to NOAA Fisheries, the one remaining processor is speculated to have a "special connection to the fishery because the processor is obviously not making any money on the venture" (Peter Fricke, personal communication).

7.1.6 Economic Impact of Commercial Fishing

Burgess and Bianchi (2004) estimated the total economic impact of just the river herring harvesting sector to be $105,785 in 2002. As was shown in Table 7.4, harvest sector employment in 2002 was 146. The overall average earnings per worker in the fishery for that year were $336 based on a total landings value of approximately $65,000. The additional $40,000 that went into the economy as a result of the river herring fishery went to wages, and non-wage expenditures such as loan payments, fuel and oil, nets, repairs, and maintenance, etc. The river herring economic impact in 2002 also funded the equivalent of one additional full time job in the overall state economy.

7.2 Recreational Fishery Economics

Economic data estimates specific to recreational river herring fishing trip expenditures are available only from the Recreational Commercial Gear License (RCGL) survey annual survey of 2001. However, landings data from the monthly RCGL surveys are unable to make reliable estimates of pounds landed and trips taken by RCGL fishermen in any given year. Unreliability of estimates from the RCGL survey is largely due to the lower response rates during the months when the river herring is occurring and because few RCGL fishermen participate in the fishery. There are no reported landings of river herring from the Marine Recreational Fisheries Statistical Survey (MRFSS).

7.2.1 RCGL Economic Impact

The economic figures are based on an expansion of the actual values reported by RCGL fishermen in the 2001 annual survey and are considered the best available estimates. A trip-level, direct economic impact assessment was made based on respondents who indicated landing river herring in gill nets. Table 7.8 shows trip characteristics and costs associated with the average overnight and day trips where RCGL fishermen reported landing river herring. The trip expenditures described below are only those that can be attributed to river herring landings. Typically, on most overnight trips, the fishermen and the non-fishers who accompanied them, engaged in other, non-fishing activities.

The expenditures shown in Table 7.8 relate to the overall proportion of river herring landed. Multiple species were typically caught along with the river herring; however, river herring comprised 55.5% of the total catch on the trips in 2004.

Expenditures by those who made overnight trips tend to be greater when compared to day trips because of the increased costs of lodging and meals. It is thought that very few RCGL trips in which river herring are landed are actually overnight trips. An average overnight trip lasted an average of 2 ½ days and resulted in total expenditures of $109.81 were attributable to river herring landings.

Table 7.8. Economic impact of RCGL trips for river herring, North Carolina, 2004 (NC DMF RCGL Survey Program).

	Overnight	Day
Number of Nights	2.64	---
Miles Traveled	147.34	95.80
# Who Fished	3.07	2.51
# Who Did Not Fish	0.73	0.27
# of People / Trip	3.79	2.78
% Who Fished	81%	92%
Lodging / Night	$22.78	---
Food / Trip	$30.76	$10.14
Ice / Trip	$4.95	$2.22
Fuel and Oil / Trip	$31.36	$14.86
Equipment Rental / Trip	$0.13	$0.18
Average Trip Expenditures	$109.81	$26.60

8. SOCIAL IMPORTANCE OF THE FISHERY

8.1 Commercial Fishery

8.1.1 Historical Importance

Fishing for river herring each spring is a long-standing tradition in northeastern North Carolina. Currently, for most participants, the primary importance of the fishery is more social and cultural than it is economic. Generations of local residents have pulled seines, set small gill nets, and drifted gill nets on the Chowan, Roanoke, Tar, Neuse, and other rivers to catch river herring for fish fry events. These events often served to raise money for a church or civic organization. However, this tradition is in jeopardy because the stock has declined to such a low level.

8.1.2 Community Reliance on the Commercial Fishery

In the past when landings of river herring were at or near their historical highs, many northeastern North Carolina communities relied on the annual runs of river herring for a significant source of economic activity. In 2004, only 35 out of 136 (roughly 26%) fishermen with recorded landings of river herring had an ex-vessel value greater than $500. At these levels, no single community in North Carolina is greatly impacted economically by the value of landings of river herring.

8.1.3 Perceived Conflicts

The Socioeconomics Program of the North Carolina Division of Marine Fisheries surveys commercial fishermen annually from various parts of the state. At the time of the writing of this management plan, a survey is currently underway in the parts of the state that has captured data from eight commercial river herring fishermen. As this survey is still underway and because of the small sample size, the results reported here must be considered preliminary.

Some of these fishermen did complain about conflicts with other commercial fishermen. The complaints ranged from gear being unattended for too long to sabotage of fishing gear. One fisherman complained that recreational fishermen sabotaged his gear because they did not want him to catch striped bass.

Nearly all of the fishermen cited negative experiences in the past year associated with state regulations. The complaints were primarily related to bag limits of striped bass and landings quotas that forced fishermen to return fish to the water that they otherwise could sell.

8.1.4 Perception of Important Issues, etc.

In the same survey of fishermen currently being conducted by the North Carolina Division of Marine Fisheries, the fishermen were asked to state which issues were most important to them in their commercial fishing business. The issue most important to river herring fishermen was that of bag limits, followed by quotas. The next most pressing issues were related to the two previous ones, that of dealing with what they felt were restrictive state regulations, and keeping up with changes in rules and proclamations. Also important issues, but less so, were the impacts of imported seafood and depressed seafood prices, in general. The fishermen were also concerned about what they saw as excessive restrictions on their use of certain fishing gears.

8.2 Recreational Fishery

The North Carolina Fisheries Reform Act of 1997 made a distinction between commercial and recreational fishermen in coastal and joint waters. Persons who previously fished with commercial gear, but did not sell their catch were required, starting in 1999, to purchase a RCGL license. This license allowed those who previously fished for river herring using a gill net to continue to do so, but with a 100-yard limit on the amount of net that can be used by a single fisherman, or up to 200-yards if there are at least two fishermen in the boat each with an active license. RCGL fishermen are prohibited from fishing using a pound net.

8.2.1 Historical Importance

Prior to the advent of the current licensing system in 1999, there were few distinctions between commercial and recreational fishermen in terms of the social and historical importance of the fishery. There are no data since 1999 that provide information on whether the change in license structure has altered the importance of the fishery for the recreational fisherman. Much of the recreational harvest of river herring is said to occur in the waters managed by the North Carolina Wildlife Resources Commission (WRC). The WRC does not have social or economic data on the importance of the river herring fishery in inland waters.

8.2.2 Community Reliance on the Recreational Fishery

There are no data available on community reliance on the recreational river herring fishery.

8.2.3 Perceived Conflicts

The 2001 annual survey of RCGL fishermen asked them about conflicts they have with other fishermen on the water, both commercial and other recreational fishermen. Slightly more than 70% of the 272 fishermen who indicated they used their RCGL to land river herring reported they did not have conflicts with commercial fishermen. About 8% were unsure whether they did or not. The remaining 21% of the survey respondents indicated they did have a least some conflict with commercial fishermen on the water. Meanwhile, 88% stated they did not have conflicts with other recreational fishermen. Three percent were not sure if they had conflicts. The remaining fishermen did claim having conflicts with other recreational fishermen.

8.2.4 Perception of Important Issues

RCGL fishermen were asked about several issues of importance to them in the 2001 annual survey. The 272 fishermen who said they landed river herring had mixed opinions about whether they felt there was too much fishing gear in the water where they typically fish. Over 27% felt there was too much gear in the water, while 61% felt that there was not too much gear in the water. The remaining respondents either were not sure or did not answer the question.

Most (71%) of the 2001 RCGL river herring survey respondents felt that they should be allowed to use more gear. Another 10% felt that they did not need to use more gear with the RCGL. The remaining respondents either were not sure or did not answer the questions.

The majority (62%) of the RCGL river herring fishermen were not satisfied with current bag limits. Another 31% were satisfied with the limits, while 7% were not sure if they were satisfied or not.

8.3 Demographic Characteristics

8.3.1 Commercial Fishermen

A specific survey of river herring fishermen was conducted by the North Carolina Division of Marine Fisheries in 1998 to obtain some demographic information on the participants in the Albemarle Sound fishery and were reported in the first North Carolina river herring management plan. That survey indicated that the average age of river herring fishermen at the time was 53, with a range of 44 to 59 years. The average fisherman had fished for 20 years and the majority had fished for between 4 and 40 years. The majority of those fishermen had a high school education.

The recent data that specifically describe the demographics of commercial river herring fishermen come from the North Carolina Division of Marine Fisheries Socioeconomic Program survey that is still underway. To date, only 8 river herring fishermen have been interviewed. Of those fishermen, the average age was 62 years with a range of 43 to 75 years old. They have been fishing for an average of 42 years with a range of 20 to 65 years. While acknowledging that this is an extremely small sample size at this point, it is interesting to note that river herring fishermen appear to be older as a group when compared to other groups of fishermen. Nearly all of the fishermen were white and all were male. Most of the fishermen had a high school diploma as their highest level of education and most of them were currently married. The average total household income for these fishermen was about $32,000 with a range of $10,000 to $75,000.

8.3.2 Recreational Fishermen

Demographic information for RCGL river herring fishermen was captured on the 2001 annual survey. Table 8.1 shows a summary of those statistics. The average RCGL fisherman who lands river herring is a little over 49 years old and has been fishing commercial gear for nearly 20 years. Over 88% were born in North Carolina and they had lived in North Carolina an average of nearly 43 years. The clear majority of RCGL river herring fishermen are currently married white males. Most have a high school diploma or some college as their highest level of education. The total average household income is between $30,000 and $75,000 dollars.

8.4 Research Recommendations

A socioeconomic impact analysis of the cumulative effects of reduced stock availability and harvest restrictions put in place over time needs to be conducted to assess the overall impact on fishermen who have traditionally relied on the fishery for economic opportunity.

A detailed and directed survey of all recreational harvest of river herring in coastal, joint, and inland waters needs to be conducted to determine not only harvest levels, but also the economic and social importance of the fishery.

Table 8.1. Demographic characteristics of RCGL fishermen who land river herring, North Carolina, 2001. (NC DMF RCGL Survey Program).

	Category Values	**Sample Size**	**Average/Percent***
Years Experience Fishing Commercial Gear		273	19.94
Born in NC		270	88.14%
Years Lived in NC		273	42.81
Age		273	49.68
	< 16 years	1	0.37%
	17 to 25	5	1.83%
	26 to 40	52	19.05%
	41 to 60	146	53.48%
	> 60 years	61	22.34%
Marital Status		269	
	Married	221	82.16%
	Divorced	21	7.81%
	Widowed	5	1.86%
	Separated	1	0.37%
	Never Married	13	4.83%
Ethnic Group		272	
	Hispanic/Latino	1	0.37%
	Caucasian/White	252	92.65%
	Asian-Pacific Islander	0	0.00%
	African-American/Black	0	0.00%
	Native America	9	3.31%
Gender		267	
	Male	251	94.01%
	Female	7	2.62%
Education		269	
	< High School	36	13.38%
	High School Diploma	88	32.71%
	Some College	92	34.20%
	College Diploma	44	16.36%
Total Household Income		266	
	< $5,000	0	0.00%
	$5,001 to $15,000	10	3.76%
	$15,001 to $30,000	35	13.16%
	$30,001 to $50,000	61	22.93%
	$50,001 to $75,000	64	24.06%
	$75,001 to $100,000	45	16.92%
	> $100,000	23	8.65%

* When categories do not add up to the total it is because of non-responders

8.5 Definitions

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

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

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

Actual or Inflated (Ex-vessel) Price and Value - The total landed dollar amount of a given species (or species landing condition and market category). Example: 100 lbs. of river herring at a PRICE of $.43 per pound will have a VALUE of $43. These values represent the amounts paid to a fisherman by a seafood dealer.

Recreational Fishing – A recreational fishing trip is any trip for the purpose of recreation from which none of the catch is sold or bartered. This includes trips with effort but no catch. Fishermen who wish to use limited amounts of commercial fishing gear in joint and coastal waters under North Carolina Division of Marine Fisheries jurisdiction are required to have a Recreational Commercial Gear License (RCGL).

9. CRITICAL, STRATEGIC AND ESSENTIAL FISH HABITATS

9.1. Introduction

Maintaining habitat quality for managed fish species is of so much concern to the U.S. Congress, that they mandated the appropriate federal management agencies to define habitats vital to fish, with a view towards facilitating their increased protection. The North Carolina General Assembly also recognizes the importance of habitat quality, as illustrated through the creation of the Clean Water Management Trust Fund and other actions. The North Carolina Environmental Management Commission (EMC) has designated various waters of the state as Outstanding Resource Waters (ORW); the MFC has designated approximately 162,000 acres of coastal waters and wetlands as Primary (PNA) and Secondary Nursery Areas (SNA) (August 2003 update); and Inland Primary Nursery Areas (IPNA) (about 30,000 acres) have been established by the WRC (2005 update). Among designations, MFC-designated PNAs have received the most protection from other management authorities.

9.2 State Critical Habitats and Strategic Habitat Areas

The MFC defines critical habitat as "The fragile estuarine and marine areas that support juvenile and adult populations of economically important seafood species, as well as forage species important in the food chain. Critical habitats include nursery areas, beds of submerged aquatic vegetation, shellfish producing areas, anadromous fish spawning and anadromous nursery areas, in all coastal fishing waters as determined through marine and estuarine survey sampling. Critical habitats are vital for portions, or the entire life cycle, including the early growth and development of important seafood species" (NCAC 3I .0101 (20) MFC 2005). Anadromous fish spawning areas are defined as, "those areas where evidence of spawning of anadromous fish has been documented by direct observation of spawning, capture of running ripe females, or capture of eggs or early larvae" (NCAC 3I.0101 (20) MFC 2005). Anadromous nursery areas are defined as, "those areas in the riverine and estuarine systems utilized by post-larval and late juvenile anadromous fish" (NCAC 3I.0101 (20) (D) MFC 2005).

Strategic Habitat Areas (SHAs) are defined in the North Carolina Coastal Habitat

Protection Plan (Street et al. 2005) as, "Specific locations of individual fish habitats or systems of fish habitats that have been identified to provide exceptional habitat functions or that are particularly at risk due to imminent threats, vulnerability, or rarity. These may include areas previously delineated by other state or federal agencies (AECs, HAPCs, ORWs, for example), or others as deemed necessary in an approved CHPP. Strategic Habitat Areas allow for site-specific management measures to be recommended." Strategic Habitat Areas may include critical habitat areas, but all critical habitat areas may not be SHAs. The term "Strategic Habitat Areas" is also used to avoid confusion with the term "Critical Habitat" used in the federal Endangered Species Act. No SHAs or Critical Habitats areas have been delineated by rule in North Carolina. However, there is currently a technical subcommittee of the Marine Fisheries Commission charged with developing more specific criteria for delineating SHAs. This subcommittee will be followed by a Department-level committee charged with developing protective measures applying to the delineated SHAs. These charges are part of the implementation plan for the newly adopted CHPP and are thus required by law. The designation of Critical Habitat is not required by law.

The location of river herring sampling data are interpolated and extrapolated to delineate anadromous fish spawning areas on Figure 5.1.1 – 5.1.3. These areas represent a subset of Critical Habitat as defined in MFC rule. However, it has yet to be determined whether all or part of these areas will become Strategic Habitat Areas with their, as yet undetermined, protections. The Strategic Habitat Areas subcommittee of the MFC (SHAC) is considering a general framework for designating Strategic Habitat Areas that incorporates fish nursery areas and anadromous fish spawning and nursery areas as defined in the MFC rulebook. However, the framework is not limited to these definitions and may actually refine and/or expand on the rulebook definitions. The CHPP implementation plan calls for significant progress on Strategic Habitat Area designation by summer 2006. At this time, the SHAC cannot endorse the designation of all anadromous fish spawning areas as Strategic Habitat Areas. This endorsement will depend on the framework that is ultimately developed.

9.3 Federal Essential Fish Habitat

Within the 1996 amendments to Magnuson-Stevens Fishery Conservation and Management Act (also known as the Sustainable Fisheries Act), Congress defined Essential Fish Habitat (EFH) for species managed by the NMFS and the federal Regional Fishery Management Councils as follows (USDOC 1996):

"The term "essential fish habitat" means those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." [16 U.S.C. 1802, Section 3, 104-297]

The U.S. Secretary of Commerce was instructed to:

"...within 6 months of the date of enactment of the Sustainable Fisheries Act, establish by regulation guidelines to assist the Councils in the description and identification of essential fish habitat in fishery management plans (including adverse impacts on such habitats) and in the consideration of actions to ensure the conservation and enhancement of such habitats." [16 U.S.C. 1855, Section 305, 104-297(b)(1)(A)]

Congress further mandated that the federal Fishery Management Councils**:**

"...shall comment on and make recommendations to the Secretary [of Commerce] and any Federal or State agency concerning any such activity that, in the view of the Council, is likely to substantially affect the habitat, including essential fish habitat, of an anadromous fishery resource under its authority." [16 U.S.C. 1855, Section 305, 104-297(b)(3)(B)]

The Atlantic States Marine Fisheries Commission has an interstate fisheries management plan for river herring (ASMFC 2004). This document describes Essential Fish Habitat for river herring in terms of habitats used for spawning, nursery, and as a migration corridor. These areas will be covered by delineation of anadromous fish spawning and nursery habitats, as a step in the SHA location process.

9.4 Habitat Protection Status

Habitats may receive various levels of protection as a result of 1) placement in some form of permanent private (conservation easement) or public (national fish hatchery, national wildlife refuge, national park, state gameland, state park) ownership; 2) receiving special designation which highlights their value and may require a higher level of scrutiny of any proposed uses (Primary Nursery Areas, Outstanding Resource Waters, Essential Fish Habitat); or 3) requiring a federal or state permit for certain types of development (CAMA permit in coastal counties, Clean Water Act Section 404 permit in wetlands, Clean Water Act Section 401 Water Quality Certification in all waters, Clean Water Act Section 402 NPDES permit for all wastewater discharges).

Some habitats which are in public ownership and completely protected from future development provide spawning and nursery habitats for river herring. These habitats include spawning and nursery areas located in federal national wildlife refuges and within the boundary of Edenton National Fish Hatchery. River herring are documented to use portions of Roanoke River National Wildlife Refuge, Alligator River National Wildlife Refuge, and Mattamuskeet National Wildlife Refuge. They likely use portions of the other coastal national wildlife refuges in North Carolina, as well. Habitats located within the boundaries of both national and state parks also should remain protected from future impacts. A national park likely to host river herring is Cape Hatteras National Seashore.

The Center for Geographic Information in North Carolinas has created a GIS coverage of protected lands in North Carolina. The coverage includes lands owned and managed by federal, state, county, and municipal governments, as well as conservation organizations, other nonprofit organizations and land trust properties. However, it does not include lands with restoration cost-share agreements in the State’s Wetland Reserve Program. Figures 5.1.1 – 5.1.3 shows these protected areas relative to Anadromous Fish Spawning Areas.

The WRC has designated IPNAs in coastal North Carolina which may serve as spawning and/or nursery habitats for river herring. These areas were established through extensive survey sampling conducted by personnel of DMF. These areas need to be maintained, as much as possible, in their natural state, and the populations within them must be permitted to develop in a normal manner with as little interference from man as possible. (NCAC T15A:10C.0501). The Inland Waters designated include: Broad Creek, Deep Creek and Lutz Creek- tributaries to North River; East Lake and Little Alligator River-tributaries to Alligator River; Martin Point Creek (Jean Guite Creek), Tull Creek and Tull Bay- tributaries to Currituck Sound (NCAC T15A:10C.0503); Duck Creek, Bath Creek, Mixon Creek, Porter Creek, Jordan Creek, right prong of South Creek, Strawhorn Creek, Muddy Creek, Bond Creek, Tooley Creek, Jacobs Creek, Jacks Creek – tributaries of the Tar-Pamlico; Slocum Creek, Hancock Creek – tributaries of the lower Neuse River; French Creek, Upper New River – New River estuary (Figures 5.1.1 – 5.1.3). In addition, the WRC has designated mainstem segments of the Roanoke, Tar, Neuse, and Cape Fear rivers as Inland Primary Nursery Areas.

Specific state critical habitat areas have been noted in various DMF anadromous fish project reports: Street et al. (1975), Johnson et al. (1977; 1981), Winslow et al. (1983;1984), Winslow (1989), and Winslow and Rawls (1992). However, the MFC has not yet designated specific sites for protection as critical habitats.

The degree to which remaining habitats not in public ownership or without special designations may be protected during federal or state permit review programs is totally dependent on the degree to which the regulatory agencies are willing to incorporate the recommendations of fishery management agencies, the commitment of permit applicants to effectively implement such recommendations, and the ability and will of management agencies to conduct follow-up studies and request regulatory agencies to enforce compliance when violations are documented.

Further protection for river herring spawning and nursery habitats may be achieved through establishment of programs which result in the restoration of function to habitats historically used by the species. One such program under development is the Edenton Bay Watershed Restoration Plan, a plan spearheaded by the North Carolina Office of the Environmental Defense Fund. Partners in the plan include Chowan County, the Town of Edenton, Albemarle RC & D Council, North Carolina Division of Soil and Water Conservation, North Carolina Division of Marine Fisheries, North Carolina State University, the University of North Carolina at Wilmington, and the U.S. Fish and Wildlife Service. The purpose of the plan is to initiate a multi-phase, multi-funded, integrated watershed restoration program focused on the restoration of water quality and watershed integrity necessary to restore the historic river herring fishery of Edenton Bay (Rader 1998). As of 2005, the program remains in the development stages.

9.5 Water Quality

The water quality of coastal rivers in North Carolina has been monitored for many years, but few studies have attempted to document the effects of water quality on river herring. Rulifson (1994) listed poor water quality, including chemical pollution, turbidity, and low dissolved oxygen as a concern in relation to the decline in river herring stocks. The few studies that have investigated this relationship have focused on the Chowan River basin. The Chowan River has experienced serious water quality problems which resulted in nuisance algal blooms and fish kills throughout the 1970s and early 1980s (Stanley 1992). During this time period, there were only three major industrial discharges within the basin: United Piece Dye Works (UPDW) textile plant at Arrowhead Beach, Farmer's Chemical fertilizer plant at Tunis, and Union Camp Corporation paper mill at Franklin, Virginia (DWQ 1997a). Otherwise, the basin had little urban development and was dominated by forest and agriculture, which combined to make up 89% of the land cover (McMahon and Lloyd 1995). The Chowan River-Dismal Swamp Basin in Virginia is mostly rural with approximately 64 percent of its land covered by forest (source: http://www.deq.state.va.us/wqa/ir2004.html, November 2005). Cropland and pasture make up another 28 percent, while only about 6 percent is classified as urban.

Due in part to nutrient inputs from these discharges, as well as non-point sources, the Chowan River was the first coastal river in North Carolina to experience major eutrophication problems. This situation ultimately led to the designation of the Chowan River as Nutrient Sensitive Waters by the EMC in 1979, providing a legal basis for limiting nutrient inputs into the system (DWQ 1997a). As a result of this designation, a number of multi-disciplinary studies and water quality management programs were initiated within the basin. Water quality management plans including the Chowan/Albemarle Action Plan (DEM 1982a) and the Chowan River Water Quality Management Plan (DEM 1982b) were implemented, targeting nutrient reductions. In 1982, the goals of the Chowan River Water Quality Management Plan included a 30 to 40% reduction in phosphorus and a 15 to 25% reduction in nitrogen (DWQ 1997a). The fertilizer plant at Tunis has since closed, although seepage from waste ponds still located on the property is of concern. Both the paper mill and textile mill have implemented technological and process changes to improve the quality of their discharges. All of the municipal wastewater treatment facilities located in the basin have converted to land application operations in order to reduce the input of nutrients directly into surface waters. In addition, to combat non-point source inputs, agricultural best management practices (BMPs) are now used to reduce nutrient, sediment, and pesticide runoff from many of the farms in the basin.

Nitrogen inputs into the Chowan River from point sources declined 92% between 1982 and 1997, with only one discharger, UPDW, still discharging a significant amount of nitrogen during that time. Most of the nitrogen from UPDW was tightly bound in the inorganic dyes in a form which is not biologically available. The DWQ renewed the UPDW discharge permit in 1998, continuing to allow a nitrogen discharge of 20 mg/l until 2003, at which time the nitrogen limit was lowered to 5.5 mg/l. As of 2005, UPDW is the only major permitted discharger in the North Carolina portion of the Albemarle watershed. However, there are numerous minor permitted discharges in the Albemarle watershed. Both types of dischargers are prevalent elsewhere in coastal North Carolina (Figures 9.1.1 – 9.1.3).

Between 50 and 75% of the nitrogen and 64-84% of the phosphorus flowing into the Chowan River in North Carolina comes from agricultural sources. In the lower river, an additional 30-37% of the nitrogen and 20-25% of the phosphorus comes from atmospheric deposition (DWQ 1997a). Estimates of nutrient sources and loads in Virginia, comprising 76% of the Chowan watershed, were unavailable at the time of this writing; and

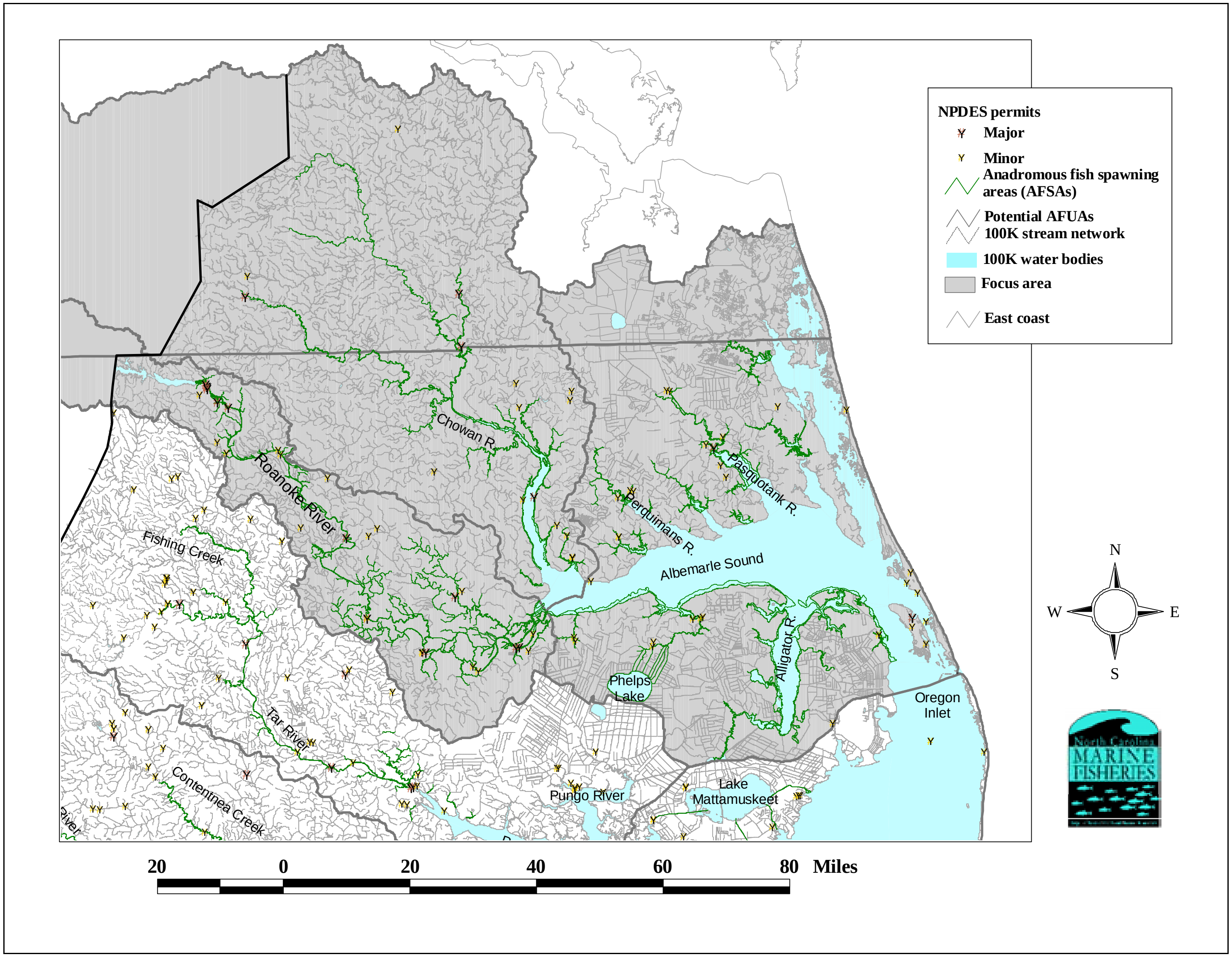


Figure 9.1.1. Location of NPDES permits in the northern coastal plain of North Carolina (DWQ data, 10/11/00).

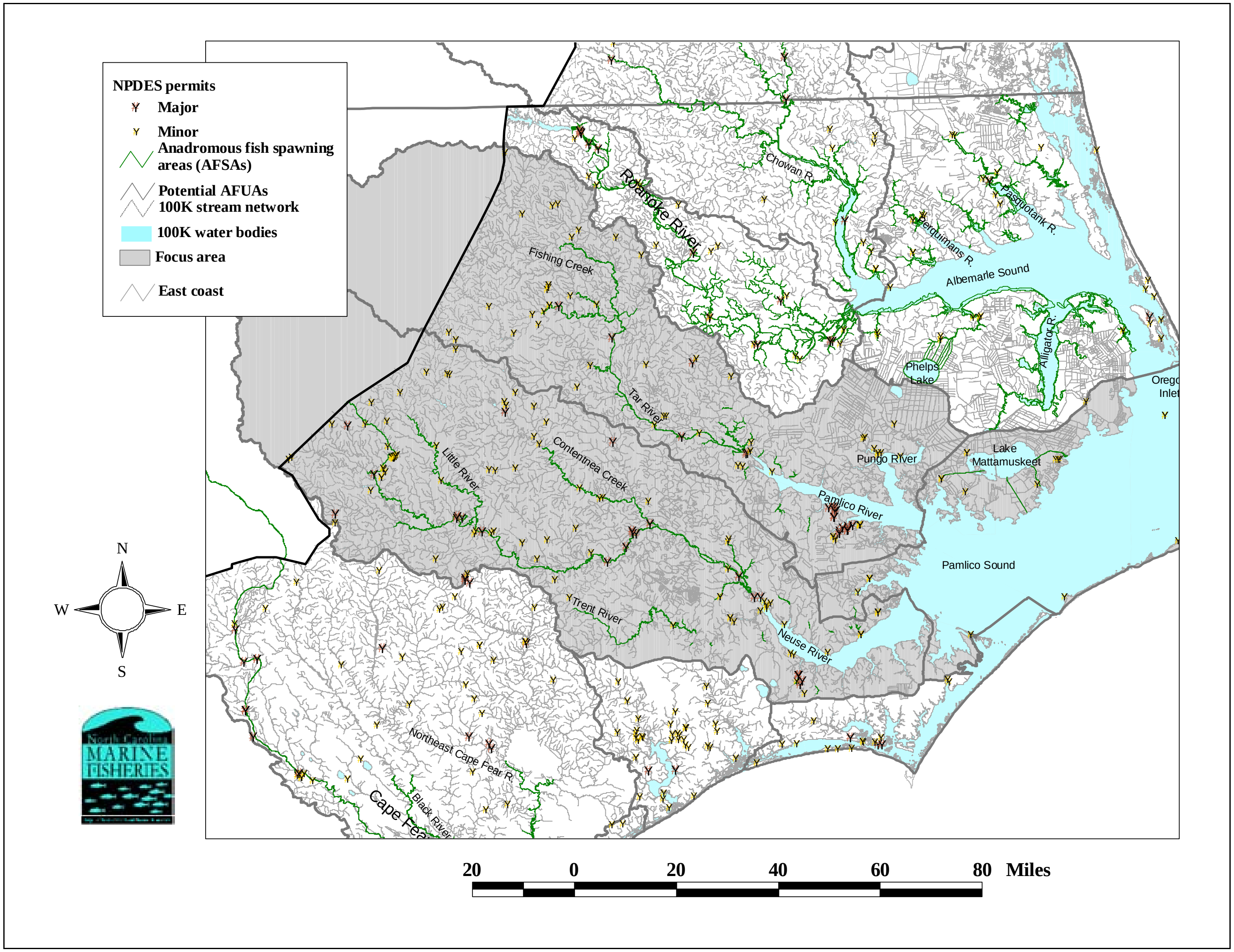


Figure 9.1.2. Location of NPDES permits in the central coastal plain of North Carolina (DWQ data, 10/11/00).

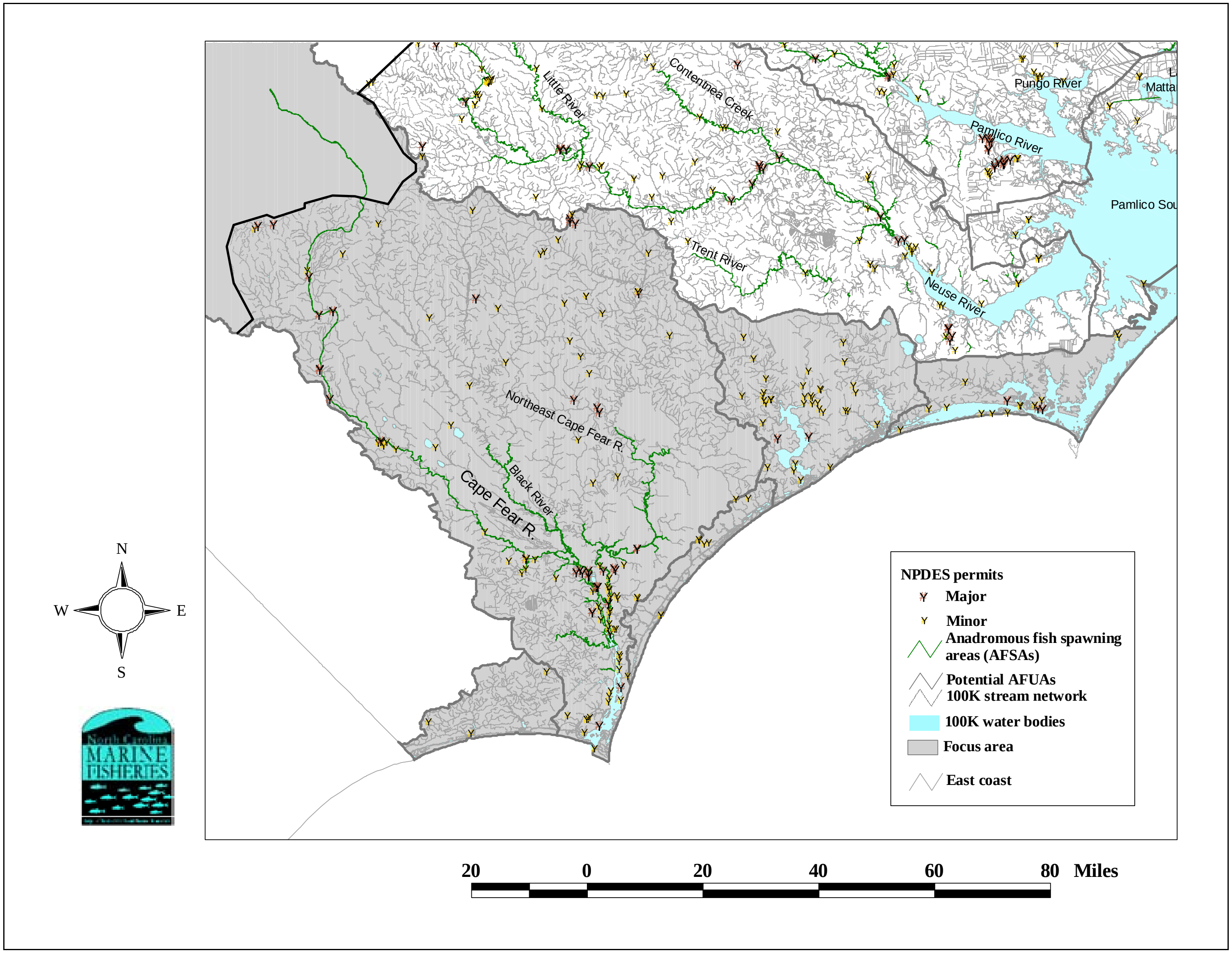


Figure 9.1.3. Location of NPDES permits in the southern coastal plain of North Carolina (DWQ data, 10/11/00).

use estimates for the Virginia portion of the Chowan watershed, indicate, however there is less agricultural land and more forested land than in the North Carolina portion (source: http://www.deq.state.va.us/wqa/ir2004.html, November 2005). There are also fewer NPDES discharges in the Virginia portion of the Chowan watershed (Source: http://gisweb.deq.virginia.gov/deqims/2004irgis.zip, November 2005).

Water quality assessment results for the Albemarle watershed are conducted annually by the North Carolina Division of Water Quality and Virginia Department of Environmental Quality. They use a variety of data, including ambient water quality monitoring data collected monthly and biological community data. These data are used to determine if the monitored water bodies are supporting their basic uses – the most basic being aquatic life. Based on 2001-2002 assessment results for North Carolina, there is only one stream rated as not fully supporting based on low biological integrity of the fish community (Figure 9.2.1 – 9.2.3). However, at that time there were also numerous unrated streams in the North Carolina portion of the Albemarle watershed. More recently, the DWQ has rated many more streams in the Albemarle watershed (Eric Fleek/DWQ, pers. comm., 2005). For Virginia, assessment results for 2004 indicate 4 stream segments with impaired support for aquatic life (Figure 9.2.1). The primary reason for classification as impaired was low dissolved oxygen. Use-support rating for areas outside the Chowan and Roanoke in North Carolina are based on 1999 assessment results.

A concern which has materialized in the last decade is the role and impact of atmospheric nitrogen deposition in coastal estuaries in general and North Carolina in particular (Paerl 1995, Paerl et al. 1999). Increases in deposition of atmospheric nitrogen to sensitive estuarine and coastal waters appears to have contributed to accelerating algal production (eutrophication) and water quality declines (hypoxia, toxicity, and fish kills) (Paerl et al. 1999). Although atmospheric nitrogen is derived from a variety of sources, including urbanization as well as agricultural and industrial growth, recent increases in the North Carolina Coastal Plain are a direct result of the substantial increase in livestock

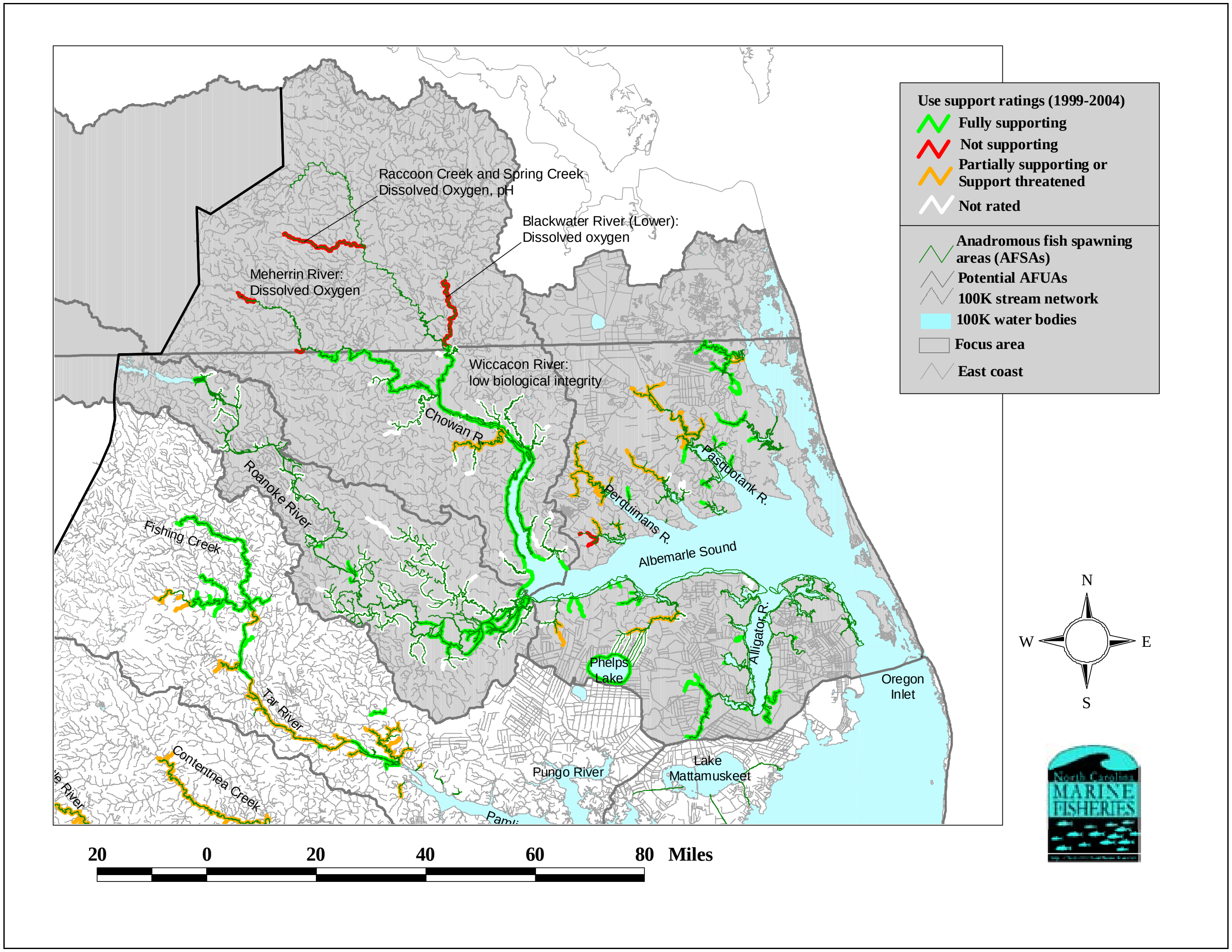


Figure 9.2.1. Use-support ratings for waters of the northern coastal plain, North Carolina. The data for Chowan and Roanoke river basins is from 2001-2002 assessment results. The Use-support data for Virginia is current for 2004, and data elsewhere was published in 1999.

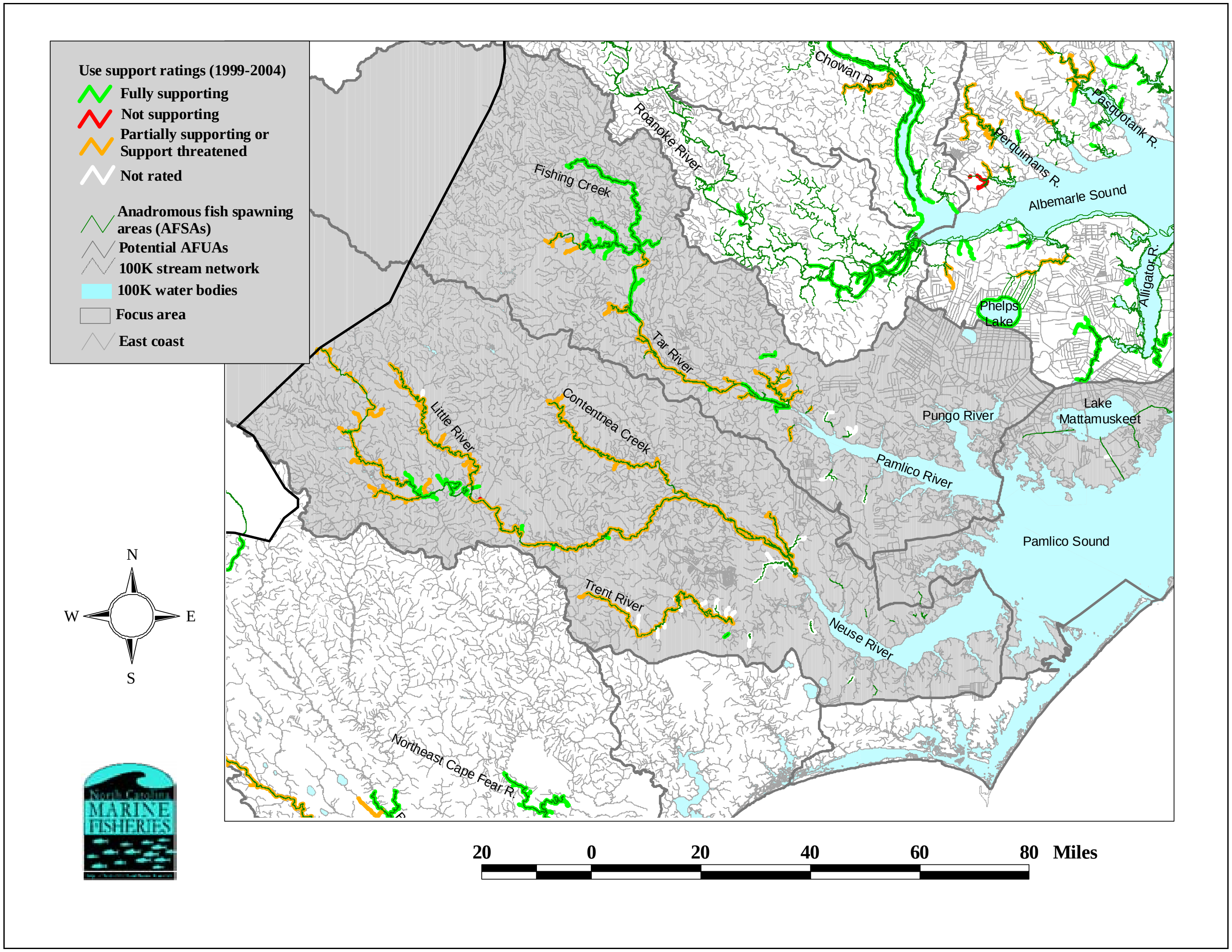


Figure 9.2.2. Use-support ratings for waters of the central coastal plain, North Carolina. The data for Chowan and Roanoke river basins is from 2001-2002 assessment results. The Use-support data for Virginia is current for 2004, and data elsewhere was published in 1999.

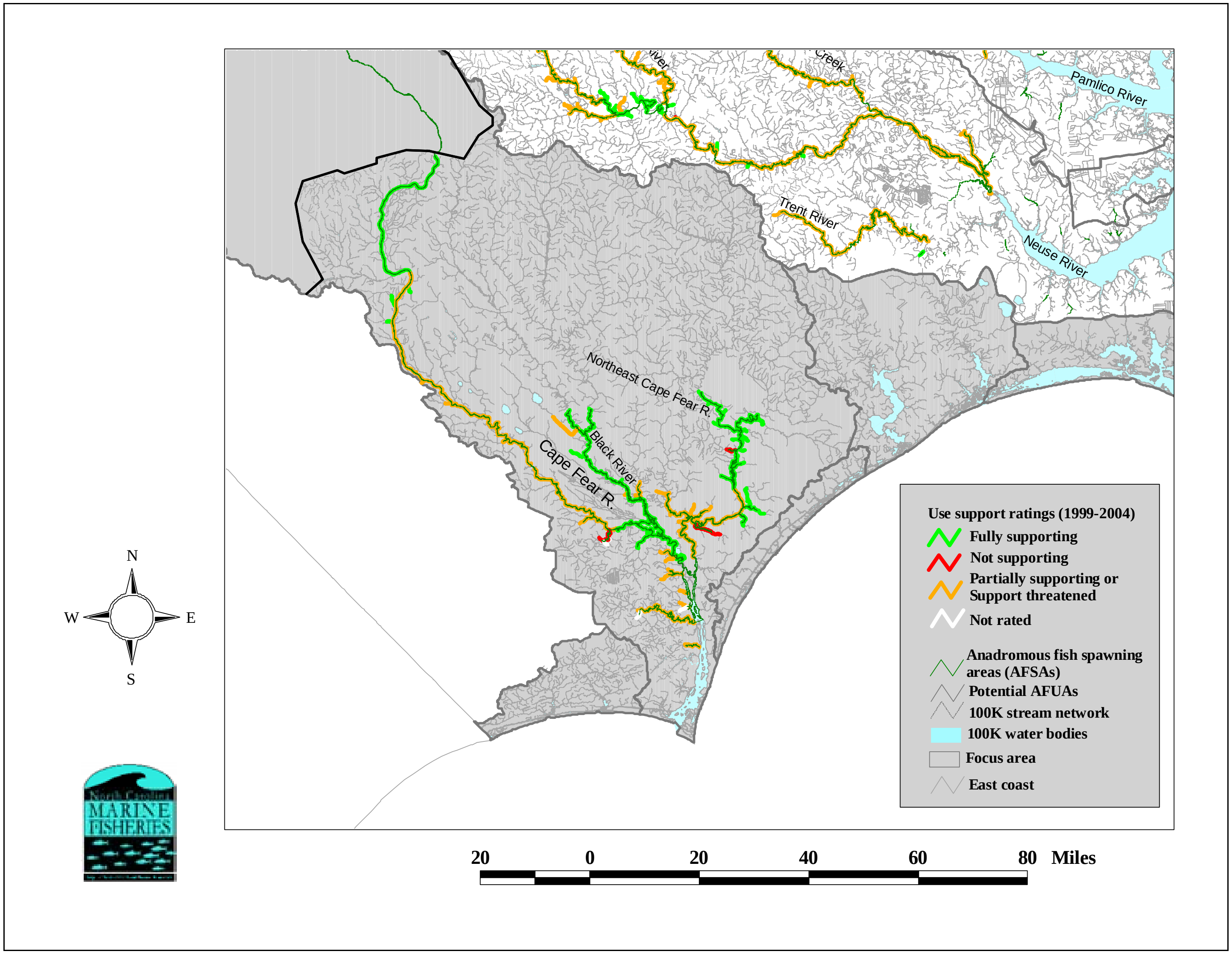


Figure 9.2.3. Use-support ratings for waters of the southern coastal plain, North Carolina. The data for Chowan and Roanoke river basins is from 2001-2002 assessment results. The Use-support data for Virginia is current for 2004, and data elsewhere was published in 1999.

operations and their associated nitrogen-rich (ammonia) wastes. However, more recent data indicated a slight decline in hog farms in nearly every coastal area of North Carolina examined from 2003-2004 (source: http://www.ncagr.com/stats/cnty_est/ctyhogyr.htm, November 2005). Both the increase in, and changes in proportions of, nitrogen sources play roles in the structuring of estuarine and coastal algal communities, and may promote major biotic changes, including the proliferation of nuisance blooms (Paerl et al. 1999).

Nuisance algal blooms in the Chowan River peaked during 1981-1983, with eight blooms documented through the DWQ ambient monitoring program. In the 15 years since that time, there have been seven blooms recorded, only one since 1994. Blooms documented from citizen complaints track closely with the ambient blooms in the early-to-mid 1980s, then raised dramatically due to citizen interest and education. Chlorophyll *a* values showed a decline since the 1980s with only seven instances where chlorophyll *a* exceeded 20 μg/l (half the state standard) from 1991 to 1995 (DWQ 1997a). In the Chowan and Pasquotank river basins combined from 1995-2000, there were 10 chlorophyll *a* samples that exceeded the standard within 7 of the 26 subbasins sampled (DWQ 2001 – Chowan and Pasquotank river basinwide report).

The National Oceanic and Atmospheric Administration (NOAA) conducted sediment sampling in North Carolina estuarine waters from 1994 through 1997 as part of their Estuarine Monitoring and Assessment Protocol (EMAP) (Balthius et al. 1998; Hackney et al. 1998; Hyland et al. 1996; Hyland et al. 1998). Of the 39 sites sampled by EMAP north of Oregon Inlet, 12 had more than two contaminants above a level where biological degradation occurs 10% of the time (Hackney et al. 1998). Nickel, chromium and DDT were the most frequent contaminants, although lead and mercury contamination in the Albemarle region accounted for 100% of the ER-L (effective range – low) exceeding among all North Carolina sites (Hackney et al. 1998). While there was no geographical clustering of these sites, the sediments at all 12 sites containing multiple (3 or more) elevated contaminants were very muddy (silt/clay fraction >90%). All sites with less silt had lower chemical levels. Repeatability of contaminant levels was moderate; only 12 of 23 chemicals found to be elevated during one year, were elevated when sampled in another year. It was also noted that in the Albemarle Sound, sediment contamination levels were likely mobilized and dispersed by hurricane associated flooding and wind throughout the estuary, thus contaminating large areas rather than getting transported out of Albemarle Sound (Hackney et al. 1998). The implications of this information for river herring are unknown.

A study by USGS found the concentration of herbicides in the Albemarle-Pamlico system highest from late May to early June, decreasing gradually until September (Source: http://nc.water.usgs.gov/albe/pubs/ALBEetroabs.htm) - which is during the later half of the spawning period for river herring. This situation could result in fresh herbicides being washed into the tributary creeks where sensitive river herring eggs and larvae are beginning their downstream migration. However, the negative consequences of this scenario could be mitigated by the elevated flow conditions needed for the herbicides and the herring to enter the system.

In 1990, DEHNR issued a consumption advisory for Chowan River fish due to elevated levels of dioxin in fish tissue. As a result of improved discharges, dioxin levels in fish in the Chowan River have dropped to the point that the fish consumption advisory was lifted in 1998 for all fish but carp and catfish. The fish consumption advisory for carp and catfish is still in effect for western Albemarle Sound and eastern portions of the Roanoke River (Source: http://www.epi.state.nc.us/epi/fish/current.html, November 2005).

Dissolved oxygen (DO) levels drop below the 4 mg/l state standard (swamp water standard) for significant periods of time in the lower Roanoke River and Albemarle Sound (Manooch and Rulifson 1989; Mulligan 1991; DEM 1992; Mulligan et al. 1993; Bales et al. 1993; Fromm and Lebo 1997; Lebo 1998). This level of dissolved oxygen is tolerated by adult river herring, but is lower than the requirement for eggs and larvae (Funderburk et al. 1991). Hypoxic events occur most frequently in late spring, summer, and early fall (Mulligan 1991) and are most frequent in the portion of the river near Plymouth, in Cashie River downstream of Sans Souci, and in western Albemarle Sound. Reviews state that the biological oxygen demand (BOD) assimilative capacity in the lower Roanoke River (Jamesville to the Sound) has been exhausted (Briggs 1991; Mulligan 1991; Mulligan et al. 1993). Continuous DO monitoring data are available from United States Geological

Survey (USGS) stations; those stations at Plymouth and Jamesville recently documented low DO events, as reported in the earlier studies referenced above. The USGS data at Plymouth indicate 21 consecutive days when daily average DO was below 5 mg/l (range between 1.0 and 4.9 mg/l) in late August and early September 1998. Ambient water quality monitoring by DWQ on a monthly basis has not recorded the low DO levels, as indicated through the USGS continuous monitoring stations. Such infrequent sampling rarely measures acute events, such as low DO. The USGS continuous monitoring stations at Plymouth is currently not operational (Source: http://nc.water.usgs.gov/, November 2005). However, there are stations upstream and downstream of Plymouth that measure dissolved oxygen.

Concentrations of DO in the Roanoke River between Roanoke Rapids and Hamilton were higher, predominantly above the 5 mg/l standard. Concentrations are generally highest near the dam and decline downstream. Low flow water quality modeling (DEM 1996) and ambient data collection efforts document DO sags downstream of Weldon and downstream of Scotland Neck. Variations in DO concentrations through the lower river have been attributed to a combination of reservoir operations, swamp water drainage, and over 30 permitted dischargers (totaling approximately 100 million gallons per day) of oxygen consuming municipal and industrial wastes (Rulifson et al. 1990; Mulligan et al. 1993; Fromm and Lebo 1997; Lebo 1998).

Despite the improvements in water quality indicators, degraded water quality has been suggested repeatedly as a cause of the decline in the Chowan River herring fishery by fishermen as well as in the scientific literature (Winslow 1989; Stanley 1992; Rulifson 1994). As a result, several studies to evaluate the impact of water quality on various life stages of river herring have been completed. Most of those studies were carried out prior to recent water quality improvements.

Two of the studies investigated the impact of pulp mill effluent on river herring. The Union Camp Corporation pulp mill stores its waste in settling ponds for much of the year, and in late fall to early winter, the waste is released into the Chowan River through a discharge canal located just north of the North Carolina-Virginia border. It had been hypothesized that this discharge caused river herring to alter their migratory route, and possibly avoid the Chowan River entirely. Kearson (1971) conducted a study to evaluate the impacts of the effluent on game fish, as designated by the WRC. Over a three-year period, 43,593 fishes were captured representing 15 game and 15 nongame species. A total of 8,436 fishes was tagged. Based on these collections and tag returns, it was determined that a mass avoidance of the pulp mill waste by game fish did not occur. Furthermore, the study indicated that concentrations of the effluent were not high enough to discourage river herring spawning.

Everett (1983) further assessed the impact of pulp mill effluent by comparing weekly river herring catches of three commercial fishermen within the Chowan River to weekly river concentrations of pulp mill effluent during the 1979-1982 seasons. During high flow years (1979, 1980, and 1982), the effluent made up a very low percentage (<5%) of river flow and did not appear to result in herring avoidance. However, during 1981, a low flow year, pulp mill waste comprised a large percentage (26%) of the flow, and based on catches, river herring did avoid the effluent. Everett (1983) further determined, based on historical flow data, that avoidance of pulp mill waste by river herring could not account for their decline. However, it was recommended that the effect of pulp mill waste on the food chain, in particular algal assemblages, and the subsequent impact on river herring be investigated.

Based on literature searching conducted at http://www.scirus.com/srsapp/ (November 2005) there was one published study examining the effects of pulp mill effluent on the food chain (Culp et al. 2003). The study was conducted in a mesocosm, using sulfite pulp mill effluent. Culp et al. (2003) compared toxic concentrations with algal biomass, taxonomic composition, benthic invertebrate abundance and composition, and insect emergence. In summary, they found that low concentrations of effluent (5% v/v) increased periphyton biomass and caused changes in community structure within the diatom-dominated community. The study results suggested that effluent has little effect on the abundance of benthic invertebrates, but significantly changes species composition. However, the main impact of pulp mill effluent was nutrient enrichment rather than harmful toxic contamination.

To evaluate the impacts of water quality on river herring larvae, O'Rear (1983) conducted larval sampling in conjunction with water quality monitoring during the early 1980s at stations throughout the basin. In addition, larvae were collected, returned to the laboratory, and observed for several days. This study suggested that water quality within the basin did not have a direct effect on river herring larvae, but it did recommend further study of the larval food chain. Unfortunately, there have not been any zooplankton food studies in anadromous fish nursery areas of the Albemarle Sound since the early to mid-1980s (Sara Winslow/DMF, personal communication 2005).

In 1982 and 1983, the zooplankton populations and the diet of juvenile blueback herring were studied in the Chowan River (Winslow et al. 1984). The study indicated that for a very productive system, zooplankton densities were low compared to James River, Virginia (the only comparable data available), suggesting that the forage base for juvenile river herring was poor. Therefore, it was hypothesized that juvenile blueback herring were selecting alternative less suitable prey within the Chowan River resulting in poorer growth compared to herring populations in other river systems. However, the study was unable to link reduced densities of zooplankton to the excessive algal blooms and poor water quality. Zooplankton populations were limited in part by the flushing effects of high flows. In addition, a shift in the zooplankton community to strong-swimming copepods and small-bodied nauplii and rotifers suggested that filter-feeding predators, such as juvenile blueback herring, were controlling the zooplankton populations in the Chowan River (Winslow et al. 1984).

In 1996 and 1997, the effects of water quality on the hatching success of blueback herring eggs were investigated within the Chowan River and several of its tributaries (Waters and Hightower 1997). This study used 11 sites from the mouth of the river to its headwaters, including mainstem river sites and smaller streams. Factors such as temperature, pH, dissolved oxygen, nutrients, and contaminants (PCBs and pesticides) were considered. The results indicated that hatching success differed significantly among sites, but was generally good (exceeding 50%) within the basin. Excluding the Dillards Creek data, the hatching success was 75% or greater. Dissolved oxygen was the only water quality parameter with values outside the reported range for normal development of blueback herring eggs. Based on correlation and regression analyses, dissolved oxygen appeared to be the primary factor related to differences in hatch rate among sites. The lowest dissolved oxygen values and lowest hatch success occurred in a few small tributaries (Dillard, Deep Swamp, and Catherine creeks). The proportion of total spawning and nursery habitat with low dissolved oxygen throughout coastal North Carolina is currently unknown. Depending on the actual portions involved, the severity of water quality impacts on successful spawning of river herring could be significant. Also, water quality in the myriad of tributary creeks could be significantly different than mainstem rivers. With river herring at such low population levels, improving and/or protecting water quality and associated hatching success in every creek could benefit toward stock recovery.

Although some work has been aimed at determining the relationship between water quality conditions and river herring abundance for the Chowan River, the impacts of water quality on river herring reproduction in other coastal river systems have not even been investigated. However, the North Carolina Division of Water Quality (DWQ) has identified water quality concerns for each coastal river in a series of basinwide water quality management plans (DWQ 1994, 1996a, 1996b, 1997a, 1997b, 1997c, 1998a, 1998b, 2001, 2005). For all river systems, these concerns include oxygen-consuming wastes, nutrient levels, toxic substances (heavy metals, chlorine, ammonia, etc.), pH, sedimentation, urban stormwater runoff, and fecal coliform bacteria levels. In addition, the plans identify concerns specific to each basin. For example, development along the North Carolina coast, particularly in the Albemarle Sound region, and the subsequent environmental impacts should be addressed. On the Roanoke and Tar rivers, the impact of reservoirs used for power generation and flood control needs to be evaluated. In these systems, downstream flows are highly regulated, and their management can affect both water quality and habitat.

The Roanoke River Water Flow Committee (RRWFC) was established in 1988 specifically to address the issue of flows on the lower Roanoke River (DMF 2004). As a result, operation of the dam on Roanoke River has changed to meet the flow requirements of striped bass during their spawning period from April to June (DMF 2004). However, the consistent application of flows targeting striped bass spawning may not be as beneficial to river herring spawning in the Roanoke system considering their differing spawning habitats (striped bass – mainstem, river herring – tributaries).

The impacts from large-scale livestock operations on water quality in downstream tributaries needs to be evaluated in the southern coastal region where hog farms are growing (source: http://www.ncagr.com/stats/cnty_est/ctyhogyr.htm, November 2005). While these problems have been identified and must be addressed, their extent and impacts in relation to river herring spawning and nursery habitat within each basin have yet to be determined.

9.6 Other Habitat Concerns

The degradation and loss of critical freshwater spawning and nursery habitats are believed to have contributed to the decline in river herring stocks along the east coast of the United States, including North Carolina (Rulifson 1994). Rulifson (1994) indicated that within North Carolina, physical impacts such as channelization, dredge and fill activities, dams, industrial water intakes, industrial waste discharges, and road construction all had the potential to impact river herring reproduction. The extent of these impacts varies among river systems, and their link to river herring adult populations has not been fully investigated.

In North Carolina, anadromous fish spawning areas have been delineated for most river systems (Figure 5.1.1 – 5.1.3). From the late 1960s to the early 1980s, several surveys were initiated for this purpose, including Baker (1968), Sholar (1975), Fischer (1980), Hawkins (1980a, 1980b), and Winslow et al. (1983). These studies demonstrated that river herring use a wide range of habitat types for spawning, such as small, densely vegetated streams; fresh and brackish marshes; hardwood swamps; and flooded low-lying areas adjacent to both mainstem rivers and tributaries. Baker (1968) indicated that herring used nearly all accessible rivers and streams in eastern North Carolina. However, much of these data are now dated, and the current status of spawning and nursery habitat is unknown for most areas. Furthermore, the overall quality of this habitat in general has never been well-documented, and the impacts of habitat degradation as a whole cannot be measured. Nevertheless, because spawning and nursery areas are so diverse and widespread, any activities that alter aquatic habitat in eastern North Carolina have the potential to adversely impact river herring in some manner.

Dredging, draining, and filling activities have altered or destroyed habitat used by river herring during various life stages. In eastern North Carolina, these activities are most often associated with agriculture, residential development, and commercial forestry (Stanley 1992). A variety of studies have estimated losses to wetlands. Although these estimates include losses of wetland areas that are isolated and not accessible to river herring, they do indicate the overall magnitude of habitat loss, which is thought to be significant in some areas. Hefner et al. (1994) reported that in North Carolina, the net loss of wetlands from the mid-1970s to the mid-1980s was 1.2 million acres (485,640 ha), the highest net loss among states in the southeastern United States. A majority of these losses were swamps and bottom land hardwood forests. In the North Carolina portion of the Chowan River basin, Craig and Kuenzler (1983) documented a 30% reduction in oak-gum-cypress forested wetlands from 1964 to 1974. Over that same period, it was also noted that 31% of the total land within the North Carolina portion of the basin had been artificially drained for agriculture (Craig and Kuenzler 1983). Based on the wetlands tracking database maintained by the Wetlands/401 Unit of the Water Quality Section, DWQ, a total of 37 projects encompassing 44 acres (18 ha) of permitted wetland losses occurred in the Chowan River basin in 1996 and 1997 (DWQ 1998a) (Table 9.1). Many of these projects occurred in the lower Chowan River basin and impacted bottomland hardwood forests, brackish marshes, headwater forests, swamp forests, and wet flats (Table 9.2).

Currently, only small areas of wetland (mostly non-riparian) can be filled without a permit and required mitigation. Land developers must also leave a fifty foot buffer (including some natural vegetation) along the Nutrient Sensitive Waters of the Chowan river basin (with numerous exemptions). Even forestry operations cannot alter riparian wetlands without a 404 permit from the USCOE or 401 water quality certification from the Division of Water Quality. However, the conversion of non-riparian wetland to residential communities in many areas undoubtedly has an impact on the hydrology and water quality of adjacent riparian wetlands. Another loss of riparian wetlands can occur during the

Table 9.1. Summary of the total Section 401 permitted impacts in the Chowan River Basin recorded by the Wetlands/401 Unit of the Water Quality Section, Division of Water Quality for 1996 and 1997 (DWQ 1998).

Year	Total permitted wetland impacts (acres)	Required mitigation
1996	22.42	
1997	21.60	
2000	8.35	13.43
2001	1.74	0.00
2002	1.63	0.96
2003	0.80	0.00
2004	0.15	0.00

Table 9.2. Fill activities by wetland type in the Chowan River and Pasquotank River basins (Albemarle Sound and its tributaries excluding the Chowan and Roanoke rivers) from 1994 to 1996.

Wetland type	Acres of wetlands permitted to be filled in the Chowan River basin (DWQ1997a)	Acres of wetlands permitted to be filled in the Pasquotank River basin (DWQ1997b)
Bottom land hardwood forest	5.54	5.81
Salt marsh	0.00	16.51
Wet flat	11.91	39.36
Pocosin	0.00	0.37
Other	30.74	68.95
Total	**48.19**	**131.43**

construction of bulkheads - which are constructed more in river herring nursery areas than spawning areas, where there is little or no erosion.

Stream channelization, most often associated with flood control projects, has also resulted in the loss of essential habitat. To evaluate this issue, Frankensteen (1976) compared a channelized creek (Grindle Creek) to a natural creek (Chicod Creek) within the Tar River basin. This work determined that high water velocities occurring in channelized sections of the stream prevented the entrance of both adult and juvenile herring into these areas. Channelization also removed in-creek vegetation and woody debris which served as a substrate for fertilized eggs. In addition, this loss of vegetation and debris reduced habitat for invertebrates resulting in a reduction in the diversity and quantity of prey for juvenile river herring. Disposal of spoil along the shoreline created spoil banks which prevented access for both adults and juveniles to sloughs, pools, adjacent vegetated areas, and backwater swamps. Problems associated with channelization have also been observed in other systems. Sholar (1975) stated that a channelized section of the New River did not provide suitable spawning habitat, contributing to reduced recruitment within the system. Hawkins (1980b) also noted that channelization had reduced habitat in Swift, Little Swift, and Bear creeks within the Neuse River basin. In the Albemarle Sound area, channelization projects have taken place on numerous tributaries, including the Cashie River, Ahoskie Creek, Joyce Creek, Pollock Swamp, Bear Swamp, and Burnt Mill Creek. The channelization projects are presented in Table 9.3, by county and miles affected. In the Albemarle Sound area, 281.1 miles of streams have been channelized. Some of these streams have since re-naturalized and the river herring have returned (Sara Winslow/DMF, personal communication 2005). However, these re-naturalized streams are being considered for re-channelization by the Division of Soil and Water (DSW). One such proposal involves the re-channelization of Ahoskie Creek, which was recommended for denial by the Division of Marine Fisheries (September 20, 2005). Granting the permit to re-channelization would effectively condone degradation of anadromous fish spawning habitat by the state of North Carolina.

Table 9.3. Channelization projects in the Albemarle Sound area, by system, county and miles affected.

Project name	Counties	Miles affected
Ahoskie Creek	Bertie, Hertford, Northampton	65.7
Cutawhiskie Creek	Hertford, Northampton	53.9
Pollock Swamp	Chowan	25.0
Horse/Flat Swamp	Hertford	26.1
Hobbsville/Sunbury	Chowan, Gates, Perquimans	60.0
Gum Neck	Tyrrell	16.9
Folley Ditch	Gates	7.4
Burnt Mill Creek	Chowan, Perquimans	9.0
Bear Swamp	Perquimans, Chowan	17.1
Total		**281.1**

Stream blockages such as dams, including beaver dams, culverts, and natural obstructions have likely eliminated or reduced access to large areas of both spawning and nursery habitat. Dams are the most common blockage, and one dam alone often denies access to large areas. For example, the Roanoke Rapids Dam located on the Roanoke River denies access to over 218 miles (350 km) of river (Collier and Odom 1989) (Figure 9.3.1 – 9.3.3). In the Chowan watershed, there is one hydropower dam on the Meherrin River in Virginia, and one on the Nottaway River (Baskerville Mill dam), also in Virginia. In addition to dams found on mainstem rivers, numerous smaller mill dams are found on creeks throughout eastern North Carolina. For example, Collier and Odom (1989) reported three such dams within the Chowan River basin on Bennetts, Indian, and Rockyhock creeks (Figure 9.3.1). The dams on mainstem and tributary portions of the Chowan drainage basin form the upstream boundaries of some documented anadromous fish spawning habitat in North Carolina and Virginia. Removing or bypassing these dams would open access to many miles of potential spawning habitat. Current plans for fish passage in the Chowan watershed include only the Bennett's Creek dam creating Merchant's Mill Pond (Mike Wicker/USFWS, pers. comm., 2005). The effectiveness of dam removal/bypassing in river herring recovery will depend on whether the runs have been extirpated from the entire stream reach impounded. In areas where the run has been extirpated for reasons other than water quality or quantity (i.e., impediments or overfishing), restocking and protection may be required to accelerate the long recovery process.

In the Neuse River basin, Quaker Neck Dam on the mainstem Neuse River has recently been removed, opening 78 miles (125 km) of mainstem habitat and another 925 miles (1,488 km) of habitat along tributaries (Mike Wicker, US Fish and Wildlife Service, personal communication). Also, the Cherry Hospital Dam located on the Little River, a tributary of the Neuse, has been removed, allowing access to another 76 miles (122 km) of habitat (Mike Wicker, US Fish and Wildlife Service, personal communication). On the Little River upstream from Cherry Hospital, there are also some more recent dam removals (Rains dam and Lowell dam; Mike Wicker, US Fish and Wildlife Service, pers. comm. 2005). On the Cape Fear River, three lock and dams prevent upstream fish migration except during boat and fish lockages and periods of high water (Robin Hall, USCOE,

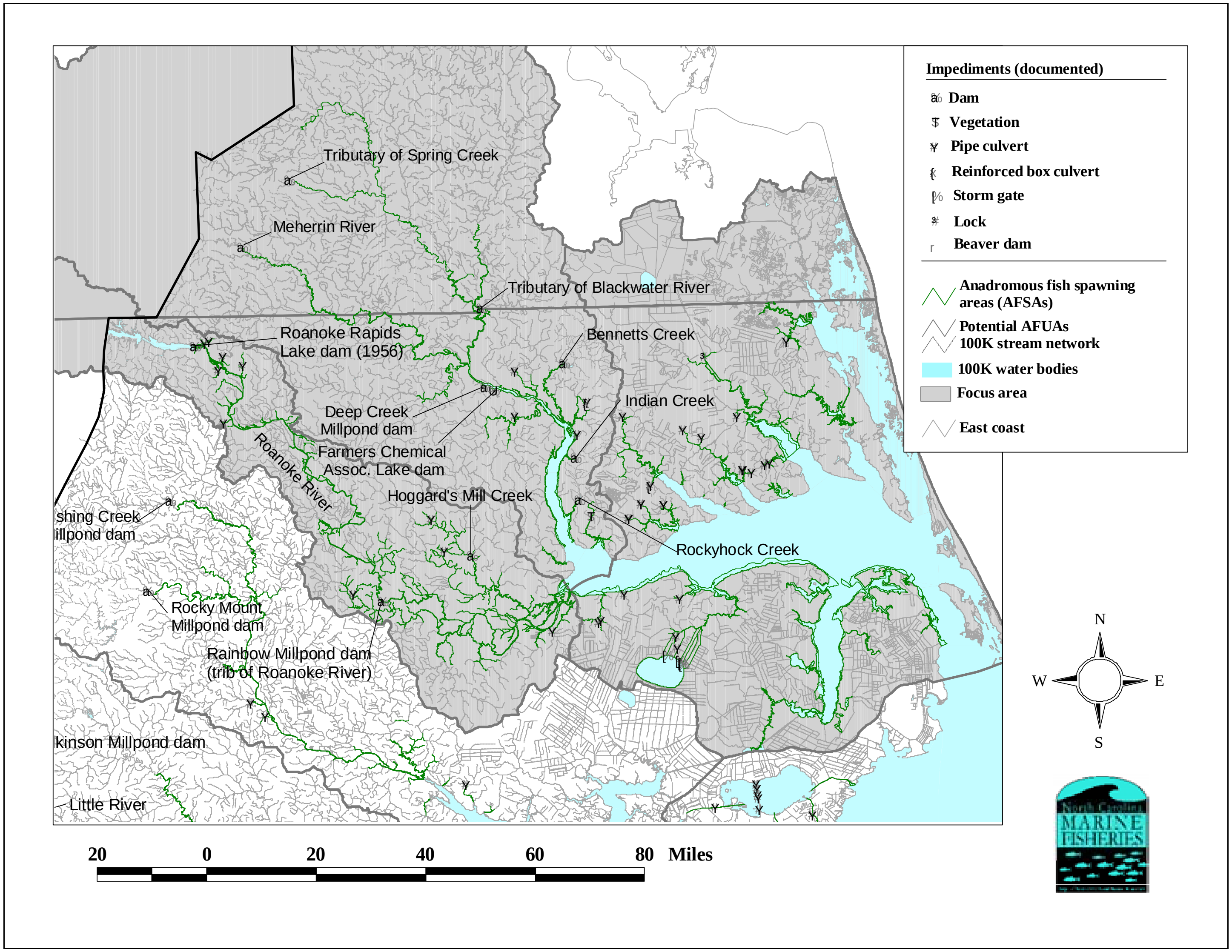


Figure 9.3.1. Documented location of dams, culverts, and other impediments on stream in the northern coastal plain of North Carolina. Sources: VDGIF data (1983), Collier and Odum (1989), Moser and Terra (1999), NCDWR data (2003), and NCDOT data (2004).

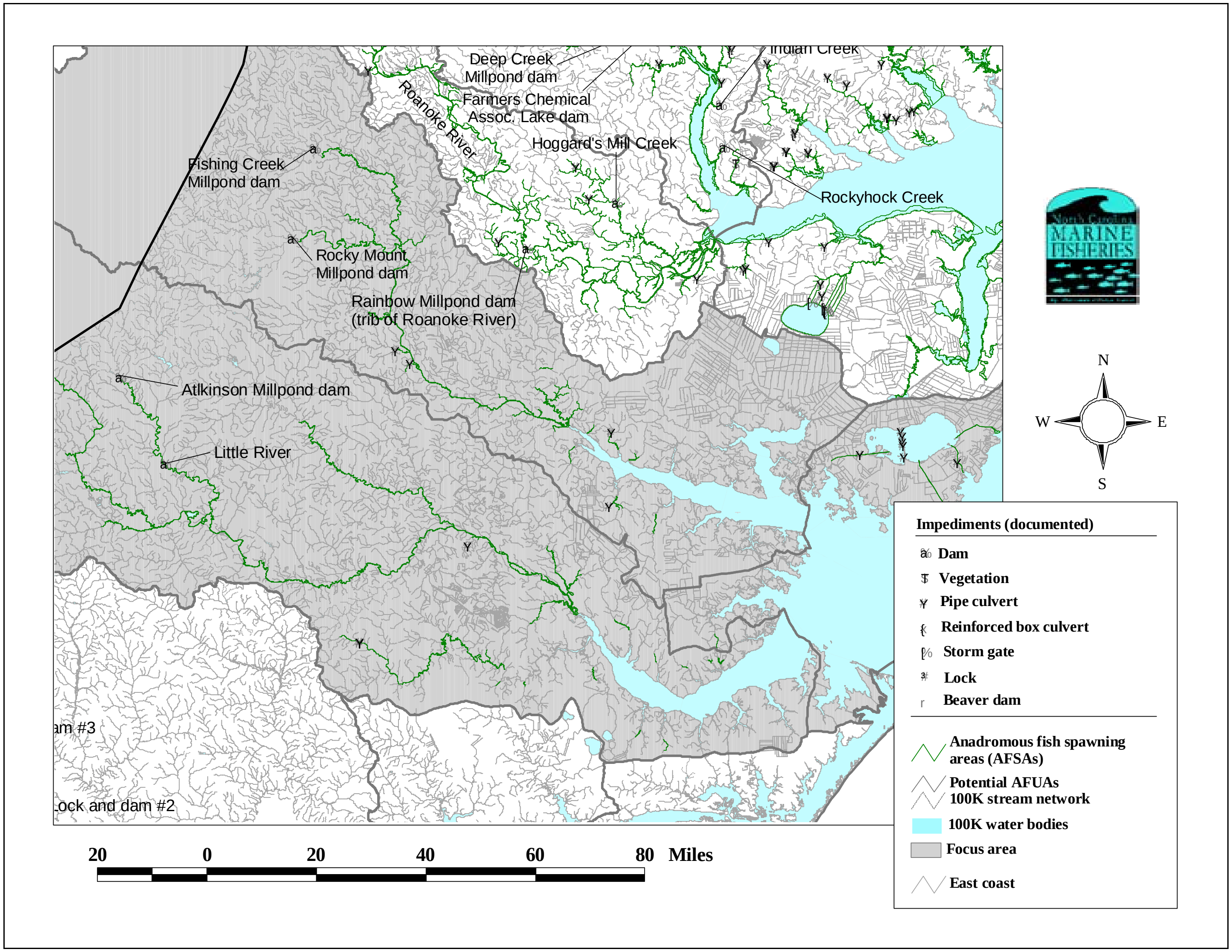


Figure 9.3.2. Documented location of dams, culverts, and other impediments on stream in the central coastal plain of North Carolina. Sources: VDGIF data (1983), Collier and Odum (1989), Moser and Terra (1999), NCDWR data (2003), and NCDOT data (2004).

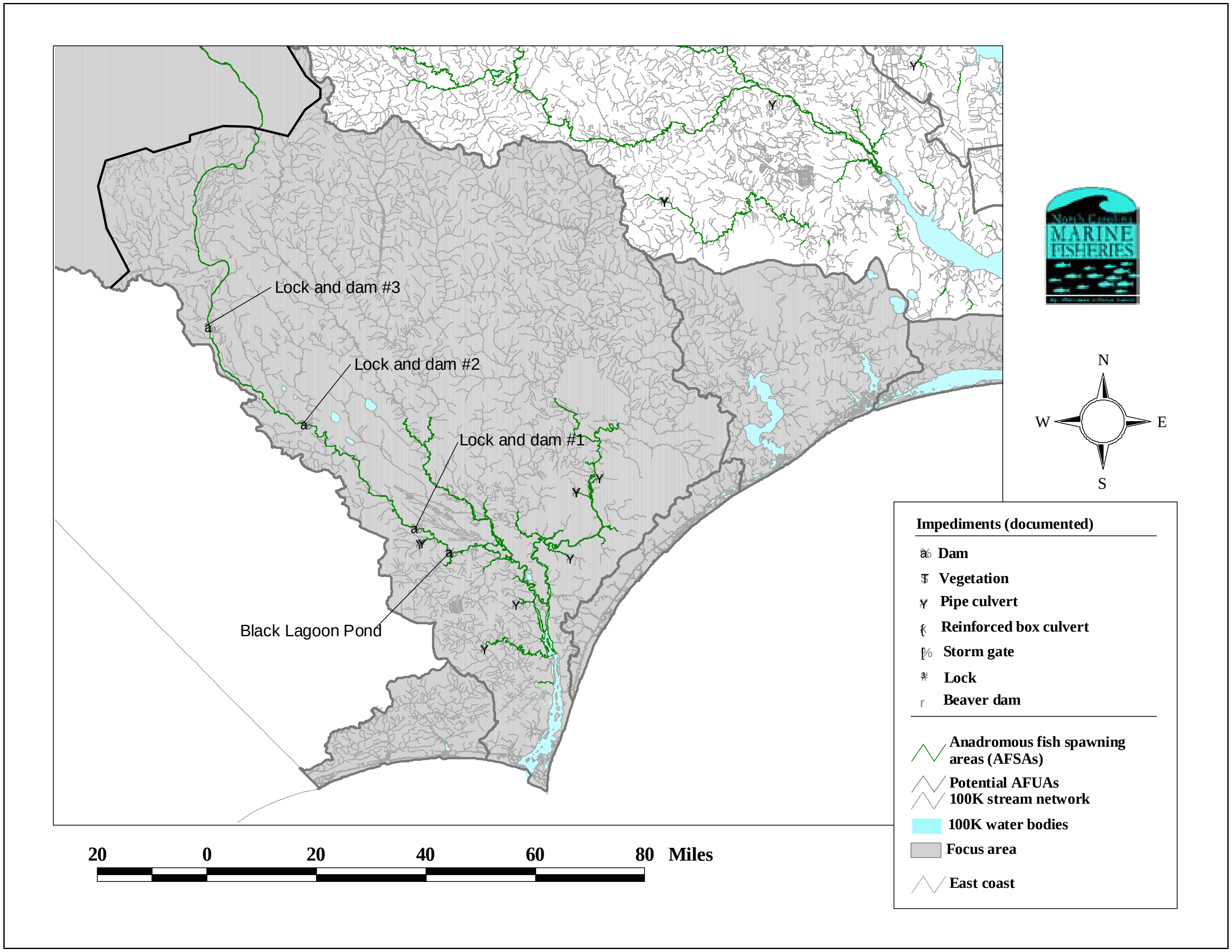


Figure 9.3.3. Documented location of dams, culverts, and other impediments on stream in the central coastal plain of North Carolina. Sources: VDGIF data (1983), Collier and Odum (1989), Moser and Terra (1999), NCDWR data (2003), and NCDOT data (2004).

personal communication, 2001) (Figure 9.3.3). There is currently growing support for lowering dams #1 and #3, and removing dam #2 (USCOE, pers. comm., 2005).

Water control structures located on drainage canals to Lake Phelps (16,600 ac, 6718 ha) and Lake Mattamuskeet (40,015 ac, 16,194 ha) limit river herring migrations into these areas. Collier and Odom (1989) listed storm gates located on Western Canal, Thirty-foot Canal, Old Canal, and Batava Canal at Lake Phelps as confirmed impediments to migration. In addition, Bee Tree Canal connecting Lake Phelps to the Scuppernong River has historically supported a significant spawning run of river herring and in the mid 1970s, a fish ladder was proposed for this canal (Kornegay and Dineen 1979). The fish passage project on Phelps Lake is currently waiting on good weather to complete construction (Mike Wicker/USFWS, pers. comm., 2005). The water control structure located on Bee Tree Canal, along with those located on other canals, have been opened on an irregular basis, allowing river herring to enter the lake and apparently spawn. In the past when access was provided, large numbers juvenile herring were collected in the lake. At Lake Mattamuskeet, the wooden flap gates of the water control structures located on each of four drainage canals were replaced in 1989 with stainless steel gates. The new gates are heavy and open only slightly. These narrow openings create high water velocities which prevent herring from entering. This action subsequently reduced the herring run (Roger Rulifson, East Carolina University, personal communication), which had formerly supported a substantial dipnet fishery (Tyus 1974). The installation of fish weirs and the replacement of the original wooden flap gates have restored some river herring and estuarine species, such as blue crabs, to Lake Mattamuskeet (Rulifson and Wall 1998).

Although dams are the most obvious obstructions, road culverts may have more overall effect on river herring. Culverts are popular, low-cost alternatives to bridges when roads must cross small streams and creeks. The effect of reduced light from culverts and bridges on river herring migratory behavior was examined in a study conducted in tributaries of Albemarle Sound and in the Neuse, Pamlico, and Cape Fear rivers in 1999 (Moser and Terra 1999). Results showed that river herring preferred to migrate through areas with some ambient lighting during the day, but required only a low amount of light – at least

1.4% of ambient light. Where lighting was less than 1.4% ambient conditions, avoidance was observed. Light measurements in the center of the structures were below this threshold in 6 ft diameter corrugated metal pipes and 6 ft by 6 ft box culverts. Sufficient light was available in 12 ft diameter pipes and bridges more than one meter above the water surface. Light was marginally adequate in bridges less than one meter above the water surface. Light penetrated approximately 10 ft inside the 6 ft diameter culverts. Since the average length of the 6 ft diameter pipes was 54 ft, approximately 30 ft in the center of the pipes was dark. Although culverts may reduce the number of herring passing upstream of the structures, some fish did successfully pass through culverts at night and, in some cases, under low light conditions (<1%) during the day. The location of documented culverts in the Albemarle Sound watershed, North Carolina are shown in Figure 9.3.1.

Although the amount of habitat affected by an individual culvert may seem small, the cumulative impact of culverts within a watershed can be substantial (Collier and Odom 1989). Collier and Odom (1989) documented two culverts in Perquimans County that were confirmed impediments, with another 18 culverts suspected of blocking herring migration throughout the Albemarle Sound region. An analysis of current obstructions to river herring spawning areas was conducted by DMF staff in 2005 using data from Collier and Odum (1989), Moser and Terra (1998), and DOT data on culvert and bridge locations (current as of 2003). The analysis revealed very few spawning areas that have been obstructed by culverts since the spawning area surveys were conducted (Figure 9.3.1). However, an overlay of detailed road network on the spawning areas, shows a significant number of potential impediments cutting off large areas of stream (Figure 9.4.1 – 9.4.3). These potential impediments should be investigated to document their status as actual impediments. It should also be noted that culverts often marked the upstream boundary of spawning areas, thus possibly underestimating the amount of spawning habitat.

Efforts to document natural obstructions, such as beaver dams and vegetation blockages have rarely been undertaken relative to anthropogenic blockages. Collier and Odom (1989) noted two vegetation blockages on Pollock Swamp Creek, Chowan County

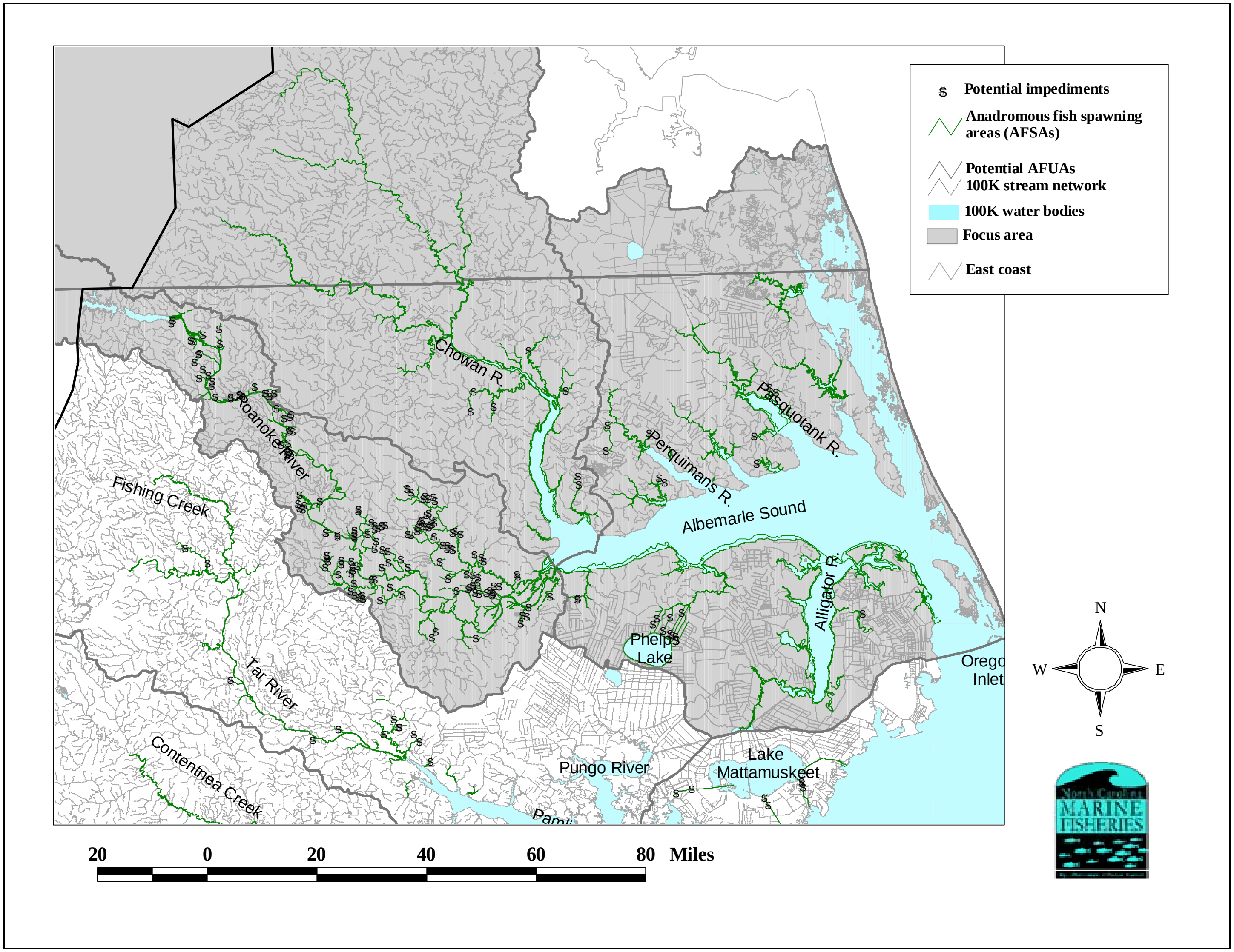


Figure 9.4.1. Location of potentially undocumented culverts in the northern coastal plain of North Carolina based on comparison of documented impediments and roads crossing streams.

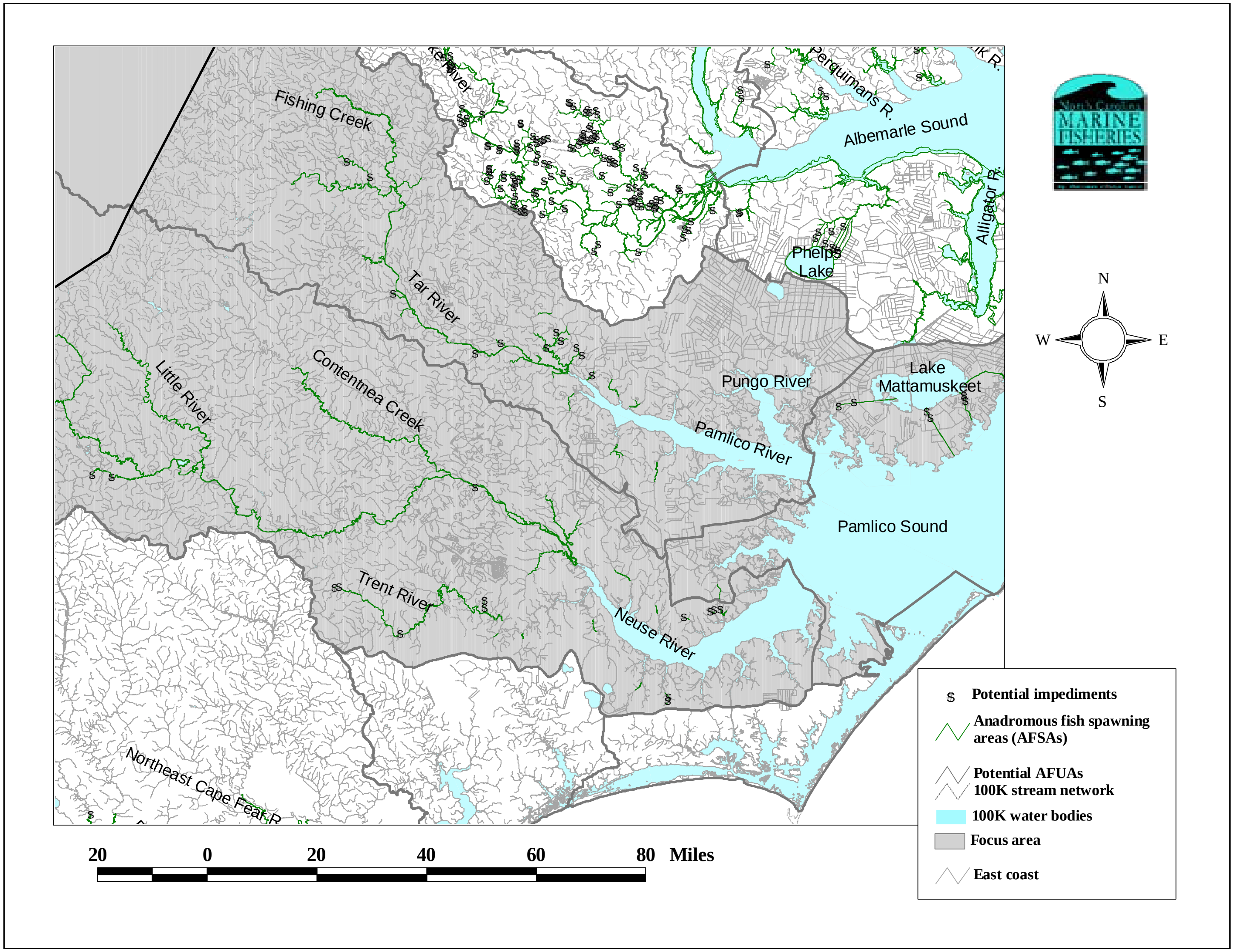


Figure 9.4.2. Location of potentially undocumented culverts in the northern and central coastal plain of North Carolina based on comparison of documented impediments and roads crossing streams.

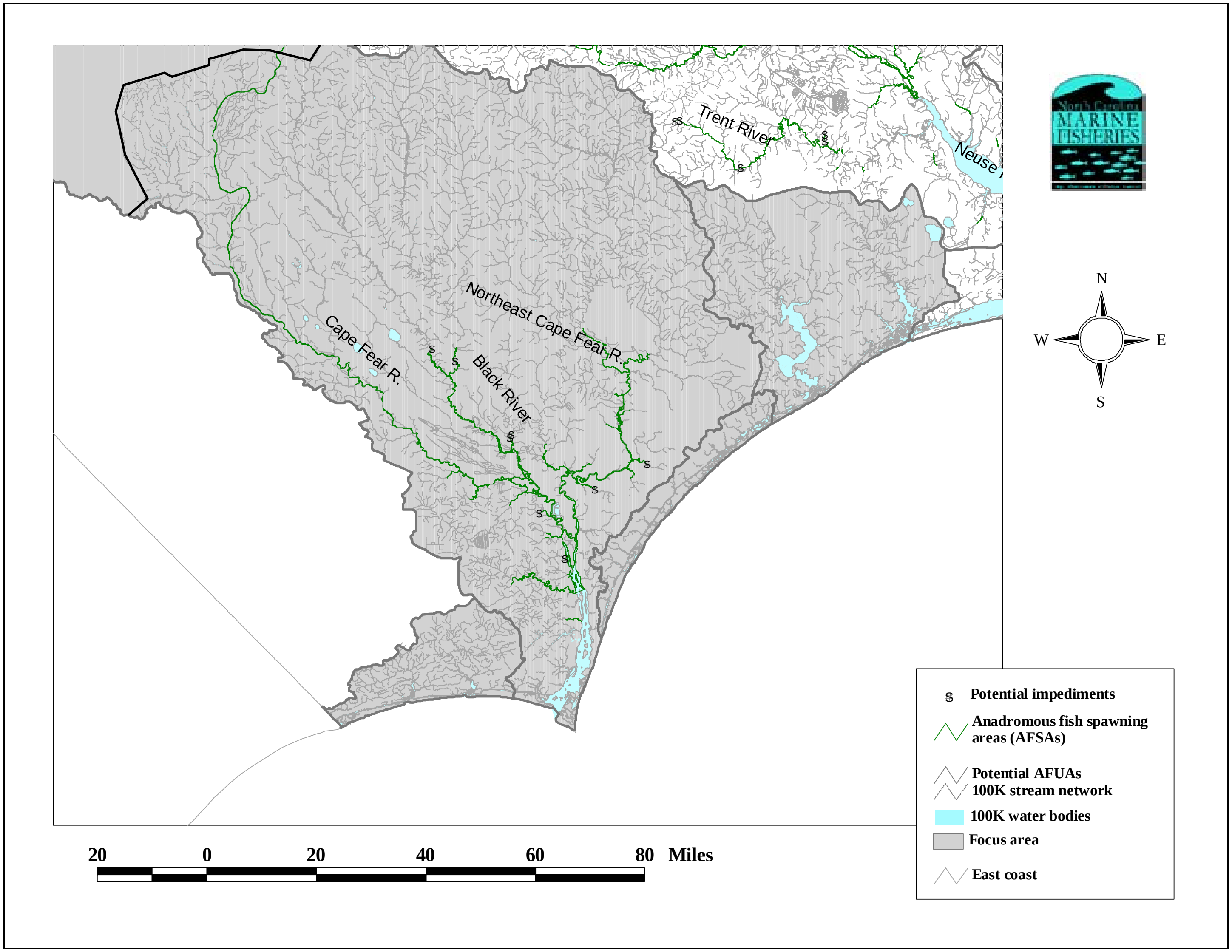


Figure 9.4.3. Location of potentially undocumented culverts in the southern coastal plain of North Carolina based on comparison of documented impediments and roads crossing streams.

and Suttons Creek, Perquimans County, as well as one beaver dam on Eastmost Swamp, Bertie County. Odom et al. (1986) indicated that log and driftwood jams on the Meherrin River created barriers that prevented the upstream migration of anadromous species. However, due to aquatic weed control programs, snagging operations, and natural events such as hurricanes Bertha (1996), Fran (1996), Bonnie (1998), Floyd (1999) and Isabel (2003), these types of blockages can be temporary in nature. Nevertheless, such barriers most often occur on small streams and creeks, and therefore, can have an impact on river herring habitat (Collier and Odom 1989). Although blockages to the upstream migration of river herring can occur, the in-stream woody debris and vegetation often provide needed spawning and nursery habitat in many streams. Fertilized river herring eggs are initially adhesive and attach to vegetation and woody debris as a substrate. In addition, both juveniles and adults use this habitat as protective cover and as feeding sites. Invertebrates that also use this habitat provide an important food source for river herring. Future projects involving log salvage and de-snagging could result in the unnecessary elimination of habitat by removing woody debris and vegetation.

10. PRINCIPAL ISSUES AND MANAGEMENT OPTIONS

Major issues and management options developed during the FMP process are briefly summarized in this section. The full issue papers, along with a detailed explanation of the issue and management options can be found in the Appendix. Management issues in the North Carolina river herring fishery have been solicited from the public, the River Herring Advisory Committee (AC), the MFC, the Finfish and Regional Advisory Committees, the DMF, the NCDENR, and the scientific community. Each issue is listed along with potential management options, recommended strategies and actions to be taken by the MFC, DMF and others.

10.1 Actions to Restore Abundance of North Carolina River Herring

10.1.1 Issue

Management required to restore the abundance of river herring.

10.1.2 Background

Based on the most recent stock assessment, the ASMA river herring stock is overfished and overfishing is currently occurring. Even under a TAC as low as 10,000 pounds overfishing continues to occur. It is the Division's responsibility, as a steward of the marine resources of North Carolina, to ensure the long-term viability of coastal fisheries for the benefit of the citizens of North Carolina. In addition, the Fisheries Reform Act (FRA) obligates the MFC to take action to end the overfishing of river herring. None of the population models examined, even under a moratorium, rebuilds the stock to the minimum biomass threshold within the preferred legal timeframe of 10 years.

10.1.3 Recommendations

- Support a zero harvest statewide, coupled with gear restrictions but allow up to 7,500 pounds set aside for research at the Division Directors discretion.

Gear Restrictions: Albemarle Sound/Chowan River Herring Management Area (15A NCAC O3J .0209), the following restrictions are proposed from January 1 – May 1:

- Eliminate the use of gill nets <3 ¼ inch stretched mesh (ISM)
- Gill nets 3 ¼ ISM restricted to 800 yards
- Cap the number of pound net participants
- Eliminate the use of drift gill nets

Other coastal systems- Given the minimal catch rates of river herring and the importance of sustaining ongoing fisheries in the remainder of the state, additional gear restrictions are only proposed in the following areas from January 1 – May 1:

- Eliminate the use of gill nets <3 ¼ ISM in canals and areas adjacent to canals leading to Lake Mattamuskeet (as described in 15A NCAC O3Q .0202)
- Restrict drift gill nets to $\geq$ 3 ¼ ISM in all other areas of the state

10.2 Monitoring Program and Stock Recovery Indicators for the River Herring Stock

10.2.1 Issue

Establishing a monitoring program and stock recovery indicators for NC river herring stock under a moratorium.

10.2.2 Background

A moratorium on the harvest of river herring requires DMF to develop methods to monitor stock status in the absence of commercial and recreational fisheries data. In addition, stock recovery indicators must be established and reached prior to declaring the stock recovered or allowing restricted harvest. Due to the historical and current dominance of blueback herring in the landings and populations estimates, they are designated as the indicator species. Without a commercial harvest from which to estimate catch and obtain samples, the DMF will have to rely completely on data collected from independent surveys in order to monitor the river herring population. To accomplish this personnel and funds will be needed.

10.2.3 Research Needs

The following surveys will be necessary to adequately monitor the stock status of the river herring population in the Albemarle Sound area and other areas of the state.

- **Spawning Area Surveys** need to be conducted in order to determine which areas are currently functioning as productive spawning areas throughout the state. The ideal sampling scheme would require that all tributaries in the Albemarle Sound area be sampled during the same year, in order to prevent any differences due to environmental changes from year to year and to avoid significant time lapses between the sampling of different systems. Considering that this would require a substantial increase in personnel and funds, it may be more feasible to consider sampling one system (or multiple systems depending on the size of the system and time required for sampling) per year on a rotating basis. The Chowan River system should be surveyed the first year and the other systems follow systematically in the following years. Data collected from these surveys will provide data to determine which areas should be considered for habitat restoration and protection through the Coastal Habitat Protection Plan (CHPP) and stock restoration efforts.

- **Juvenile Abundance Index (JAI) Surveys** will continue through the long-term juvenile seine survey (11 core stations). The JAI was determined to be a valid indicator of cohort strength and to have value as a management tool and stock indicator. The juvenile survey should be expanded to all tributaries of the Albemarle Sound as well as other areas of the state in order to determine which areas are currently functioning as river herring nursery areas.
- **Establish Pound Net Sets in the Chowan River and Other Tributaries**

  In order to collect data on adult river herring in the Chowan River system, the Plan Development Team (PDT) recommends that at least 6-pound nets be set in the river in the spring during the spawning run. The nets should be located: two in the lower river, two in the middle, and two in the upper section of the Chowan River. From these nets estimates of CPUE, percent of repeat spawners, as well as size, age and sex data from alewife and blueback herring would be obtained. These data are necessary to monitor the stock status and without the pound net survey in the Chowan River, estimates of SSB and recruitment may be impossible to obtain.

  Although the Chowan River is the dominant system for river herring in North Carolina, the PDT feels it is also important to collect data from other tributaries of the Albemarle area. The ideal monitoring program would require pound nets be set in all tributaries of the Albemarle Sound area to determine river herring stock status. However, it is important to spend initial effort and funds on the Chowan River and expand to other areas of the Albemarle Sound and other areas of the state as funds and personnel are available.
- **The Albemarle Sound Area Independent Gill Net Survey (IGNS)** has been conducted since 1991. Even though the survey was developed to monitor the status of striped bass, data for numerous other species are also obtained through the survey. The Division will continue to utilize the IGNS to collect adult blueback herring and alewife, providing CPUE, percent repeat spawners, size, age and sex composition data. Adequate personnel and funds if provided would allow for expansion of the gill net survey into tributaries of the Albemarle Sound area for collection of river herring data.

10.2.4 Stock Recovery Indicators

Stock recovery indicators are to be used to evaluate and determine recovery status of the river herring stock. Many of these indicators were established through the 2000 FMP and are considered to be viable options for this FMP.

- **Juvenile Abundance**

  The restoration target for juvenile abundance of blueback herring is to achieve a three-year moving average catch per unit of effort (CPUE) of at least 60.

- **Percent Repeat Spawners**

  The Chowan River blueback herring spawning stock should contain at least 10% repeat spawners. (Percent of spawning stock that have spawned more than once.)

- **Spawning Stock Biomass (SSB)**

  The restoration target to restore Chowan River blueback herring SSB to a Minimum Stock Size Threshold (MSST) is 4 million pounds.

- **Recruitment**

  Recruitment of age three blueback herring should be restored to a three-year moving average of at least 8 million fish.

10.2.5 Recommendations

- Establishment and maintenance of an intensive monitoring and data collection program and emphasize the fact that without additional funds and personnel the recommendations cannot be accomplished. Support the four stock recovery indicators as trigger points for management action. All available stock recovery indicators must be met for the stock to be considered recovered.

- Conduct all sampling of the monitoring and data collection program
  1. Spawning Area Survey
     - Conduct spawning area survey in all tributaries of the Albemarle Sound beginning with the Chowan River.
     - Expand spawning area survey to other systems of the state as money and personnel become available.

  2. Juvenile Abundance Survey
     - Continue to conduct the long-term alosines juvenile abundance seine survey in the Albemarle Sound area.

- Expand the juvenile abundance survey to all tributaries of the Albemarle Sound area.
- Expand the juvenile abundance survey to other areas of the state as money and personnel become available.

3. Pound Net Sets
    - Set at least 6 pound nets in the Chowan River system.
    - Expand pound net sets to other tributaries in the Albemarle Sound area.
    - Expand pound net sets to other areas of the state if spawning area and juvenile surveys identify significant spawning runs in these areas.

4. Independent Gill Net Survey
    - Continue data collection from the Albemarle Sound Management Area IGNS, and expand survey into all tributaries of Albemarle Sound for collection of river herring data.
    - Use IGNS in other areas of the state to collect river herring data and expand the surveys to include all tributaries.

- Utilize all available stock recovery indicators to evaluate stock status and assure that the indicators are reached prior to removing harvest restrictions.

- Continue the stock monitoring and data collection program for 5 years with no alterations in data collection or management strategies before reassessing stock status.

- Strongly support that funding and personnel be provided to conduct the recommended sampling, as it is essential in order to adequately monitor the status of river herring stocks in North Carolina.

10.3 River Herring Restoration (Stocking Programs)

10.3.1 Issue

Enhancing restoration of river herring through stocking programs.

10.3.2 Background

The prohibition on the harvest of river herring alone may not be adequate to restore river herring to a viable fishery within the prescribed time frame. Stocking is one measure to be explored as an additional support for restoring North Carolina’s river herring resource. One approach is adult relocation, which involves capturing adults in watersheds that support a sustainable spawning run and releasing the individuals into a depleted system. Another approach to increasing the abundance of river herring is through stocking larval herring into target watersheds. This involves capturing broodstock, egg collection and fertilization, incubation and hatching, and then reintroduction into the target watershed. Literature review on river herring larval restoration programs in other states have been for short durations and detailed monitoring has not been completed. It is therefore difficult to quantify their success. However, adult stocking programs have shown a positive effect.

Current indications are that the current spawning stock biomass may not be sufficient to fully utilize the available spawning habitat in many areas of North Carolina. If some of the State's waterways are not habitat limited, then adult river herring relocation to these areas might benefit restoration. Re-evaluation of the spawning areas (Spawning Area Surveys) will aid in this determination. Larval river herring have been stocked in large numbers in some states but evaluation of their subsequent contribution is lacking. Larval stocking is much more expensive than adult relocation. Larvae are susceptible to predation, disease and are sensitive to environmental conditions. The Division lacks hatchery capability, therefore a co-operative partnership with hatchery facilities would be required for larval stocking. Currently, neither the WRC hatchery or U.S. Fish and Wildlife Service Edenton National Fish Hatchery have resources or capacity available for larval river herring production.

10.3.3 Research Needs and Pilot Program

The following needs would have to be addressed in considering a stocking program.

- Adult Relocation
  1. Conduct watershed surveys to determine
     - Areas of viable and non-viable spawning runs
     - Areas with greatest brood stock yield potential
     - Watersheds with most viable environmental conditions
  2. Establish a Plan for Stocking via Adult Relocation
     - Determine time and staff requirements
     - Identify equipment and facilities needed
     - Procure necessary funds
  3. Collection/Transportation/Relocation of Adults
     - Collection of a predetermined number of adult river herring
     - Transportation of adults from a viable spawning run to the area of concern within the closest possible proximity

4. Monitoring
   - Conduct monitoring and analysis to determine the impact of adult relocation

- Larval Stocking

1. Conduct Watershed Surveys
   - Determine areas of viable and non-viable spawning runs
   - Determine areas with the greatest probability of brood stock yield

2. Establish a Plan for Larval Stocking Program
   - Create partnerships with other agencies
   - Determine time and staff requirements
   - Identify equipment and facilities needed
   - Procure necessary funds

3. Collection of Broodstock
   - Collection of a predetermined number of adult river herring broodstock
   - Remove eggs from female river herring to yield a target number of larvae
   - Fertilize eggs with milt from male river herring
   - Transport fertilized eggs to partnership agency for incubation and hatching

4. Stocking of Larval Herring
   - Collection of larval staged river herring from partnership agency
   - Transport and stock larval herring to the watershed of concern
5. Monitoring
   - Conduct monitoring and analysis to determine the impact of larval stocking

10.3.4 Recommendations

- Spawning and nursery area surveys be updated immediately and the best course of action be evaluated concerning river herring restoration programs.
- Evaluation of the current conditions of spawning areas and runs needs to be determined for sound management decisions. In addition, the implementation of any stocking plan also needs to state specific objectives such as total numbers of stocked individuals needed, absolute time frame of the stocking project, and the monitoring program that will be utilized. Resource enhancement through the relocation of adults, stocking of larval staged individuals, or a combination of the two should be explored as possible aid in rebuilding the abundance of river herring. However, for any future stocking project to be made possible cooperative partnerships

must be established. The Division would have to identify additional resources to conduct a full scale stocking program of this scope.

10.4 Striped Bass Predation as it Relates to River Herring

10.4.1 Issue

The impacts of predation on river herring by other species, with emphasis on striped bass.

10.4.2 Background

Numerous food habitat studies (Manooch 1973; Cooper et al. 1998; Patrick and Rulifson 2003; Tuomikoski 2004; Rudershausen et al. 2005) have been conducted on striped bass in the Albemarle Sound area. All of these studies have shown that striped bass feed on numerous species of finfish and invertebrates and prey will vary by season and area. Striped bass have been described as opportunistic, generalists and selective feeders throughout their range and clupeid prey dominate the diets of Atlantic coast populations (Walter et al. 2003). Overall, Atlantic menhaden is the predominant finfish species consumed by striped bass in the Albemarle Sound area (Manooch 1973; Cooper et al. 1998; Patrick and Rulifson 2003; Rudershausen et al. 2005). In the spring an increase in the occurrence of adult blueback herring and alewife occurs in striped bass stomachs but this would be expected during the coinciding spawning migrations (Manooch 1973; Patrick and Rulifson 2003). During the fall emigration of juvenile river herring an increase in Age-1 striped bass selectivity for these species occurs (Rudershausen et al. 2005).

River herring recruitment failure coupled with high exploitation has resulted in dramatic populations declines. Even though the decline in river herring stocks did not coincide with the resurgence of the striped bass population to an all time high, predation on such depleted river herring stocks are likely having an impact.

10.4.3 Research Needs

- Encourage additional research on predation, not limited to striped bass
- Expand predation work outside the Albemarle Sound area
- Encourage research in the ocean relative to unknown predation

- Encourage development of procedures and data collection for ecosystem management approach

10.4.4 Recommendations

- Endorse additional research on predation and restoration programs for river herring.
- Consideration on development of an Albemarle Sound multi-species ecosystem management program and the science necessary to make it happen.

10.5 Atlantic Ocean Harvest of River Herring

10.5.1 Issue

River herring bycatch in the Atlantic Ocean fisheries.

10.5.2 Background

Harvest of river herring by offshore fisheries has long been a concern of state and regional management agencies because their migratory patterns subject them to direct and bycatch harvest in coastal waters. Substantial ocean landings of river herring were reported by foreign fishing fleets between 1967 and 1972. The fisheries primarily harvested fish less than 7.5 inches long and mostly immature (Street and Davis 1976). Since 1977, the foreign fishery for river herring within the U.S. Exclusive Economic Zone (200 mile limit) has been restricted by federal rules under the authority of the Magnuson-Stevens Act. Since 1981, total annual allocation has been limited to 220,460 pounds. Even though foreign fishing pressure on river herring stocks in offshore waters has been reduced for 28 years, the population has not recovered anywhere along the Atlantic Coast.

River herring occurs as bycatch in the Atlantic herring fishery but is generally low and likely not significant to the coastwide population. Bycatch of river herring also occurs in the Atlantic mackerel fishery, but since 1981, these fisheries have been limited to an allowed bycatch of 220,000 pounds.

All coastal states, in cooperation with the appropriate Fishery Management Councils, ASMFC and NMFS need to ensure that bycatch monitoring programs for alosines, through observer programs (at-sea or shore based) are implemented. Bycatch data are critical to understanding sources of mortality and associated impacts to river herring stocks.

10.5.3 Research Needs

- Endorse additional research coastwide to collect river herring bycatch data from the Atlantic mackerel, Atlantic herring and other pelagic fisheries.

10.5.4 Recommendations

- Endorse additional research coastwide to collect and assess river herring bycatch to a high level of precision from Atlantic mackerel, Atlantic herring and other pelagic fisheries and requests that NMFS allocate funds to conduct such studies.

10.6 Critical Habitat- Anadromous Spawning and Nursery Areas

10.6.1 Issue

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

10.6.2 Background

The DMF has conducted anadromous spawning and nursery area surveys in the Albemarle Sound area, Tar-Pamlico, Neuse, White Oak, New and Cape Fear river systems. Except for the Albemarle Sound area, no directed surveys have occurred since the early 1980s. Anadromous fish spawning areas are those areas where evidence of spawning of anadromous fish has been documented by direct observation of spawning, capture of running ripe females, and/or capture of eggs or early larvae (15A NCAC 3I .0101 (20) (C)). Anadromous fish nursery areas are those areas in the riverine and estuarine systems used by post-larval and later juvenile anadromous fish (15A NCAC 3I .0101 (20) (D)). The MFC has the authority to designate Critical Habitat Areas, Anadromous Spawning and Nursery Areas and regulate fishing activity in these areas. The WRC can designate waters Inland Primary Nursery Areas (IPNA), however the WRC has no additional regulatory authority in these areas. The majority of the river herring spawning areas are in Inland Waters under the jurisdiction of the WRC. Recommendations will be submitted to the WRC requesting that they consider pursuing adoption of the MFC spawning area and nursery area definitions and designation of documented spawning areas.

10.6.3 Research Needs

- Update the spawning and nursery area surveys conducted previously in all areas.
- Identify potential incentives to landowners for protection of riparian buffers in the management area.
- Develop, identify and clarify what critical habitat actions are needed to protect, enhance and restore habitats and water quality affecting river herring.

10.6.4 Recommendations

- Advocate the adoption of DMF identified anadromous spawning and nursery areas in the Albemarle Sound area for river herring into rules. In other coastal areas of the state where river herring spawning areas have been identified, rule adoption should also occur. Update anadromous nursery area surveys in the systems outside the Albemarle area.
- Advocate stronger enforcement of regulations protecting critical habitat in the management areas.
- Purchase land adjacent to critical habitat areas to ensure that these areas are protected.
- Advocate that coastal counties undertake the preparation and aggressive funding of open space preservation and conservation plans (e.g., Wake County Consolidated Open Space Plan, which adopted a minimum goal of 30% of the county preserved).
- Continue to make recommendations on all state, federal and local permits where applicable.
- Support implementation of habitat recommendations of the Coastal Habitat Protection Plans, the Albemarle-Pamlico Estuarine Study, and the Estuarine Shoreline Protection Stakeholders Report.
- Maintain, restore and improve habitat to increase growth, survival and reproduction of river herring.

10.7 Water Quality

10.7.1 Issue

Water quality improvements in river herring management areas.

10.7.2 Background

General concerns exist about point and non-point source discharges in each of the basins relative to river herring populations. The water quality of coastal rivers in NC has been monitored for many years, but few studies have attempted to document the effects of water quality on river herring.

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

10.7.2 Research Needs

- Membrane Water Treatment Plants: Evaluate the impacts/effects of reverse osmosis plants on receiving waters and aquatic resources.

- Water quantity: Evaluate the effects of existing and future water withdrawals on water quality, water quantity, and fisheries habitat in coastal watersheds.

- Contaminants: Determine if contaminants are present and identify those that are potentially detrimental to various life history stages of river herring. Specific areas of concern include the lower Neuse, Pamlico, Chowan and Roanoke rivers.

10.7.3 Recommendations

- Work in coordination with agencies such as the Division of Water Quality (DWQ), Division of Water Resources, Division of Land Quality, and Natural Resource Conservation Service to maintain, restore and improve water quality to increase growth, survival and reproduction of river herring. Priority activities identified include the establishment of buffer strips and conservation easements within each basin, and the continued refinement of best management practices on lands used primarily for agriculture, silviculture and industrial and residential development.

- Support implementation of recommendations of DWQ basinwide water quality management plans, particularly measures that will reduce nutrient loading, sediment delivery and associated turbidity in all coastal watersheds.
- Support implementation of habitat and water quality recommendations of Coastal Habitat Plans, the Estuarine Shoreline Protection Stakeholders Report (1999), and the Albemarle-Pamlico Estuarine Study (1994).

10.8 Blockages of Historical Spawning Habitat

10.8.1.1 Issue

To identify blockages to historical spawning areas and develop strategies to minimize impacts of blockages.

10.8.1.2 Background

A blockage is defined as any man made or natural obstruction that impedes river herring movement to historical spawning areas. Blockages such as dams, including beaver dams, culverts, stream channelization and natural obstructions have likely eliminated or reduced access to large areas of both spawning and nursery habitat. Collier and Odom (1989) conducted a survey documenting blockages throughout eastern North Carolina. Mainstem dams occur in all coastal rivers in North Carolina. The lowermost dams are located around the fall line in the Meherrin, Roanoke, Nottoway, Tar and Neuse rivers (Hightower 2001).

Numerous smaller mill dams are found on creeks throughout the eastern part of the state. Removing or bypassing these dams would open access to many miles of potential spawning habitat. Water control structures located on drainage canals to Lake Phelps and Lake Mattamuskeet also limit river herring migrations. Modifications to water control structures are under way to provide access to Lake Phelps and Lake Mattamuskeet. Natural obstructions, such as beaver dams and vegetation blockages, are not nearly as common as the other barriers and efforts to identify these have rarely been undertaken.

Although dams are the most obvious obstruction, road culverts may have more overall effect on river herring. Culverts are a low-cost alternative to bridges when roads must cross small creeks. River herring avoid access through culverts has been observed, when the amount of light is below the threshold (Moser and Terra 1999).

Despite the enactment of protective environmental regulations and the existence of both federal and state regulatory review processes, threats to the maintenance of river herring habitat access and quality are still significant.

10.8.2 Research Needs

- Chowan River- investigate abundance and spawning contribution of river herring in the Blackwater, Nottoway and Meherrin rivers; determine impacts of dams on spawning (require Virginia agencies to participate in the management process)

- Tar River- investigate feasibility of fish passage on Rocky Mount Mill Dam and Tar River Reservoir Dam. Would provide an additional 20-40 miles of spawning habitat but not clear if beneficial to river herring.

- Neuse River- investigate the feasibility of removing Milburnie Dam in Wake County.

10.8.3 Recommendations

- Identify all man-made physical obstructions to river herring migrations (update of Collier and Odom project), prioritize impediments for removal/replacement after identification and conduct investigation of the research needs.

10.9 Entrainment and Impingement of Eggs and Larvae

10.9.1 Issue

Blueback herring and alewife eggs, fry and juveniles are removed from coastal rivers through water withdrawals.

10.9.2 Background

Millions of gallons of water are pumped each day from coastal rivers by industrial, municipal and agricultural water users. During the river herring spawning season, eggs and fry drifting downstream with river currents are subject to being suctioned out of the rivers through various water pumping systems. Juvenile river herring that have not fully developed their swimming abilities are also susceptible to being removed via water intakes. Removal of these eggs, fry and juveniles represent a direct loss of river herring reproductive success.

10.9.3 Research Needs

- The magnitude and seasonal timing of agricultural water withdrawals from coastal river is unknown. Division of Water Resources and Division of Water Quality should require documentation of these withdrawals, so that the extent of entrainment of river herring eggs, fry and juveniles can be estimated.

- Comprehensive list of industrial and municipal water withdrawals and their intake specifications by river system coast-wide.

- Data on the density and distribution of river herring eggs, fry and juveniles in coastal rivers are needed so that potential losses can be estimated.

- Identify effective engineering solutions to prevent entrainment and impingement of river herring eggs, fry and juveniles.

- Research is needed to determine the fate of river herring eggs, fry and juveniles that are impinged, and then released through screen cleaning operations.

10.9.3.1 Recommendations

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

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12. APPENDICES

12.1 Appendix 1. – Issue Papers

The issue papers developed during the FMP process appear in this section. Management issues in the North Carolina river herring fishery have been solicited from the public, the River Herring Advisory Committee (AC), the NCMFC, the Finfish and Regional Advisory Committees, the NCDMF, the NCDENR, and the scientific community. Each issue is described in detail along with potential management options, recommended strategies, and actions to be taken by the NCMFC, NCDMF, and others. The issues discussed include:

- Actions to Restore Abundance of North Carolina River Herring
- Monitoring Program and Stock Recovery Indicators for River Herring Stocks
- River Herring Restoration (Stocking Program)
- Striped Bass Predation as it Relates to River Herring
- Atlantic Ocean Harvest of River Herring (Bycatch)
- Critical Habitat- Anadromous Spawning and Nursery Areas
- Water Quality
- Blockages of Historical Spawning Habitat
- Entrainment and Impingement of River Herring Eggs, Larvae and Juveniles

12.1.1 Actions to Restore Abundance of North Carolina River Herring

Issue:

Management required to restore the abundance of North Carolina river herring.

Introduction:

River herring (alewife and blueback) once supported large fisheries within the Albemarle Sound Management Area (ASMA); however, landings have drastically declined since the mid 1970's. Commercial landings have declined from an average greater than 10 million pounds in the 1970s to ~ 250,000 pounds in 2005 (Rawls 2004). Gear restrictions were implemented in 1995 and in February 2000, the North Carolina Marine Fisheries Commission (MFC) approved the original River Herring Fisheries Management Plan (FMP). In this original plan, the stock assessment indicated that the long-term decline in landings was directly related to a decline in population abundance and that the fishery was not sustainable at current fishing mortality rates (NCDMF 2000). In addition, the number of spawning females (spawning stock biomass) and the number of juveniles they produced were at all time low levels. In turn, closed seasons and a Total Allowable Catch (TAC) were put in place to cap the harvest at a minimal level. Considering population abundance, projections of how the river herring population would respond to these management measures were not optimistic, with suggestions that improvement in population abundance would only come with considerable improvements in recruitment. The MFC and DMF considered the social and economic consequences of management options and adopted the 2000 FMP with a clear warning that if recruitment did not improve, more stringent measures would need to be taken.

Since 2001, the ASMA fishery has been unable to harvest the TAC. A new stock assessment completed in May 2005 indicates that the status of the population has deteriorated further, and the anticipated improvement in recruitment has not occurred (Grist 2005). Based on the 2005 assessment, further directed harvest may cause an already heavily exploited stock to collapse. None of the population models examined, even under a moratorium, rebuilds the stock to the minimum biomass threshold within the preferred legal timeframe of 10 years required by the Fisheries Reform Act (FRA) (G.S. 113-182.1(b)(4)). If a moratorium is implemented and no other restoration or restocking efforts are considered, the stock is predicted to take more than 20 years to recover. This issue paper addresses 1) status of the river herring stocks, 2) management options, 3) additional restoration efforts, and 4) the Division recommendations for restoring the abundance of North Carolina river herring.

Current Authority:

1) G.S. 143B-289.51. Marine Fisheries Commission – creation; purposes.

2) G.S. 113-132. Jurisdiction of fisheries agencies.

3) G.S. 113-224. Cooperative agreement by Department

4) G.S. 113-131. Resources belong to public; stewardship of conservation agencies; grant and delegation of powers; injunctive relief.

5) G.S. 113-181. Duties and powers of Department.

6) G.S. 113-182.1. Fishery Management Plans

Discussion:

Overfished Status

Based on the status of the current stock and the most recent stock assessment, the ASMA river herring stock is overfished and overfishing is currently taking place. It is the Division's responsibility, as a steward of the marine resources of North Carolina, to ensure the long-term viability of coastal fisheries for the benefit of the citizens of North Carolina. In addition, the FRA obligates the MFC to take action to end the overfishing of river herring. None of the population models examined, even under a moratorium, rebuilds the stock to the minimum biomass threshold within the preferred legal timeframe of 10 years.

Management Options

a. Moratorium on Harvest – prohibit any commercial or recreational harvest of river herring in all coastal waters. This option would provide maximum protection of river herring to fishing mortality and a maximum likelihood of increasing stock abundance.

b. TAC – would cap the harvest at a minimal level and provide minimal protection of the resource while allowing the social aspects of fishing and consumption to continue.

c. Gear Restrictions by Area – In order to minimize discard mortality during a moratorium or after reaching a TAC, gear restrictions will be needed for each management option.

Moratorium on Harvest

For the Albemarle Sound/Chowan River Herring Management Area (15A NCAC 03J .0209), the following restrictions are proposed January 1st – May 1st in the ASMA:

- Eliminate the use of gill net <3 ¼“ (3 ¼“ gill net restricted to 800 yards)
- Cap the number of pound net participants
- Eliminate the use of river herring drift nets

Given minimal catch rates of river herring and the importance of sustaining ongoing fisheries in the remainder of the state, additional gear restrictions are only proposed in the following areas Jan 1st – May 1st:

- Eliminate the use of gill net <3 ¼“ in canals and areas adjacent to canals leading to Lake Mattamuskeet (as described in 15A NCAC 03Q. .0202 15.v.A-E)
- Restrict drift gill nets to >= 3 ¼“ in all other areas of the state

TAC option

For the Albemarle Sound/Chowan River Herring Management Area (15A NCAC 03J .0209), the following restrictions are proposed from season closure – May 1st in the ASMA:

- Eliminate the use of gill net <3 ¼“ (3 ¼“ gill net restricted to 800 yards)
- Prohibit river herring harvest from pound nets
- Eliminate the use of river herring drift nets

Given minimal catch rates of river herring and the importance of sustaining ongoing fisheries in the remainder of the state, additional gear restrictions are only proposed in the following areas from season closure to May 1st:

- Eliminate the use of gill net <3 ¼“ in canals and areas adjacent to canals leading to Lake Mattamuskeet (as described in 15A NCAC 03Q. .0202 15.v.A-E)
- Restrict drift gill nets to >= 3 ¼“ in all other areas of the state

d. Restoration – In conjunction with any fishing restriction implemented, restoration programs in the following areas must also be considered as aid. Issues such as stock enhancement through stocking programs and addressing concerns with habitat and water quality have been explored in-depth and can be referenced in corresponding issue papers.

a. Stocking Programs
b. Critical Habitat
c. Water Quality
d. Blockages
e. Entrainment / Impingement

All of these issues have been explored in depth and are presented in corresponding issue papers. It is the opinion of DMF that any improvement in stock abundance through fishing and gear restrictions be supplemented by addressing concerns in these other areas.

Management Options/Impacts

Status quo

+ No changes in management or fishing practices
+ Action requires no additional resources
- **Non-viable option**
- River herring stock unlikely to recover to a viable fishery
- Non-compliance with FRA
- Fishery Collapse

Allocate a Total Allowable Catch (TAC)

+ Minimal harvest aid for river herring stock recovery

+ Would allow social aspects of herring fishing and consumption to continue until recovery
- **Non-viable option**
- Stock unlikely to recover to a viable fishery
- Non-compliance of FRA
- TAC as low as 10,000 lbs considered overfishing
- Requires changes in management and fishing practices

State-wide moratorium on river herring harvest

+ Compliance with FRA
+ Aid for river herring stock recovery
- Requires changes in management and fishing practices
- Ends last vestiges of social aspects of herring fishing/consumption until recovery
- Discard mortality of river herring continues without gear restrictions

Gear restrictions

+ Aid for river herring stock recovery
- Requires changes in management and fishing practices

Combined (moratorium coupled w/ gear restrictions)

+ Compliance with FRA
+ Maximum likelihood for river herring stock recovery
+ Minimal discard mortality of river herring
- Requires changes in management and fishing practices
- Ends last vestiges of social aspects of herring fishing/consumption until recovery

DMF Recommendation

The Division recommends that the MFC approve a statewide moratorium, on any commercial or recreational harvest, coupled with the recommended gear restrictions for ASMA and other specified areas

The Division also recommends any improvement in stock abundance through a moratorium/gear restrictions be aided though pursuing other restoration programs

Advisory Committee Recommendation

The AC recommended that the MFC maintain a 100,000 pound TAC for the commercial river herring fishery in the Albemarle Sound/Chowan River Herring Management Area. Motion passed by unanimous vote.

The AC recommended a statewide 12 fish/person/day recreational creel limit. Motion passed by unanimous vote.

References

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12.1.2 Monitoring Program and Stock Recovery Indicators for River Herring Stocks

Issue:

Establishing a monitoring program and stock recovery indicators for the North Carolina river herring stock under a moratorium.

Background:

The North Carolina river herring fishery has seen dramatic declines from commercial landings in excess of 10 million pounds in the early 1970's prior to harvest restrictions, to just over 249,000 pounds in 2005 (Rawls 2004), with harvest restrictions in place since 1995. Once one of the largest fisheries in the state, the river herring fishery has all but disappeared. Problems such as overfishing, degradation of habitat and water quality and loss of spawning habitat are all possible causes of the decline (DMF 2000).

The North Carolina Marine Fisheries Commission (NCMFC) adopted the first River Herring Fisheries Management Plan (FMP) in February of 2000. The North Carolina Division of Marine Fisheries (NCDMF) is currently updating that plan which is scheduled for completion in the spring of 2006. The initial plan and stock assessment outlined a severe decline in population abundance, high mortality rates, low recruitment, low spawning stock biomass (SSB), a decrease in the number of repeat spawners and a continued decline in juvenile abundance (Carmichael 1999). The current stock assessment completed in May 2005 has shown the status of the stock has further deteriorated, with projections for stock recovery reaching 25 years, approximately doubling from the 1999 assessment projections. (Grist 2005). Based on the Fisheries Reform Act (specifically G.S. 113-182.1) the NCDMF is required to develop FMP's that end overfishing and achieve sustainable harvest of overfished fisheries within 10 years of

FMP adoption. Based on the 2005 assessment, the river herring stock (blueback herring and alewife) is overfished and overfishing is occurring. Projections indicate that yearly landings of as little as 10,000 pounds would still lead to overfishing. Thus, it is the opinion of the NCDMF that the only way to attempt to reach statutory requirements is to implement a moratorium on the harvest of river herring in North Carolina along with other stock enhancement measures.

It should also be noted that significant declines in river herring stocks are not just occurring in North Carolina, but in most states up and down the east coast. These declines have prompted the Atlantic States Marine Fisheries Commission (ASMFC) to conduct a coastwide stock assessment on river herring, which will begin upon the completion of the American shad stock assessment currently underway.

Current Authority:

G.S. 143B-289.51.	Marine Fisheries Commission – creation; purposes.
G.S. 113-132.	Jurisdiction of fisheries agencies.
G.S. 113-224.	Cooperative agreement by Department
G.S. 113-131.	Resources belong to public; stewardship of conservation agencies; grant and delegation of powers; injunctive relief.
G.S. 113-181.	Duties and powers of Department.
G.S. 113-182.1	Fishery Management Plans.

Discussion:

A moratorium on the harvest of river herring will require NCDMF to develop methods to monitor stock status in the absence of commercial and recreational fisheries data. NCDMF needs to outline a program for continued stock status monitoring during the moratorium, and in addition establish stock recovery indicators that must be reached prior to declaring the stock recovered or allowing restricted harvest. Due to the historical and current dominance of blueback herring in the landings and population estimates, the PDT for both the 2000 and 2006 FMP designated blueback herring as the indicator species. Management measures for the 2006 FMP will be developed and monitored based on this designation. There were several stock recovery indicators established in the 2000 FMP which will be presented and considered here as viable indicators for the 2006 FMP. Without a commercial harvest from which to estimate catch and obtain samples, the NCDMF will have to rely completely on data collected from independent surveys in order to monitor the river herring population.

Monitoring Program and Data Collection

The monitoring and data collection program will be increasingly important in the absence of commercial and recreational fisheries data. The following surveys will be necessary to adequately monitor stock status of the river herring population in the Albemarle Sound area and other areas of the state.

Spawning Area Survey

Anadromous spawning area surveys have been conducted in the Albemarle Sound area periodically since 1972. Due to budget cuts, the last spawning area survey conducted for river herring was in the Chowan River system in 2001. The NCDMF will need to conduct spawning area surveys in order to determine what tributaries are presently functioning as productive spawning areas.

The ideal sampling scheme would require that all tributaries in the Albemarle Sound area be sampled in the same year, in order to prevent any differences due to environmental changes from year to year and to avoid significant time lapses between the sampling of different systems. Considering that this would require a substantial increase in personnel and funds, it may be more feasible to consider sampling one system (or multiple systems depending on the size of the system and time required for sampling) per year on a rotating basis. Since landings from the Chowan River have contributed an average of 72.3% of the state's total landings since 1972 the PDT feels it would be appropriate to conduct a spawning area survey in the Chowan River system the first year. The other systems in the Albemarle Sound area would be sampled systematically in the following years.

Although the Albemarle Sound area is the center of the river herring fishery in North Carolina, contributing an average of 97.7% of the state's total landings since 1972, other areas of the state also have river herring fisheries. Prior to 1981, spawning area surveys were conducted in the Tar-Pamlico, Neuse, White Oak, New and Cape Fear River systems. The PDT recommends that spawning area survey work subsequently be conducted in these systems to determine the status of these systems.

Spawning area surveys will provide data that is needed to determine which areas should be considered for habitat restoration and protection, via designation of strategic habitat areas by the Coastal Habitat Protection Plan (DMF 2005). This information will also identify areas to concentrate potential stocking or adult trap and transport restoration efforts. In addition, age, sex length/weight, percent repeat spawners, fecundity and egg/larvae data from alewife and blueback herring that is system specific can be obtained. This information is particularly important in the absence of any commercial and recreational fisheries data accompanying a moratorium.

This is a fishery independent survey and a moratorium on river herring harvest will not affect collection of these data.

Juvenile Abundance Survey

In order to monitor juvenile abundance, NCDMF will continue conducting the long-term alosine juvenile seine survey. Eleven core stations in the western Albemarle Sound area have been established and monitored through this survey since 1972 (Rawls 2004).

One of the goals of the 1999 stock assessment was to validate the juvenile abundance index (JAI) for the Albemarle Sound area and determine if it was a good indicator of year class strength for blueback herring and alewife. The JAI was determined to be a valid indicator of cohort strength, and to have value as a management tool and stock indicator (Carmichael 1999).

The PDT recommends expanding the alosine juvenile survey to all tributaries of the Albemarle Sound as well as other areas of the state in order to determine which areas are currently functioning as river herring nursery areas. Other areas of the state have not been sampled since 1981.

This is a fishery independent survey and a moratorium on river herring harvest will not affect collection of these data.

Establish Pound Net Sets in Chowan River and Other Tributaries

Although river herring are harvested in other tributaries of the Albemarle Sound by other gear types, historically and presently, the largest fishery is the Chowan River pound net fishery (Grist 2005). The river herring PDT recommends that the 2006 FMP for river herring be developed using blueback herring as the indicator species. In addition, the 2005 stock assessment utilized the catch at age data from alewife and blueback herring from the Chowan River pound net fishery to estimate exploitation rate and abundance (Grist 2005).

In order to collect data on adult river herring in the Chowan River system, the PDT recommends that at least 6 pound nets be set in the river in the spring during the river herring spawning run. The PDT recommends that there be two pound nets in the lower Chowan River, two in the middle, and two in the upper section of the river. From these nets estimates of CPUE, percent of repeat spawners as well as size (length/weight), age and sex data from alewife and blueback herring can be obtained. These data will be necessary in order to monitor stock status. It should be noted that without a DMF pound net survey in the Chowan River to collect appropriate data, estimates of SSB and recruitment may be impossible to obtain.

Although the Chowan River is the dominant system for river herring in North Carolina, the PDT feels it is important to collect data from other tributaries of the Albemarle Sound as well. Spawning surveys historically have identified river herring spawning runs in almost every tributary of the Albemarle Sound. Contribution of stocks from these other tributaries to the overall river herring population is not known at this time. The PDT suggest that an ideal monitoring program would require pound nets be set in all tributaries of the Albemarle Sound area to determine river herring stock status for the entire Albemarle Sound area. Realizing however that the Chowan River is the main spawning run for river herring in North Carolina, the PDT feels it is important to spend initial effort and funds on this area and expand to other areas of the Albemarle Sound and other areas of the state, as funds and personnel are available.

Data that would be obtained in this survey is currently obtained through sampling of the Chowan River commercial pound net fishery. In the event of a moratorium, this data would no longer be available, making this survey essential to adequately monitoring stock status.

Albemarle Sound Area Independent Gill Net Survey

The DMF has conducted an Independent Gill Net Survey (IGNS) in the Albemarle Sound area since 1991. This survey was developed to monitor stock status of striped bass, but has been used to collect data for various other species as well (Winslow 2005).

The NCDMF will continue to utilize the Independent Gill Net Survey (IGNS) that is conducted in the Albemarle Sound area from November through May to collect samples of adult blueback herring and alewife. Data such as CPUE, percent repeat spawners, size, age and sex composition can be obtained from this survey. Since the survey is conducted throughout the Albemarle Sound area, it is certain that the information collected does not exclusively represent the Chowan River spawning stock, but stocks of various tributaries in the area. However, considering the survey's long-term database, it would be useful to continue collection of the data for comparison across years.

This is a fishery independent survey and a moratorium on river herring harvest will not affect collection of these data.

Stock Recovery Indicators

The PDT recommends stock recovery indicators for blueback herring be used to evaluate and determine recovery status of the river herring stock. Many of these stock recovery indicators were established through the 2000 FMP, and are considered to be viable options for the 2006 FMP development. The development of both the 2000 and 2006 FMP is based on blueback herring as the indicator species for determining stock status.

Juvenile Abundance

The JAI was validated in the 1999 stock assessment, and determined to be a valuable stock indicator (Carmichael 1999).

The stock recovery indicators relative to juvenile abundance were established in the 2000 FMP. The restoration target for juvenile abundance of blueback herring is to achieve a three-year moving average catch per unit of effort (CPUE) of at least 60.

Percent Repeat Spawners

Another valuable source of information that can be obtained from aging samples is percent of repeat spawners. This is the percent of the spawning stock that is determined to have spawned more than once. The percentage of repeat spawners in the Chowan River pound net fishery has declined drastically since the late 1980's, and this causes concern due to the loss of spawning potential.

The PDT recommends restoring the Chowan River blueback herring spawning stock so that it contains at least 10% repeat spawners. This was also a recommended stock restoration target in the 2000 FMP (DMF 2000).

Spawning Stock Biomass (SSB)

According to the 2000 stock assessment for river herring, a spawning stock biomass and recruitment plot indicates that strong year classes are much more likely when SSB is above 4 million pounds and poor year classes are much more likely when SSB is below 2.5 million pounds (Carmichael 1999).

One of the restoration targets of the original FMP was to restore Chowan River blueback herring SSB to a Minimum Stock Size Threshold (MSST) of 4 million pounds. This level of SSB was considered the minimum level that would allow for a sustainable harvest. The PDT feels that the 4 million pound MSST goals are appropriate for the development of the 2006 FMP.

Although SSB is considered a valuable indicator of stock health, in the event of a moratorium, estimates of SSB must be obtained by a method other than using commercial catch data. Recruitment and SSB could be estimated using data collected from pound nets that could be set by DMF in the Chowan River.

Recruitment

The 2000 FMP established recruitment stock recovery indicators for Chowan River blueback herring. The FMP recommended restoring recruitment of age three blueback herring to a three-year moving average of at least 8 million fish. The PDT feels that this restoration target is appropriate for the 2006 FMP.

Management Recommendations

Conduct all recommended sampling of the monitoring and data collection program.

Spawning Area Survey

Conduct spawning area survey in all tributaries of the Albemarle Sound beginning with the Chowan River.
Expand spawning area survey in other systems of the state as money and personnel become available.

Juvenile Abundance Survey

Continue to conduct the long-term alosine juvenile abundance seine survey in the Albemarle Sound area.
Expand the juvenile abundance survey to all tributaries of the Albemarle Sound area.
Expand the juvenile abundance survey to other areas of the state as money and personnel become available.

Pound Net Sets

Set at least 6 pound nets in the Chowan River system.
Expand pound net sets to other tributaries in the Albemarle Sound area.
Expand pound net sets to other areas of the state if spawning area and juvenile surveys identify significant spawning runs in these areas.

Independent Gill Net Survey

Continue data collection from the ASMA IGNS, and expand survey into all tributaries of Albemarle Sound for collection of river herring data.
Use IGNS in other areas of the state to collect river herring data and expand these surveys to include all tributaries.

Utilize all available stock recovery indicators to evaluate stock status and assure that the indicators are reached prior to removing harvest restrictions.

Continue the stock monitoring and data collection program for 5 years with no alterations in data collection or management strategies before reassessing stock status.

Strongly support that money and personnel be identified to conduct the recommended sampling, as it is a necessity in order to adequately monitor the status of river herring stocks in North Carolina.

DMF Recommendations

Strongly support all management recommendations, with emphasis on the necessity of the monitoring and data collection program and the fact that without money and personnel these recommendations cannot be accomplished.

Advisory Committee Recommendations

Support the establishment and maintenance of an intensive and efficacious monitoring program as recommended by DMF.

Adopt the following four stock recovery indicators as the trigger points for management action. Stock conditions below these recovery indicators would not be considered recovered. The motion passed 7 to 1.

- Blueback herring JAI three-year moving average CPUE of 60
- Single year percent repeat spawners for Chowan River blueback herring of 10%
- SSB for Chowan River blueback herring of 4 million pounds
- Recruitment for Chowan River blueback herring a three-year moving average of 8 million fish

References:

Carmichael, J.T. 1999. Status of Blueback Herring in the Chowan River, North Carolina 1972-1998. North Carolina Division of Marine Fisheries Morehead City, NC.

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Winslow, S.E. 2005. North Carolina Striped Bass Monitoring. Annual Progress Report, Grant F-56, Segment 11. North Carolina Division Of Marine Fisheries, Morehead City, NC.

Albemarle Sound Area- River Herring Project

Personnel and budget needs to re-establish a river herring monitoring project in the Albemarle Sound area. This work would be conducted in the coastal, joint and inland waters of the Albemarle Sound area. Tasks under this project would include: spawning and nursery area surveys, adult sampling to obtain size, age and sex data, and juvenile surveys. If river herring projects were to be started in the coastal areas outside the Albemarle Sound area, costs and personnel needs would have to be increased threefold.

Additional funding would be necessary to establish this monitoring program. The initial start up cost of this project would be significant due to equipment needs.

PROJECTED COSTS

	FY1	FY2+
SALARY	138,848	138,848
OPERATING	223,500	61,100
TOTAL	362,348	199,948
FTE POSITIONS	3	3

Albemarle Sound Area- Anadromous

Spawning Area Surveys (February-May)

- Chowan/Salmon Creek/Edenton Bay
- Perquimans/Yeopim
- Pasquotank/Little
- Roanoke/Cashie
- Meherrin/Blackwater/Nottoway
- Scuppernong/Mackeys Creek
- Alligator
- Currituck Sound/North River

Juvenile Abundance Index Survey (June – November)

- Core seine stations
- Expand sampling areas- seine and trawl

Independent Adult Sampling (February – May)

- Pound nets- Chowan
- Expand sampling to other systems
- Gill net survey above and beyond current Independent Gill Net Survey

12.1.3 River Herring Restoration (Stocking Program)

Issue:

Enhancing restoration of river herring through stocking programs.

Background:

Alarming concerns over the decline of river herring (alewife and blueback) landings and abundance and the Fisheries Reform Act requirement to end river herring overfishing in North Carolina has obligated the North Carolina Division of Marine Fisheries (NCDMF) to recommend the state-wide prohibition of any take of these species in both commercial and recreational fisheries. This management measure was recommended by the NCDMF with the hope of providing maximum protection of the resource and a maximum likelihood of increasing stock abundance. Unfortunately, a prohibition alone may not be adequate to restore river herring to a viable fishery in the prescribed time frame. Several other measures; stocking, habitat restoration, and improving water quality are also being explored as additional support for restoring NC's river herring resource. This issue paper addresses the possibility of providing restoration of river herring through stocking programs (adult relocation and/or larval stocking).

Current Authority

1) G.S. 143B-289.51. Marine Fisheries Commission – creation; purposes.

2) G.S. 113-132. Jurisdiction of fisheries agencies.

3) G.S. 113-132. Cooperative agreement by Department

4) G.S. 113-131. Resources belong to public; stewardship of conservation agencies; grant and delegation of powers; injunctive relief.

5) G.S. 113-181. Duties and powers of Department.

General Background on Stocking Programs

One approach to stocking river herring is through the relocation of adults. This involves capturing adult river herring in watersheds that support a healthy, sustainable spawning run and releasing these individuals into a depleted waterway. One such project in Massachusetts's is the "River Herring Restoration and Enhancement - Merrimack River Watershed". This river herring restoration effort began in 1995 by The Central New England Fishery Resources Office (CNEFRO) of the U. S. Fish and Wildlife Service. Annually, CNEFRO stocks approximately 10,000 river herring in the Merrimack River. Herring are trapped and transferred during April and May from a variety of rivers. In 2003, with the assistance of the Middleborough-Lakeville Herring Fishery Commission on the Nemasket River (MA) and the NH Fish and Game Department on the Cocheco/Oyster River (NH), more than 13,000 herring were transferred to the Merrimack. Cooperative partnerships between agencies are critical to provide adequate resources to carry out conservation efforts of this magnitude (USDI 2004). Although no current monitoring program for this restoration project are underway, habitat modifications to aid with this stocking program are taking place with the anticipation of future restored herring runs. In addition, other adult relocation programs have produced returning spawners; for example in Carr Pond, RI a depleted run of ~10,000 adults in the early 90's has been restored to a current annual run exceeding 350,000 individuals (Gilbert Stuart Museum 2002).

Another approach to increasing the abundance of river herring is through stocking larval herring into a watershed. This involves capturing broodstock, egg collection and fertilization, incubation and hatching, and then reintroduction into the target watershed. The "Anacostia Tributary System Herring Reconnaissance and Larval Stocking Project" in Maryland is one example that can be used as a possible model. This five year stocking program was initiated in 2000 and similar to the Merrimack project is made possible through a cooperative partnership. The Anacostia Fish Passage Working Group and the Potomac Crossing Consultants are working together on several mitigation projects designed to compensate for environmental impacts in the replacement of the Woodrow Wilson Bridge. One is specifically an attempt to help restore migratory river herring to historical spawning areas. Each spring a migratory fish survey and larval stocking program for river herring is conducted. River herring broodstock are captured, eggs are collected, fertilized, and then transported to the Maryland Department of Natural Resources Joseph H. Manning Fish Hatchery at Cedarville State Forest in Charles County, Maryland. After incubation and hatching, larvae are transported into Anacostia River tributaries for release. Since the induction of this project, approximately 13.1 million river herring larvae were stocked in Anacostia River tributaries. Again, cooperative partnerships were critical in providing fish, staff, and facility assistance in this conservation effort. In conjunction with this stocking program nearly all existing downstream fish blockage(s) on the Northwest Branch Anacostia were scheduled to have been removed and/or modified by 2004 thereby permitting full upstream migration and utilization of spawning habitat by these fish returning as adults (MWCG/ICPRB 2004). Findings from this stocking study supported conducting a priority monitoring program for at least an additional 5 years to measure the impact of stocking and habitat modification on upstream migration and spawning of river herring.

Literature on river herring restoration through stocking effort has yielded reports on the relocation of adults and the stocking of larval-stage fish; however, due to the short duration and available resources of these projects few detailed monitoring studies are currently underway. It is therefore difficult to quantify their success.

In this issue paper it's been necessary to use other species (i.e. American shad) as surrogates in areas where information is lacking. In addition, it must be understood that stocking is not a stand-alone measure, and any stocking program must be coupled with other conservation efforts such as preserving existing spawning stock and habitat and water quality restoration. Furthermore, additional information gathering and planning is required; specifically, target areas of restoration, goals of the numbers stocked, and an absolute time frame of the stocking project. In addition to any management tools used to aid in the rebuilding of this stock, it is imperative that the existing NC river herring be protected to ensure that there is a maximum likelihood of a future viable river herring fishery.

Discussion

1. **Is river herring restoration via stocking programs a feasible and realistic possibility?**

<u>Adult Relocation</u>

a. Restoration of the Concord River, Massachusetts via adult relocation has possibly shown signs of success. Concord River herring populations became extinct in the 1800's due to dam construction. In 2000, seven thousand adults were transferred from Nemasket River and after successful spawning an estimated 2,000,000 juveniles migrated downstream. The spring of 2003 would have shown the earliest signs of return spawners (CRAR 2005).

b. Successful adult stocking took place within Narrow River to Carr Pond, RI. Adults were relocated from the Connecticut River and other tributaries to Carr Pond. After spawning, brood stock returned to their native streams; however, offspring returned to Narrow River and Carr Pond in successive years and from a depleted run of ~10,000 adults in the early 90's the current annual run exceeds 350,000 (Gilbert Stuart Museum 2002).

c. Current indications are that the current spawning stock biomass is not sufficient to fully utilize the available spawning habitat in many areas of North Carolina (NCDMF 2005). If North Carolina waterways are not habitat limited in certain areas then adult stocking should be beneficial to river herring restoration.

Larval Stocking

a. Larvae have been documented to be successfully hatched and released into waterways. The Anacostia river herring restoration project successfully released over 13 million river herring larvae from 2000-2004 (MWCG/ICPRB 2004). In addition, experimental fry culture at the Harrision Lake National fish Hatchery successfully cultured, marked, and stocked over 220,000 larval river herring in James River, VA in 2005. However, both projects lack follow up monitoring programs to measure the success that these projects have had on actual spawning runs.

b.Larval stocking of American shad has been successful in North Carolina and other states. It is well documented and may show the possibility of successful river herring larval stocking efforts.

For example, restoration on the Susquehanna River is overseen by the Susquehanna River Anadromous Fish Restoration Cooperative. Partners in the cooperative are: Maryland Department of Natural Resources; New York Division of Fish, Wildlife and Marine Resources; Pennsylvania Fish and Boat Commission; Susquehanna River Basin Commission; U.S. Department of Commerce, National Marine Fisheries Service; and U.S. Department of the Interior, Fish and Wildlife Service.

The program involves passage of adult American shad at Conowingo, Holtwood, Safe Harbor, and York Haven hydroelectric dams, as well as stocking of American shad fry produced from fertilized eggs obtained since 1990 from the Hudson and Delaware rivers. Tank spawned fry produced using adult shad from the Conowingo fish lifts are also stocked. Abundance and distribution of American shad juveniles in the Susquehanna River are also monitored annually. From an estimated 3,516 shad in 1984, the current population estimate has risen to 1,005,797 (Susquehanna River Anadromous Fish Restoration Committee 2005).

2. Comparisons of adult relocation and larval-stage stocking

a. Research suggests that adult relocation stocking projects have been successful in other states. Although larval herring have been successfully stocked in large numbers, monitoring to measure their contribution to the abundance of return spawners is lacking.

b. Larval stocking is more expensive than adult relocation.

c. Fewer resources needed in adult relocation versus larval stocking. No egg collection, fertilization, and transportation to hatchery facilities required.

d. NCDMF lacks hatchery capability and a co-operative partnership with a hatchery facilities are required for larval stocking. Preliminary research shows co-operative hatchery capacity may not be a feasible alternative.

1. NCWRC does not have the resources available without impacting striped bass and American shad production.
2. USFWS Edenton Hatchery may have seasonal hatchery capacity available.
3. USFWS Harrison Lake, Virginia Hatchery may also have seasonal hatchery capacity, but lack funds and mode of larval transportation.

e. Larvae are susceptible to predation. Larval herring are preyed upon by a host of other species; including fish, reptiles, amphibians, mammals, and birds. A Connecticut Lake study estimated only 1 out of 80,000 spawned alewife produced a juvenile fish that escaped alive (Blankenship 2000).

f. Larvae are more sensitive than adults to environmental conditions. Exposure to significant changes in environmental conditions such as temperature and dissolved oxygen can be lethal (Stickney 1994).

g. Eggs/Larvae are prone to disease. During an experimental river herring fry culture at Harrison Lake National Fish Hatchery, the first 3 shipments of eggs experienced devastating fungus growths (Odom 2005).

3. Downfalls of stocking programs

Is stocking sound management? – Stocking programs are done at great expense and may actually mask the decline of the natural fish stocks (Oregon Trout 2005). In addition, for a stocking program to be successful, the program must provide fish for an area or population, have a positive return for the money invested, and have the fewest negative impacts on the native population or residents as possible (MICRA 2005). Should managers of a resource try to mitigate the decline of a population through stocking technology or is it better to direct their resources to the problems that have directly caused the decline?

Transportation mortality – Stress resulting from transportation can lead to high mortality. One study showed red drum that were transported for 5 hrs experienced an immediate 1% mortality, with a cumulative mortality after 10 days of 12 to 51% (Tomasso and Carmichael 1988). Stress from transportation can also lead to an increased possibility of disease. As a result of stress, immune responses in animals can become suppressed allowing disease organisms to proliferate (Bejerang and Sarig 1991), with the development of epidemic as soon as 24 to 48 hrs and as long as 2 wks after the stress event (Stickney 1995).

Limited North Carolina river herring spawning stock biomass – The 2005 river herring stock assessment shows spawning stock biomass to be at an all time low, so are these levels a feasible pool for adult relocation and what affects will the removal of adults have on the existing spawning run in that area?

Genetics – Hatchery raised fish suffer from a variety of problems, including genetic and behavioral changes, which contribute to low survival rates in the wild. Even more detrimental to wild fish stocks is the transmission of genetic defects and disease (Oregon Trout 2005).

Cost to Benefit (Success rate (return %)) – Larval stocking programs have yielded less than adequate return rates of adults. Chinook studies within the Snake River have demonstrated an average smolt-to-adult return rate of only 1.3% (FPC 2005).

4. Research and Program Set Up Considerations

Adult Relocation

I. Conduct Watershed Surveys to Determine:
   1. Areas of viable and non-viable spawning runs
   2. Areas with the greatest probability of brood stock yield
   3. Watershed with most viable environmental conditions

II. Establish a plan for stocking via adult relocation
   1. Determine hours and staff requirements
   2. Identify equipment and facilities needed
   3. Procure necessary funds

III. Collection/Transportation/Relocation of Adult Herring
   1. Collection of a predetermined amount of adult river herring
   2. Transportation of adults from a viable spawning run to the area of concern within the closest possible proximity

IV. Monitoring
   1. Conduct monitoring and analysis to determine the impact of adult relocation

Larval Stocking

I. Conduct Watershed Surveys
   a. Determine areas of viable and non-viable spawning runs
   b. Determine areas with the greatest probability of brood stock yield

II. Establish a plan for larval stocking program
   a. Create partnerships with other agencies
   b. Determine hours and staff requirements
   c. Identify equipment and facilities needed
   d. Procure necessary funds

III. Collection of Brood stock
  a. Collection of a predetermined amount of adult river herring brood stock
  b. Remove eggs from a predetermined amount of female river herring for a target number of river herring larvae
  c. Fertilize eggs with milt from an equal amount of male river herring
  d. Transport fertilized eggs to partnership agency for incubation and hatching

IV. Stocking of Larval Herring
  a. Collection of larval staged river herring from partnership agency
  b. Transport and stock larval herring to the watershed of concern

V. Monitoring
  a. Conduct monitoring and analysis to determine the impact of larval stocking

5. **Possible Funding Sources**
   a. Local governments that have an interest river herring restoration
   b. National Oceanic and Atmospheric Administration (NOAA) Community Based Restoration
   c. Federal Resource Grant (FRG) pilot study
   d. USFWS Fish Passage Funds
   e. USFWS Partners for Fish and Wildlife Program
   f. General Assembly
   g. Golden Leaf
   h. North Carolina Clean Water Trust Fund (NCCWTF)

Management Options/Impacts

Status quo-No stocking
+ No rule changes
+ Action requires no additional resources
- River herring stock unlikely to quickly recover to a viable fishery

Update spawning and nursery area surveys to assess stocking needs
+ No rule changes
+ Implementation of a stocking program on any scale still needs further

information gathering and planning for a successful outcome
+ Information obtained from river herring spawning surveys will enable sound decisions on stocking projects
- River herring stock unlikely to quickly recover to a viable fishery
- Additional funds required to conduct area surveys

Establish adult relocation programs
+ Increased likelihood of rebuilding river herring abundance through no-take provision coupled with stocking programs
+ Sources exist to apply for funds
+ Will create positive public support for river herring recovery
+ Cost of larval stocking program is more expensive than adult relocation
+ Eggs and larvae suffer high mortality rates
- Viable and sustainable brood stock sources are not known in NC
- Could promote public perception of stocking as a “cure all”
- May require the collection of more brood stock than larval stocking
- Possible transportation mortality of limited brood stock
- Additional funds required to establish stocking program

Establish larval stocking programs
+ Increased likelihood of rebuilding river herring abundance through no-take provision coupled with stocking programs
+ Will create positive public support for river herring recovery
+ Would require the collection of less brood stock than adult relocation
+ Sources exist to apply for funds
- Division hatchery capability does not currently exist
- Additional funds required to establish stocking program
- Viable and sustainable brood stock sources are not known in NC
- Could promote public perception of stocking as a “cure all”
- Cost of larval stocking program is more expensive than adult relocation
- Eggs and larvae suffer high mortality rates

Establish a combination of both adult relocation/larval stocking projects
+ Potential maximum likelihood of rebuilding river herring abundance through no-take provision coupled with stocking programs
+ Will create positive public support for river herring recovery
- Viable and sustainable brood stock sources are not known in NC
- Could promote public perception of stocking as a “cure all”
- Division hatchery capability does not currently exist
- Cost of larval stocking program is more expensive than adult relocation
- Possible transportation mortality
- Eggs and larvae suffer high mortality rates
- Additional funds required to establish stocking program

DMF and Advisory Committee Recommendation

The River Herring PDT and AC recommends that the DMF proceed immediately to update the river herring spawning and nursery area surveys and evaluate the best course of action concerning river herring stocking programs.

Additional information gathering to evaluate current conditions of spawning areas and runs needs to be determined for sound management decisions. In addition, the implementation of any stocking plan also needs to state specific objectives such as total numbers of stocked individuals needed, absolute time frame of the stocking project, and the monitoring program that will be utilized. Resource enhancement of river herring through the relocation of adults, stocking of larval staged individuals, or a combination of the two should be explored as possible aid in rebuilding the abundance of NC river herring. However, for any future stocking project to be made possible cooperative partnerships (i.e. with NCWRC, USFWS, FRG) must be established to provide adequate resources to carry out conservation efforts of this magnitude. In researching stocking programs of river herring along the entire east coast not one project was established and carried out alone. NCDMF will have to identify additional resources to conduct a full-scale stocking program of this scope.

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Prepared 12-13-05, updated 2/13/06

12.1.4 Striped Bass Predation as it Relates to River Herring

Issue:

The impacts of predation on river herring by other species, with emphasis on striped bass.

Background:

Numerous food habit studies (Manooch 1973; Cooper et al. 1998; Patrick and Rulifson 2003; Tuomikoski 2004; Rudershausen et al. 2005) have been conducted on striped bass in the Albemarle Sound area. All of these studies have shown that striped bass feed on numerous species of finfish and invertebrates and will vary by season and area. Striped bass have been described as opportunistic, generalists, and selective feeders throughout their range in the wild (Merriman 1941; Raney 1952; Manooch 1973; Boynton et al. 1981; Gardiner and Hoff 1982; Matthews at al. 1988; Cooper et al. 1998), and clupeid prey dominate the diets of Atlantic coast populations (Walter et al. 2003).

Striped bass have long been suspected of consuming large numbers of Atlantic menhaden in Atlantic coastal systems (Oviatt 1977), and modeling indicates that the current striped bass population size may be capable of limiting populations of clupeid prey along the US Atlantic coast (Hartman 2003). Overall, Atlantic menhaden is the predominate finfish species consumed by striped bass in the Albemarle Sound area (Manooch 1973; Cooper et al. 1998; Patrick and Rulifson 2003; Rudershausen et al. 2005). In the spring an increase in the occurrence of adult blueback herring and alewife occurs in striped bass stomachs but would be expected during spawning migrations (Manooch 1973; Patrick and Rulifson 2003). During the fall emigration of juvenile river herring an increase in Age-1 striped bass selectivity for these species occurs (Rudershausen et al. 2005).

Current Authority:

NC General Statutes: G.S. 113-181. Duties and Powers of Department
G.S. 143B .289.51 Marine Fisheries Commission-creation/purpose
G.S. 113-224 Cooperative Agreements by Department

Discussion:

River herring recruitment failure coupled with high exploitation has resulted in dramatic population declines. Even though the decline in the river herring stocks did not coincide with the resurgence of the striped bass population to an all time high, predation on such small river herring stocks are likely having an impact.

Recent striped bass feeding habit studies (Patrick and Rulifson 2003; Tuomikoski 2004; Rudershausen et al. 2005) are similar to historical studies (Manooch 1973). Both current and historical studies generally agree that there are differences in prey selection between eastern and western regions of the sound and diversity between seasons. Menhaden dominated stomach contents throughout the area and seasons. The eastern samples had a higher occurrence of anchovies and blue crabs and the western samples blueback herring and alewife. During the spring and fall the occurrence of blueback herring and alewife increased in the samples.

Management Options/Impacts

Status Quo- No action

+ No changes in management or fishing practices
- River herring stock unlikely to quickly recover to viable fishery

Encourage additional research on predation (not just striped bass)

+ Need for research outside the Albemarle Sound area
+ Unknown ocean predation
+ Addresses seasonality of river herring availability
- Could prolong fishing restrictions actually caused by predation impacts rather than overfishing

Establish river herring restoration programs

- + Potential maximum likelihood of rebuilding river herring abundance
- + Create positive public support for river herring recovery
- - Could overshadow other measures necessary for recovery

Allow increase in striped bass harvest

- + Reduce predation on river herring
- + Positive public support from the recreational and commercial fishermen
- - Impact on striped bass population
- - Other species prey on river herring

Move toward Ecosystem Management approach

- + Provide for management of all species and habitat
- - Data are not available nor are procedures established for ecosystem management

DMF Recommendation: Endorse additional research on predation and restoration programs for river herring.

Advisory Committee Recommendation: Endorse additional research on predation and restoration programs for river herring and to consider development of Albemarle Sound multi-species ecosystem program.

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2/16/06
4/3/06

12.1.5 Atlantic Ocean Harvest of River Herring

Issue

River herring bycatch in the Atlantic Ocean fisheries.

Background

Harvest of river herring by offshore fisheries has long been a concern of state and regional management agencies because the migratory patterns of alewife and blueback herring subject them to direct and bycatch harvest in coastal waters. Unfortunately, given the diverse nature of offshore fisheries it can be difficult to accurately monitor harvest levels, and it is impossible to allocate the harvest to particular producer areas.

Since 1950, the National Marine Fisheries Service (NMFS) has collected landings statistics for river herring and recorded the information under the species heading "Alewife" (blueback herring and alewife) (Figure 1). Total alewife landings by state are available, but offshore and riverine landings are not consistently recorded separately.

The NMFS landings data may or may not include riverine and near shore ocean harvest (0 – 3 miles), depending on how a given state reports the information. Other known sources of blueback herring harvest are not included in the coastal statistics. For example, blueback herring migrate as far North as the Bay of Fundy, and are thus vulnerable to further harvest by Canadian fisheries. Also, both joint-venture (U.S. vessels deliver catch to foreign processing vessel at sea) and directed foreign vessel fisheries harvest some river herring as bycatch, mostly in the Atlantic mackerel and Atlantic herring fisheries.

Foreign Harvest in the U.S.

Substantial oceanic landings of river herring were reported by foreign fishing fleets operating in the United States coastal waters between 1967 and 1972. In 1969, the total reported landings of river herring in the foreign fishery peaked at 24 million pounds. Foreign fleets harvested primarily fish that were less than 7.5 inches long and mostly immature (Street and Davis 1976). This level of fishing pressure on sub-adult river herring probably was a major factor in their declines along the Atlantic coast seen in the mid-1970s.

Since 1977, the foreign fishery for river herring within the U.S. Exclusive Economic Zone (200 mile limit) has been restricted by federal rules under the authority of the Magnuson-Stevens Act. The annual allocation of river herring landings to the foreign fisheries between 1977 and 1980 was 1.1 million pounds. Since 1981, total annual allocation has been limited to 100 metric tons (220,460 lb), less than 2% of the total US river herring harvests in a typical year prior to that period. However, because the foreign trawl fishery and the joint-venture fishery for Atlantic mackerel take mostly immature river herring as a bycatch, the potential for overharvesting effects on the stocks still exists. Even though foreign fishing pressure on river herring stocks in offshore waters has been reduced for 28 years, the population has not recovered anywhere along the Atlantic Coast.

Domestic Harvest in the U.S.

Domestic commercial harvest in the Atlantic Ocean is another possible cause of blueback herring decline. Since the recovery of Atlantic herring, *Clupea harengus* stocks, both effort and landings of Atlantic herring have increased (Anonymous 1998). The bycatch of blueback herring in this fishery is generally low and likely not significant to the coastwide population of blueback herring but the impact of bycatch by nearshore boats on homewater returns of river herring in nearby rivers is unknown (Bill Overholtz, NOAA Fisheries- NEFC, personal communication). There has also been an increase in the landings of blueback herring from offshore fisheries in Connecticut during the 1990s (CTDEP/Marine Fisheries Division, unpublished data) as well as anecdotal reports of the presence of blueback herring in the Atlantic herring catch.

To improve management of river herring under the cooperative Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fishery Management Plan for Shad and River Herring, the ASMFC contracted an investigation of ocean landings of both shad and river herring in the late 1980s. Acknowledging potential discrepancies in NMFS and state ocean landings data, Harris and Rulifson (1989) attempted to separate riverine and state territorial ocean landings from true offshore harvest. Results indicate that total ocean landings of river herring from 1978 through 1987 ranged between 52,100 and 688,400 pounds and accounted for 0.5% to 11% of the river herring landings (Table 1). The range is somewhat misleading, since in most years' ocean landings were around 2% of the total. The unusually high value of 11% observed in 1978 was attributed to low coast-wide landings and unusually high ocean landings of river herring in Massachusetts. States having significant ocean landings of river herring from 1978 through 1989 were Massachusetts, Virginia, New York, and North Carolina, with harvest taken as bycatch in other fisheries. There are no known directed ocean fisheries for river herring.

Reported ocean landings do not include bycatch by joint venture or foreign fisheries for Atlantic mackerel. Since 1981, these fisheries have been limited to an allowed bycatch of 220,000 pounds of river herring, most of which were immature. Between 1981 and 1989 bycatch in these fisheries ranged between 16,000 and 220,000 pounds (Table1). In the early 1990s river herring accounted for 5 to 10% of the catch in the Atlantic mackerel fishery. Since that time the migration patterns of Atlantic mackerel have shifted further offshore, outside the area used by river herring, eliminating this bycatch (J. Rhule, NC Rep. MAFMC, personal communication).

The NMFS has been conducting an observer program in the Atlantic herring fishery since 1994 (NEFMC 2005). Observer trips occur from Cape Cod north and are divided between the purse seine, mid-water trawl and pair trawl fisheries. From 1994 through 2004, no river herring bycatch was observed in the purse seine fishery, 69,741 pounds in the mid-water trawl fishery and 45,024 pounds in the pair trawl fishery. During 2004, two pounds of river herring were observed in the Atlantic herring mid-water trawl fishery and 20,209 pounds in the pair trawl fishery. The Maine Department of Marine Resources established an observer program in the Atlantic herring fishery in 1997 and reported that the fishery relative to river herring was a clean fishery. The bycatch estimates of river herring have ranged from 404 – 7,319 pounds. From 2000 through 2002, a Canadian observer program was conducted in their mid-water trawl fishery on George's Bank, with 2,000 pounds of river herring bycatch (NEFMC 2005).

The ASMFC Shad and River Herring Technical Committee (October 2005) at the request of the Management Board are taking steps to gather and analyze existing bycatch data collected by NMFS and anecdotal reports of river herring observed in markets as "bait" along Atlantic Coast states. The Technical Committee has made a request to the ASMFC Shad and River Herring Management Board to intercede with NMFS or the appropriate Fishery Management Councils to prioritize the alosines for bycatch monitoring, either in the on-board observer program or some shore based program. Better data for bycatch of shad and river herring in the Atlantic herring, Atlantic mackerel and other pelagic fisheries is crucial to understanding sources of mortality for these important fishes.

Commercial ocean harvest of river herring also occurs as bycatch in other fisheries of various gear types: gill nets, otter trawls, and haul seines. From 1980 through 2004, the majority of the river herring harvest (in river and ocean) was taken in North Carolina

(62.5%), Maine (18.5%) and Virginia (12.3%). Beach haul seines and trawls accounted for the major portions of North Carolina's Atlantic Ocean landings during 1962 – 2004. From 1975 – 2004, Atlantic Ocean river herring landings from North Carolina have ranged from 0 to 143,232 lbs, with an average during the period of 21,371 pounds per year.

Current Authority

NC General Statutes: G.S. 113-181. Duties and Powers of Department
G.S. 143B .289.51. Marine Fisheries Commission- creation/purpose
G.S. 113-224. Cooperative Agreements by Department

Discussion

In general river herring stocks are declining coastwide. Each coastal state, in cooperation with the appropriate Fishery Management Councils, ASMFC and NMFS needs to ensure that bycatch monitoring programs for alosines, either through an on-board observer program or shore based programs are implemented. Bycatch data are crucial to understanding sources of mortality and associated impacts to river herring stocks.

Management Options/Impacts

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

1. No action
   + No additional restrictions on fishing practices.
   - Uncertainty of impacts relative to river herring bycatch on stocks
   - Continued harvest/bycatch of mainly sub-adult river herring and sexually mature river herring.

2. Endorse additional research coastwide to collect river herring bycatch data from Atlantic mackerel, Atlantic herring and other pelagic fisheries.

   + Increases the understanding of river herring bycatch and provide biological data.
   + Provide continuity between areas and data collection of the fisheries.
   + Data could be incorporated into river herring coastwide stock assessment in the future.
   - Funding and personnel would have to be obtained to conduct the program(s).
   - Would take several years to have adequate data.

DMF Management Recommendation:
Endorse additional research coastwide to collect and assess river herring bycatch to a high level of precision from ocean fisheries. Request NMFS to allocate adequate funds to conduct such studies.

Advisory Committee Management Recommendation
To adopt Management Option 2- endorse additional research coast-wide to collect river herring bycatch data from the Atlantic mackerel, Atlantic herring, and other pelagic fisheries.

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Table 1. Total ocean landings of river herring (Harris and Rulifson 1989).

Year	Domestic	Ocean % of Total landings	Bycatch	Total
1978	688,400	11.4		
1979	52,100	1.1		
1980	92,060	0.8		
1981	238,830	2.9	24,250	263,080
1982	274,480	2.1		
1983	114,050	1.2	16,241	130,291
1984	244,500	2.5	42,833	287,333
1985	66,360	0.5	220,656	287,016
1986	137,740	1.5	37,700	175,440
1987	135,380	2.4	179,674	315,054
1988			152,999	
1989			166,888	

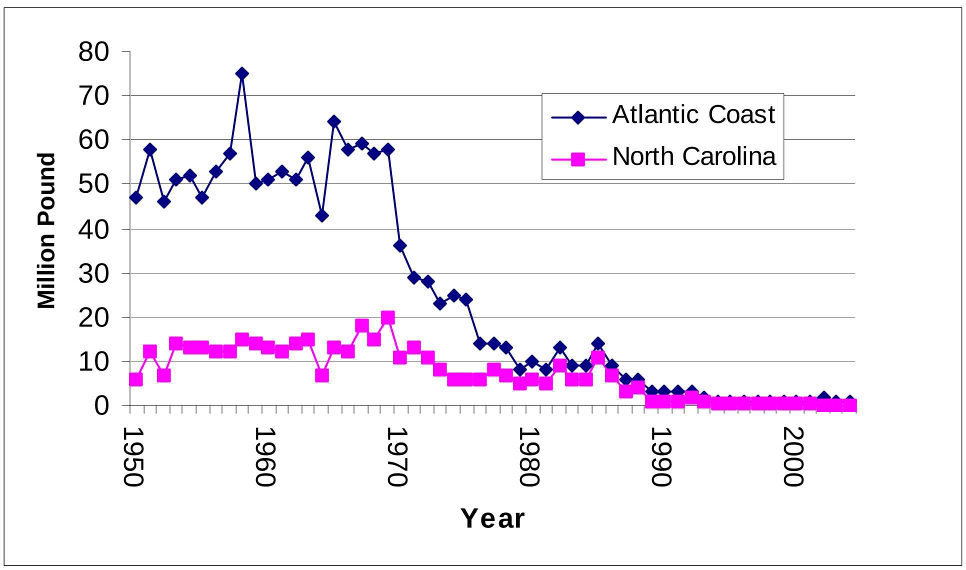

Figure 1. Total landings of river herring by Atlantic Coastal states and North Carolina, 1950 – 2004.

12.1.6 Critical Habitat- Anadromous Spawning and Nursery Areas

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

Background: Protection of the quantity and quality of river herring (blueback herring and alewife) habitat, is essential to the goal of this plan. Increasing human activity across North Carolina continues to have a significant influence on habitat quantity and quality as well as associated wildlife and fisheries resources. Habitat alterations have already significantly impacted some resident wildlife populations either directly or indirectly. Wetlands form a unique interface between terrestrial and aquatic ecosystems, providing valuable water related functions and important habitat for a broad range of fish and wildlife species. Major conversions of coastal and freshwater wetlands have occurred due to agricultural and silvicultural expansion, industrial development, and urban encroachment, including resort communities. Impacts on the entire system of coastal aquatic habitats are magnified due to the loss or disruption of important wetland functions and connections. It is estimated that North Carolina has already lost 34% of its coastal wetlands (DCM 1999), which are critical fisheries habitat. Craig and Kuenzler (1983) reported a 30% reduction in oak-gum-cypress wetlands from 1964 to 1974 in the NC portion of the Chowan basin. Habitat conservation and protection is directly related to environmental quality.

Current Authority:

General Statutes of North Carolina

G.S. 143B-289.52	Marine Fisheries Commission- powers and duties
G.S. 143B-279.8	Coastal Habitat Protection Plans
G.S. 113-132	Management Jurisdiction
G.S. 113-129	North Carolina Wildlife Commission–powers and duties
G.S. 113-134	Rules
G.S. 113-182	Regulations of Fishing and Fisheries

Marine Fisheries Commission Rules

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

3I .0101 Definitions

(20) (C) Anadromous fish spawning areas are those areas where evidence of spawning of anadromous fish has been documented by direct observation of spawning, capture of running ripe females, or capture of eggs or early larvae.

(D) Anadromous fish nursery areas are those areas in the riverine and estuarine systems utilized by post-larval and later juvenile anadromous fish.

North Carolina Wildlife Resources Rules

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

10C.0500 Primary Nursery Areas

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

The DMF has the authority to designate Critical Habitat Areas, Anadromous Spawning and Nursery Areas and regulate fishing activities in these areas. DMF has conducted anadromous spawning and nursery area surveys in the Albemarle Sound area, Tar-Pamlico, Neuse, White Oak, New and Cape Fear river systems. Except for the Albemarle Sound area, no directed surveys have occurred since the early 1980s. Figures 1 and 2 shows the areas in each system that has been documented to function as spawning and/or nursery areas for river herring. Although these areas have been identified by DMF, they have not been adopted into rule, making the designations only descriptions of the areas.

The 1997 Fisheries Reform Act mandates that DENR shall prepare Coastal Habitat Protection Plans (CHPP). The goal of the CHPPs is the long-term enhancement of coastal fisheries associated with coastal habitat. The DMF, DWQ and DCM developed the first CHPP, with assistance from other federal and State agencies. The plan: (1) describes and classifies habitats and associated biota, (2) evaluates the function, value to coastal fisheries, status, and tends of the habitats, (3) identifies existing and potential threats to the habitats and the impact on coastal fishing and (4) recommends actions to protect and restore habitats. The CHPP distinguishes six habitat types supporting coastal fisheries: water column, shell bottom, submerged aquatic vegetation, wetlands, soft bottom and hard bottom. By approving the CHPP in December 2004, the actions of the MFC, EMC and the CRC must be consistent with the recommendations outlined therein.

Special waters classification by the EMC such as Outstanding Resource Waters (ORW) are given higher water quality standards and additional consideration of impacts by DCM prior to issuing development permits. The EMC has also designated the Chowan River, Neuse River and Tar-Pamlico River basins Nutrient Sensitive Waters (NSW), thus requiring nutrient management strategies for both basins. The nutrient management strategy includes a 30% reduction in nitrogen loading from agriculture, no net increase in phosphorous, protection for riparian areas, stormwater runoff control, and wastewater discharge standards. Substantial reductions in nutrient loading have already been achieved in the Chowan River Basin. Adherence to the rules already put in place and proposed by the EMC, as part of the NSW management strategies should slow the eutrophication in the Neuse and Tar-Pamlico basins.

Regulations by the CRC do not allow authorization of projects that can violate water quality standards or adversely affect the life cycle of estuarine resources. The CRC regulates development activities in Areas of Environmental Concern (AEC), which include coastal wetlands. Generally, no development is allowed in coastal wetlands except water dependent activities, such as docks. However, the majority of wetlands bordering anadromous fish spawning habitats are not within the CRC jurisdiction. The EMC manages all wetlands through the 401/404 Certification Program, under the federal Clean Water Act. This program focuses on avoiding and minimizing filling of wetlands and stream through review of all Environmental Assessments (EAs), Coastal Area Management Act (CAMA), and ACOE permit applications to determine if the project will violate water quality standards. Although both DWQ and DCM are authorized to protect wetlands and submerged lands, dredging, filling and other shoreline modifications are permitted. Over half of North Carolina's original wetlands have been destroyed in the past 200 years. Estuarine shoreline continues to be armored at a rate of at least 25 mi/yr (NCCF 1997). Furthermore while these programs recognize the relatively greater biological value of nursery areas and outstanding resource waters, they fail to adequately address cumulative impacts from piecemeal development.

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

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

Management Recommendations:

- Advocate the adoption of DMF identified anadromous spawning and nursery areas in the Albemarle Sound area for river herring into rules. In other coastal areas of the state where anadromous spawning areas have been identified for use by river herring rule adoption should occur. Update anadromous nursery area surveys in systems outside the Albemarle area.
- Advocate stronger enforcement of regulations protecting critical habitat in the management areas.
- Purchase land adjacent to critical habitat areas to ensure that these areas are protected.
- Advocate that coastal counties undertake the preparation and aggressive funding of open space preservation and conservation plans (example, Wake County Consolidated Open Space Plan, which adopted a minimum goal of 30% of the county preserved).

- Continue to make recommendations on all state, federal and local permits where applicable.
- Support implementation of habitat recommendations of the Coastal Habitat Protection Plans, Albemarle-Pamlico Estuarine Study, and the Estuarine Shoreline Protection Stakeholders Report.
- Maintain, restore and improve habitat to increase growth, survival and reproduction of river herring.

Research Needs:
- Update the spawning and nursery area surveys conducted previously in all areas.
- Identify potential incentives to landowners for protection of riparian buffers in the management area.
- Develop, identify and clarify what critical habitat actions are needed to protect, enhance and restore habitats and water quality affecting river herring.

DMF Recommendation- Support habitat protection, the management recommendations and research needs.

AC Recommendation- Support habitat protection, the management recommendations and research needs.

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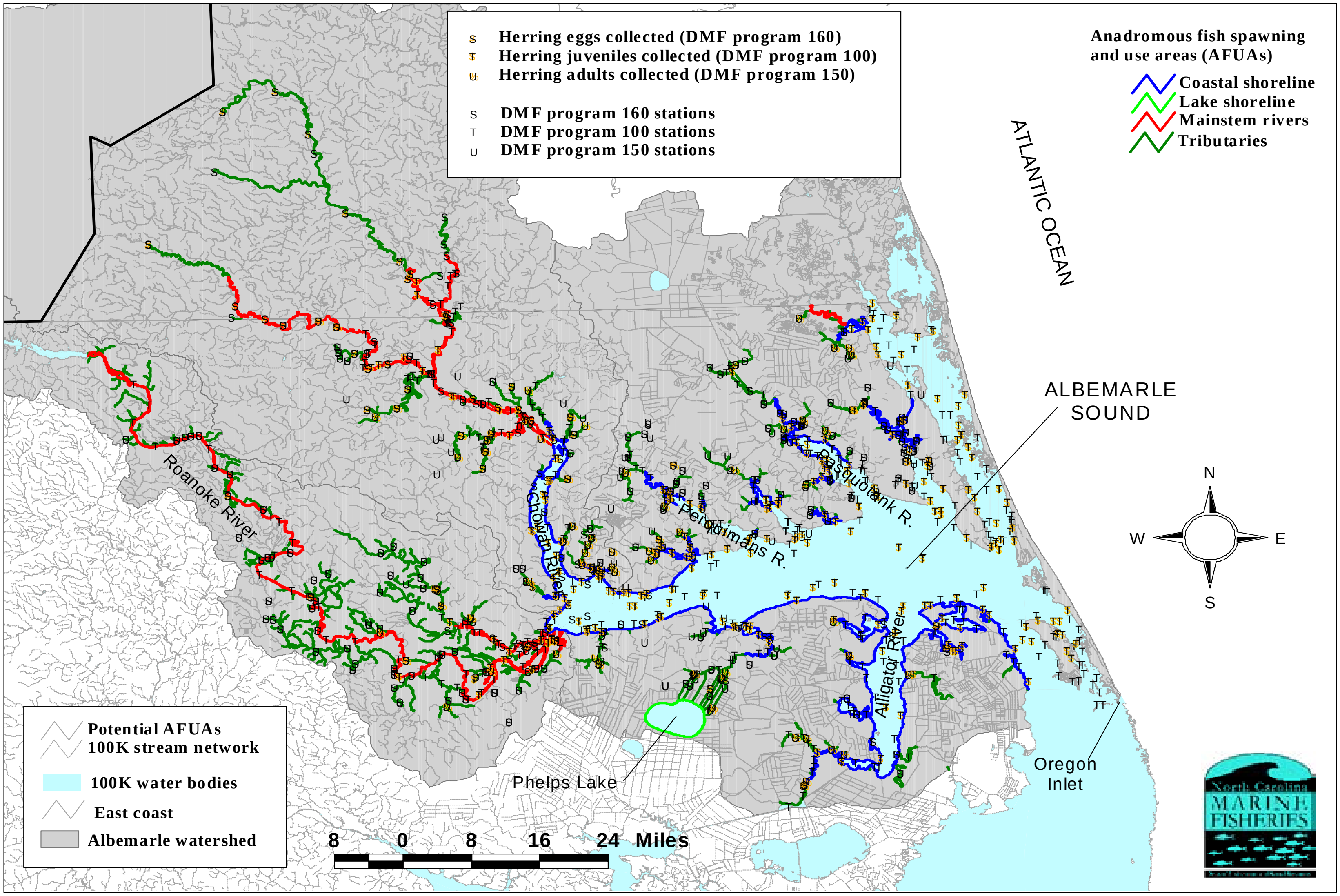

Figure 1. Anadromous fish spawning and use areas by hydrographic type with location of river herring collections by DMF.

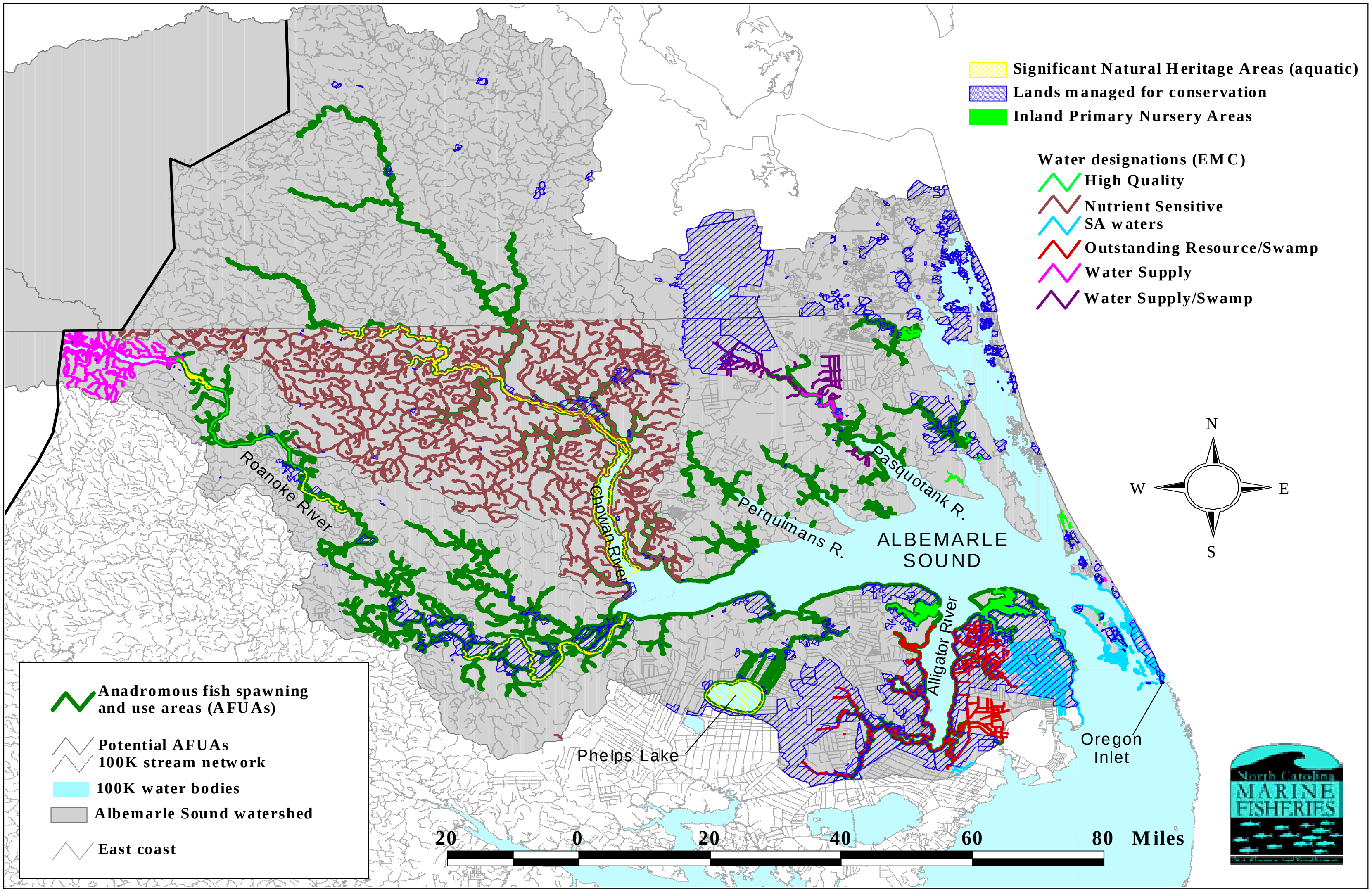

Figure 2. Regulatory designation and conservation of anadromous fish spawning and use areas and their associated watersheds.

12.1.7 Water Quality

Issue: Water quality improvements in river herring management areas.

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

The water quality of coastal rivers in NC has been monitored for many years, but few studies have attempted to document the effects of water quality on river herring. Rulifson (1994) listed poor water quality, including chemical pollution, turbidity, and low dissolved oxygen as a concern in relation to the decline in river herring stocks. The few studies that have investigated this relationship have focused on the Chowan River basin.

Current Authority:

General Statutes of North Carolina

G.S. 143B-289.52	Marine Fisheries Commission- powers and duties
G.S. 143B-279.8	Coastal Habitat Protection Plans

Discussion:

Point Source Discharges

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

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

The Chowan River was the first coastal river in North Carolina to experience major eutrophication problems in part due to nutrient inputs from point source dischargers, which resulted in the classification of Nutrient Sensitive Waters by the EMC in 1979. Since that time best management practices have been implemented in agriculture, municipal wastewater treatment facilities in the basin have converted to land application, the fertilizer plant at Tunis closed, and paper and textile mills have implemented processes to improve the quality of their discharges. Nitrogen inputs into the Chowan River from point sources have declined 92% between 1982 and 1997.

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

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

Non-point discharges

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

Maintenance of good water quality in spawning and nursery habitats is essential to the well-being of river herring stocks. High concentrations of suspended solids (500-1000 mg/L^{-1}) significantly reduce hatching and survival of river herring eggs. When impacts on reproductive processes are severe, year-class strength, and ultimately recruitment of individuals to the fishery, is significantly reduced. Management strategies focused on the protection and maintenance of the water quality functions of wetlands, specifically for nonpoint source pollutant abatement, need to be strengthened and enforced in coastal North Carolina. DWQ has identified the need for more widespread monitoring data to better assess the impacts of nonpoint sources of pollution on water quality.

Hypoxia Events

Dissolved oxygen (DO) concentrations >5 mg/L are recommended for all life history stages of river herring. As oxygen levels drop below this standard, potential population impacts include deformities and reduced hatch of eggs, postlarval and larval mortality (Klauda et al. 1991).

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

Blue-green algae blooms

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

Pfiesteria

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

Contaminants

The persistence of dioxins, mercury and other contaminants in our river basins can have significant and adverse impacts on aquatic and terrestrial organisms, and when absorbed or ingested by humans, pose serious and life threatening consequences. Dioxins are unintentionally produced in many manufacturing and incineration processes and are some of the most carcinogenic substances known to man. Dioxins do not mix with water, instead binding tightly with sediment, food particles and organic matter, leaving extremely low concentrations dissolved in the water. Due to the slow breakdown rate of dioxins, organisms (like large fish such as bass and bowfin) exposed to continuous sources of dioxins tend to have higher levels in their tissues than fish that are lower in the food chain. Bioaccumulation of these substances in certain sections of the A/R management area has resulted in fish consumption advisories being posted to warn the public of the health risks posed by eating fish. Research needs in the southern systems include an assessment of the sediments in the lower Neuse and Pamlico rivers for the presence of contaminants resulting from Hurricane Floyd.

DWQ has monitored dioxin levels in fish tissues from the Roanoke River, Chowan River and Albemarle Sound since 1989. Fish consumption advisories for the Roanoke River and Welch Creek have been in place since 1990 and for Albemarle Sound since 1991. The current advisory, as of March 2001, covers Welch Creek; the Roanoke River from the U.S. Highway 17 bridge near Williamston to the mouth of the Albemarle Sound; and Albemarle Sound from Bull Bay to Harvey Point and west to mouth of the Roanoke River and the mouth of the Chowan River at the US Highway 17 Bridge. The advisory reads, "Catfish and carp from these waters may contain low levels of dioxins. Women of childbearing age and children should not eat any catfish or carp from this area until further notice. All other persons should eat no more than one meal per person per month of catfish and carp from this area."

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

Channelization

Stream channelization, most often associated with flood control projects, has also resulted in impacts to water quality and loss of essential habitat. Channelization results in high water velocities occurring preventing the entrance of adult and juvenile herring in areas. These type projects also removed in-creek vegetation and woody debris which serves as substrate for fertilized eggs and reduced habitat for invertebrates resulting is a reduction in diversity and quantity of prey for juvenile herring. Disposal of spoil along the created spoil banks prevents access for adults and juveniles to sloughs, pools, adjacent vegetated areas and backwater swamps.

Sholar (1975) stated that a channelized section of the New River did not provide suitable spawning habitat, contributing to reduced recruitment within the system. Hawkins (1980) also noted that channelization had reduced habitat in Swift, Little Swift and Bear creeks within the Neuse River basin. In the Albemarle Sound area, channelization projects have taken place on numerous tributaries, including the Cashie River, Ahoskie Creek, Joyce Creek, Pollock Swamp, Bear Swamp and Burnt Mill Creek. In the Albemarle area, 281.1 miles of streams have been channelized (Table 1). Some of these creeks have "re-naturalized" and river herring have returned but it has taken almost 35 to 40 years. Some of these streams are being considered for "re-channelization" by the Division of Soil and Water (DSW). Allowing these projects to proceed would condone degradation of anadromous spawning habitat and water quality.

Management Recommendations:

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

1. Eutrophication: Limit nutrient discharges which amplify algae blooms and stimulate growth of other aquatic vegetation that can negatively affect water quality, cause fish kills, and restrict fishing and boating activities. Develop nutrient discharge limits with DWQ and local soil and water conservation districts.

2. Sediment discharges: Control sediment discharges into the watershed which are adults, and quality of spawning habitats. Sedimentation from erodible agricultural fields, urban development, unstable shorelines and road construction is exacerbated by the loss of wetlands and vegetated riparian zones. Develop sediment discharge limits with the NC Division of Land Quality and local soil and water conservation districts.

3. Oxygen demanding effluents: Encourage DWQ to develop an accurate oxygen budget for waters within each coastal river basin. Require existing and future dischargers to comply with BOD limitations such that dissolved oxygen levels in basin waters are not compromised.

4. Anthropogenic fish kills: Limit anthropogenic-caused fish kills, such as those caused by livestock lagoon failures and other sewage discharges which severely reduce fish abundance and eliminate or reduce spawning stock. This should also include assessment of effluents produced as a by-product of reverse osmosis facilities.

5. Impervious surface areas: Encourage the development and implementation of adequate stormwater management plans to minimize the use of impervious surfaces in urban and developed areas.

6. Riparian zones: Protect existing vegetated riparian zones and establish new buffers along coastal waterways.

7. Wetlands: Protect existing wetland habitat from loss to development, encourage restoration of prior converted wetlands, and advocate creation of wetland habitat where appropriate.

8. Spawning/nursery areas: Protect spawning and nursery areas of resident and anadromous species from development practices, which degrade habitat quality.

9. Shoreline hardening: Encourage developers to maintain shoreline in its natural state. When shoreline stabilization cannot be avoided, promote the use of shoreline protection that provides the least impact to aquatic organisms. Research conducted in coastal NC rivers by the WRC has determined that riprap (rock) shorelines support greater fish diversity and higher densities of fishes than bulkhead shorelines.

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

Research Needs:

- Membrane Water Treatment Plants: Evaluate the impacts/effects of reverse osmosis plants on receiving waters and aquatic resources.

- Water quantity: Evaluate the effects of existing and future water withdrawals on water quality and quantity and fisheries habitat in coastal watersheds.

- Contaminants: Determine if contaminants are present and identify those that are potentially detrimental to various life history stages of river herring. Specific areas of concern include the lower Neuse, Pamlico, Chowan and Roanoke rivers.

DMF and Advisory Committee Management Recommendation:

- Work in coordination with agencies such as the Division of Water Quality (DWQ), Division of Water Resources, Division of Land Quality, and Natural Resource Conservation Service to maintain, restore and improve water quality to increase growth, survival and reproduction of river herring. Priority activities identified include the establishment of buffer strips and conservation easements within each basin, and the continued refinement of best management practices on lands used primarily for agriculture, silviculture and industrial and residential development.

- Support implementation of recommendations of DWQ basinwide water quality management plans, particularly measures that will reduce nutrient loading, sediment delivery and associated turbidity in all coastal watersheds.

- Support implementation of habitat and water quality recommendations of Coastal Habitat Protection plans (CHPPs), the Estuarine Shoreline Protection Stakeholders report (1999), and the Albemarle-Pamlico Estuarine Study (1994) which includes the Comprehensive Conservation and Management Plan (CCMP).

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Table 1. Channelization projects in the Albemarle Sound area, by system, county and miles affected.

Project name	**Counties**	**Miles affected**
Ahoskie Creek	Bertie, Hertford, Northampton	65.7
Cutawhiskie Creek	Hertford, Northampton	53.9
Pollock Swamp	Chowan	25.0
Horse/Flat Swamp	Hertford	26.1
Hobbsville/Sunbury	Chowan, Gates, Perquimans	60.0
Gum Neck	Tyrrell	16.9
Folley Ditch	Gates	7.4
Burnt Mill Creek	Chowan, Perquimans	9.0
Bear Swamp	Perquimans, Chowan	17.1
Total		**281.1**

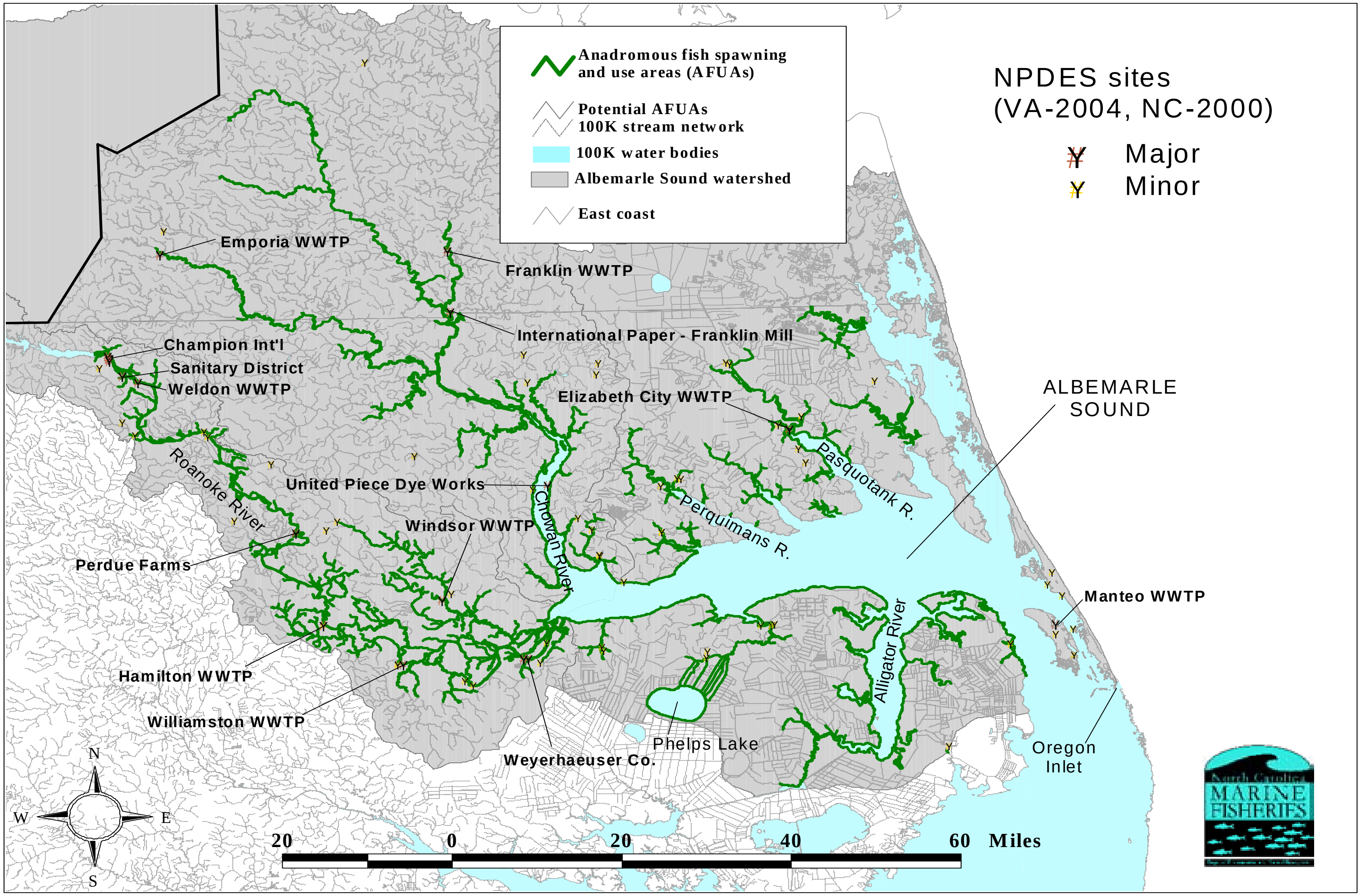

Figure 1. Location of National Pollution Discharge Elimination System (NPDES) sites in the Albemarle Sound watershed.

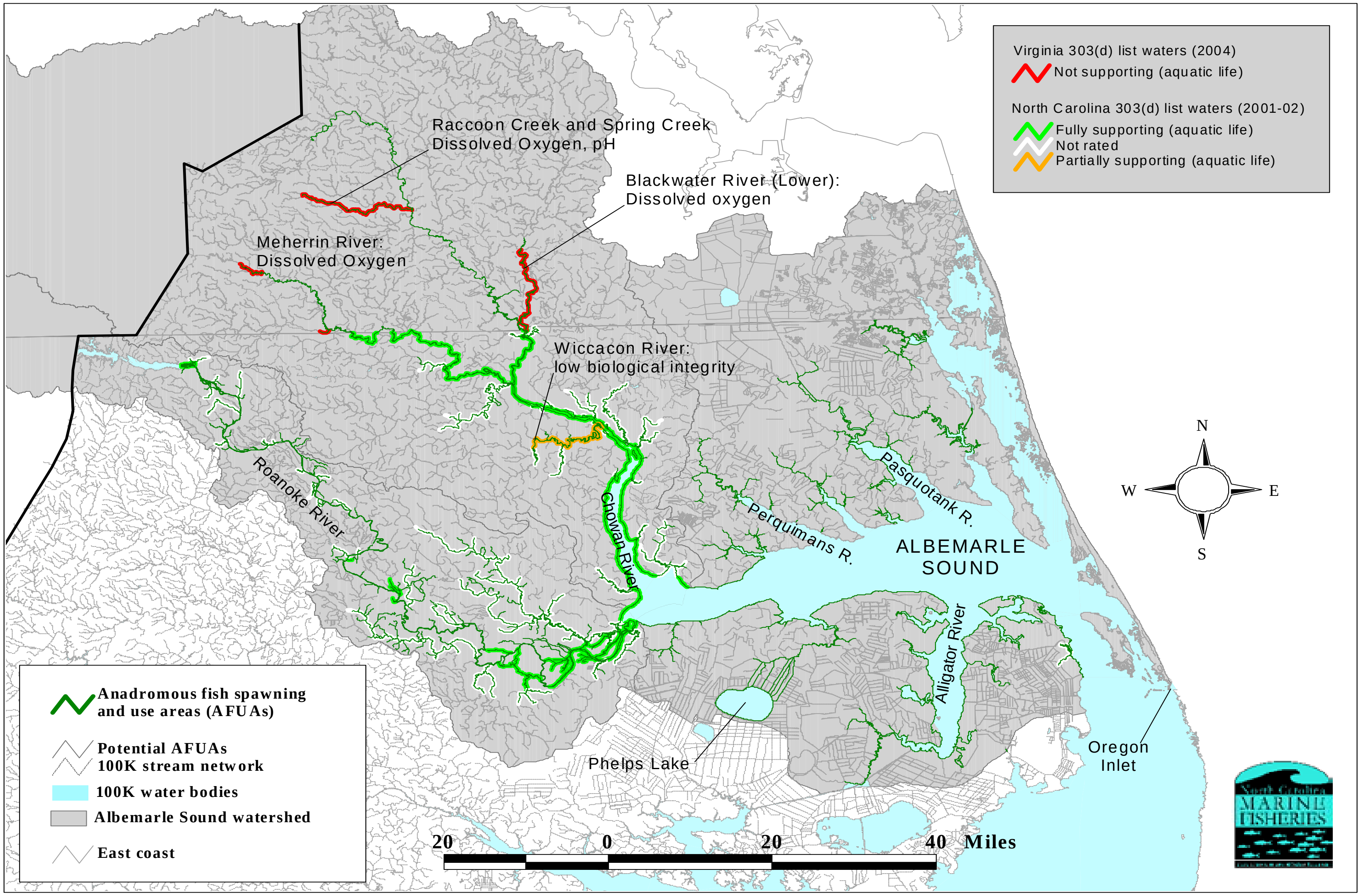

Figure 2. Use Support assessment results for streams of the Albemarle Sound drainage. Streams rated as “Not Supporting” are considered impaired.

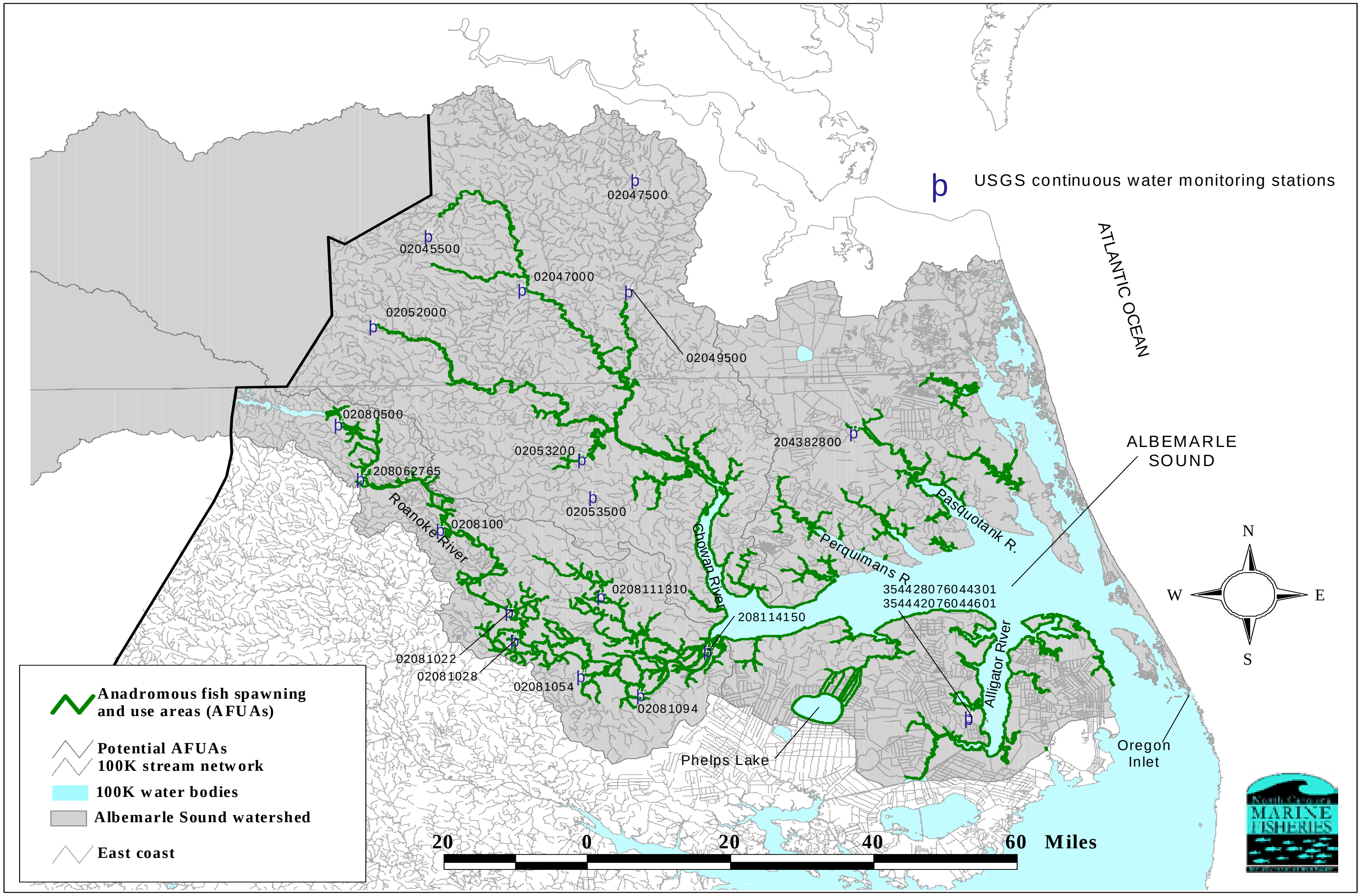

Figure 3. Location of continuous water quality and quantity monitoring stations in the Albemarle Sound watershed.

12.1.8 Blockages of Historical Spawning Habitat

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

Background: A blockage is defined as any man made or natural obstruction that impedes river herring trying to reach historical spawning areas. Blockages such as dams, including beaver dams, culverts and natural obstructions have likely eliminated or reduced access to large areas of both spawning and nursery habitat. Mainstem dams occur in all coastal rivers in North Carolina. The lowermost dams are located around the fall line (transitional area between the piedmont and coastal plain) in the Meherrin, Roanoke, Nottoway, Tar and Neuse rivers (Hightower, 2001). Blockages and/or possible impediments for the Albemarle Sound area are shown in Figure 1 and Figure 2.

Numerous smaller mill dams are found on creeks throughout eastern North Carolina. Collier and Odom (1989) reported three such dams within the Chowan River basin on Bennett's, Indian (Dillard's) and Rockyhock creeks. Removing or bypassing these dams would open access to many miles of potential spawning habitat. The effectiveness of dam removal/bypassing in river herring recovery will depend on whether the runs have been extirpated from the stream reach impounded. In systems where the run has been extirpated restocking and protection to accelerate the recovery process will be needed.

Water control structures located on drainage canals to Lake Phelps and Lake Mattamuskeet limit river herring migrations. Collier and Odom (1989) listed storm gates located on Western Canal, Thirty-foot Canal, Old Canal and Batava Canal at Lake Phelps as confirmed impediments to migration. A fish passage project on Lake Phelps is currently underway and waiting for good weather to complete construction. Modifications to water control structures are under way to provide access to Lake Phelps and Lake Mattamuskeet.

Although dams are the most obvious obstruction, road culverts may have more overall effect on river herring. Culverts are a low-cost alternative to bridges when roads must cross small creeks. Moser and Terra (1999) showed that river herring preferred to migrate through areas with ambient lighting during the day, but required only a low amount of light- at least 1.4% of ambient light. Where lighting was less, avoidance was observed. Light measurements were below the threshold in 6 ft diameter corrugated metal pipes and 6 ft by 6ft box culverts. The amount of habitat affected by an individual culvert may seem small but the cumulative impact of culverts within a watershed can be substantial (Collier and Odom 1989).

Natural obstructions, such as beaver dams and vegetation blockages, are not nearly as common as anthropogenic barriers, and efforts to identify them have rarely been undertaken. Collier and Odom (1989) and Odom et al. (1986) did note several vegetation blockages and log jams in the Albemarle area.

It is probable that these blockages have had detrimental impacts to river herring populations in the Albemarle area rivers/creeks and in the Tar-Pamlico, Neuse, and Cape Fear rivers.

Chowan River

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

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

Numerous small mill pond dams are located on tributaries to the Chowan River (Collier and Odom 1989).

Roanoke River

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

Cape Fear

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

Tar River

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

Neuse River

The first blockage in the Neuse River is currently Milburnie Dam at river mile 183. The next obstruction is Falls of Neuse Dam at river mile 195. A substantial amount of habitat was restored in 1998 with the removal of the Quaker Neck Dam on the mainstem and Cherry Hospital Dam on the Little River, both near Goldsboro (Bowman and Hightower 2001). Subsequent dam removals have occurred on the Little River at Raines Mill and most recently at Lowell Mill (2006), both in Johnston County.

Current Authority: Neither DMF nor WRC has authority covering existing dams unless a hydroelectric facility comes up for relicensing. At this point both agencies would have certain rights and privileges to comment on settlement agreements submitted to the Federal Energy Relicensing Commission (FERC). The Clean Water Management Trust Fund does have monies available to buy existing dams or have them opened for fish passage, and receive input from both agencies on where fisheries priorities exist in the state.

Discussion

Access of river herring to spawning habitat has been impacted or eliminated in North Carolina streams as a result of dams, culverts and various natural obstructions. Despite the enactment of protective environmental regulations and the existence of both federal and state regulatory review processes, threats to the maintenance of river herring habitat and quantity are still significant.

Management Recommendations

Identify all man-made physical obstructions to river herring migration (update Collier and Odom project)

Prioritize impediments for removal/replacement after identified

Research Needs:

Chowan River

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

Tar River

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

Neuse River

Investigate the feasibility of removing Milburnie Dam in Wake County.

Once spawning areas have been re-evaluated and if impediments are removed or altered the system should be monitored after such time.

DMF Management Recommendation: Endorse the update of Collier and Odom project, removal/replacement of impediments and the research needs.

Advisory Committee Management Recommendation: Endorse the update of Collier and Odom project, removal/replacement of impediments and the research needs.

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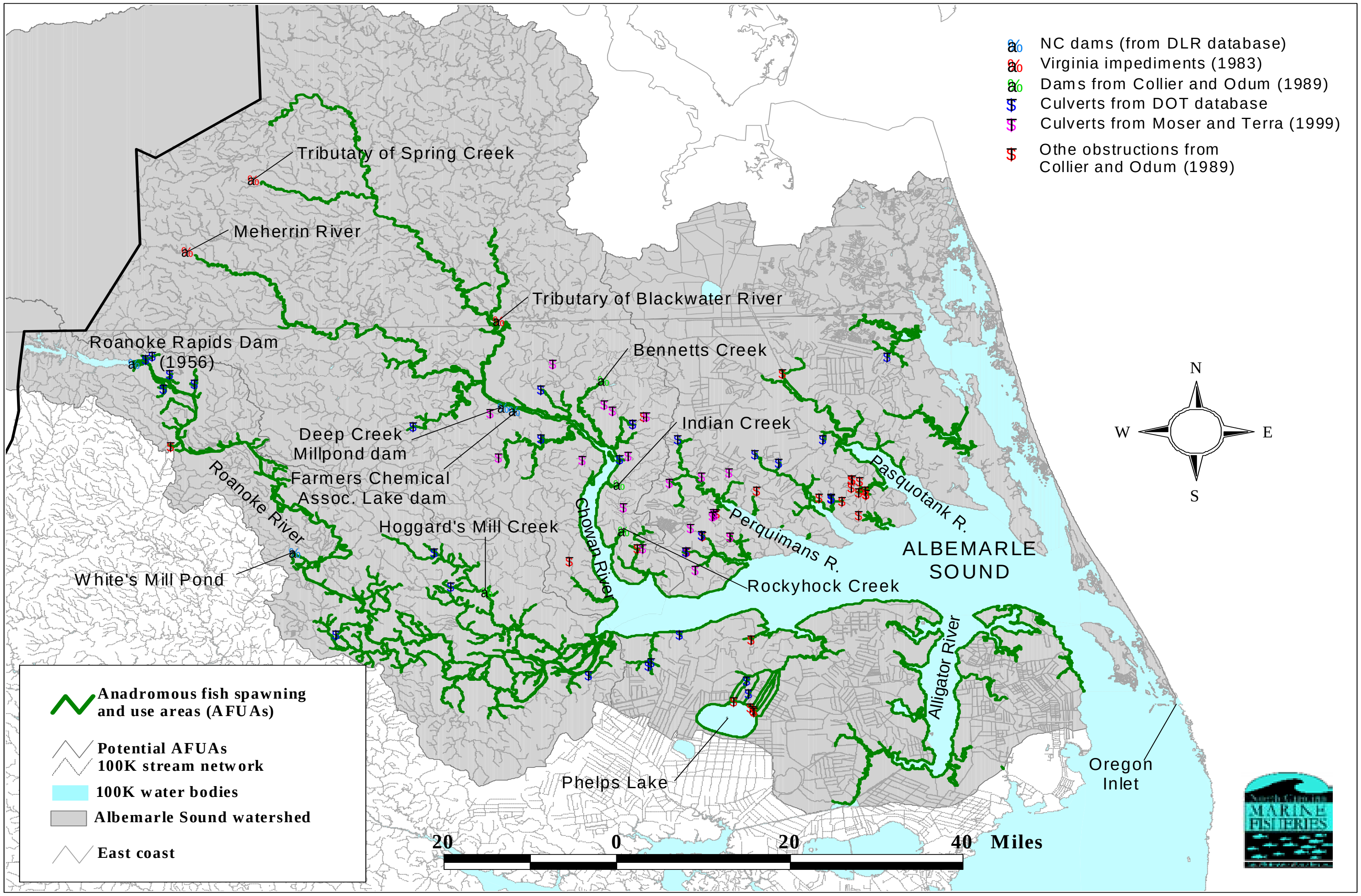

Figure 1. Documented location of dams, culverts and other likely impediments within the Albemarle Sound watershed.

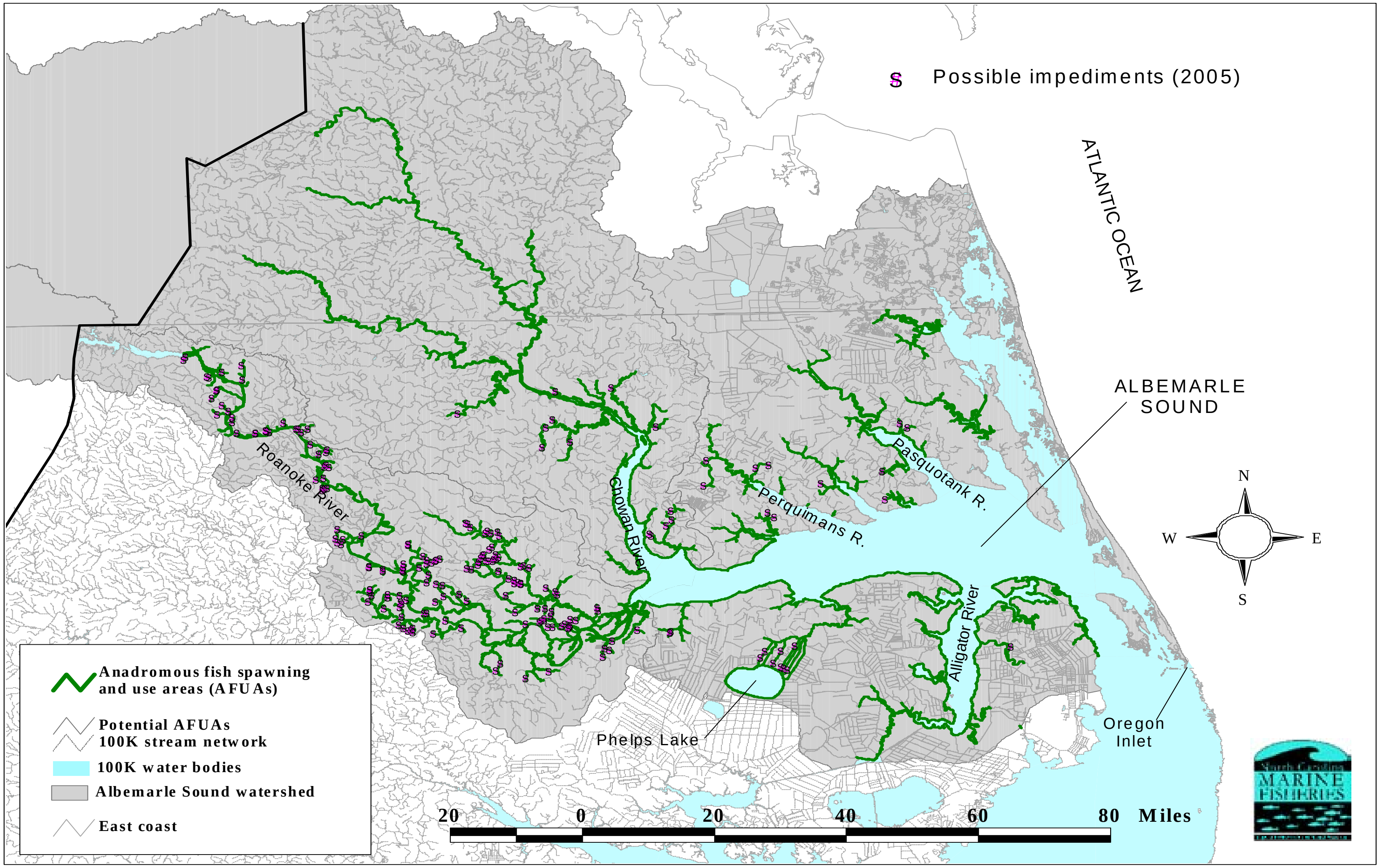

Figure 2. The intersection of roads and anadromous fish use areas where no dams, culverts or likely impediments recorded.

12.1.9 Entrainment and Impingement of River Herring Eggs, Larvae and Juveniles

Issue: Blueback herring and alewife eggs, fry and juveniles are removed from coastal rivers through water withdrawals.

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

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

Discussion: Alewife eggs are approximately 0.80 – 1.27 mm and blueback herring 0.87 – 1.11 mm in diameter. Once hatched, river herring larvae are approximately 4.0 – 19.9 mm in length. Transformation to the juvenile stage is completed in both species at ~20 mm total length. River herring eggs, fry, and juveniles are unable to avoid being entrained into most water withdrawal systems. Once entrained, eggs, fry, and juveniles may be considered completely lost from the river. Even if the withdrawn water is returned to the river (such as is the case with industrial cooling water), river herring are killed by high water pressure, turbulence, abrasion, and exposure to excessive temperatures. Some intake structures are equipped with fine-mesh screens to exclude fish eggs and larvae however the screens require constant cleaning with air and water jets to remove debris. In many instances, fish eggs and fry may not be completely entrained into the system but might be impinged on screens by water pressure. Little is known about the survival rates of eggs and fry that are impinged, then released from screen cleaning operations, but damage from pressure and abrasion seems likely. The importance of egg, fry, and juvenile losses through water intakes is unknown however, for those populations in which spawners are few, these losses could theoretically be significant.

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

Management Recommendations:

- Continue to give close attention to state and federal permit requests in which water withdrawal structures are involved in coastal rivers. Agency comments on proposed water intakes should, where data are available, provide estimates of river herring eggs, fry, and juveniles that could potentially be lost.

- Monitor the progress of USEPA's implementation of Section 316(b) rules as these rules may apply to water withdrawal points in North Carolina's coastal rivers.

- In the absence of effective exclusion technology, require water users to curtail withdrawals during periods in which river herring eggs, fry, and juveniles may be present.

Research Needs:

- The magnitude and seasonal timing of agricultural water withdrawals from coastal rivers is unknown. Division of Water Resources and Division of Water Quality should require documentation of these withdrawals, so that the extent of entrainment of river herring eggs, fry, and juveniles can be estimated.

- Comprehensive list of industrial and municipal water withdrawals and their intake specifications by river system coast-wide.

- Data on the density and distribution of river herring eggs, fry, and juveniles in coastal rivers are needed so that potential losses can be estimated.

- Identify effective engineering solutions to prevent entrainment and impingement of river herring eggs, fry, and juveniles.

- Research is needed to determine the fate of river herring eggs, fry, and juveniles that are impinged, and then released through screen cleaning operations.

DMF Management Recommendation:

DMF has no direct authority to regulate facilities that withdraw water from North Carolina's coastal rivers. Our management recommendations are therefore limited to those stated in the **Management Recommendations and Research Needs** section of this paper.

Advisory Committee Management Recommendation:
DMF has no direct authority to regulate facilities that withdraw water from North Carolina's coastal rivers. Our management recommendations are therefore limited to those stated in the **Management Recommendations and Research Needs** section of this paper. **The AC also recommends that DWQ and DWR be required to interface NPDES discharges and whole watershed management.**

References

Bozeman, E.L., Jr. and M.J. Van Den Avyle. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic)—alewife and blueback herring. U.S. Fish and Wildlife Service Biological Report 82(11.11). U.S. Army Corps of Engineers, TR EL-82-4. 17pp.

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Section 12.2 Appendix 2 - Stock Assessment

Stock Status of River Herring

1972-2004

May 2005

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Abstract.

One of the largest freshwater fisheries in the world was once that for shad and herring in North Carolina's Chowan River, but declining catches and juvenile abundance led the North Carolina Division of Marine Fisheries to develop a river herring management plan in 2000. A quantitative analysis of population abundance and exploitation rates is an important component of the management plan. In 2005, an updated stock assessment to quantify the 2000 management measures was conducted examining both blueback herring and alewife. Although blueback herring and alewife are landed in other areas of the Albemarle Sound by a variety of gears, the largest fishery, both in the present and historically, is that of the Chowan River pound nets. Catch-at-age data from the Chowan River pound net fishery were used to estimate exploitation rates and abundance from 1972 to 2003. Cohort and annual catch curves provided initial estimates of mortality, while a spreadsheet based catch at age model incorporating a multinomial error distribution provided estimates of annual recruitment, abundance at age, and fishing mortality. Bootstrapping and log-likelihood profiling were used to evaluate the precision of model estimates. Estimated fishing mortality for 1972 to 1994 is 0.90 for blueback herring, and except for 1995 and 1997, fishing mortality has ranged from 0.98 in 1998 to 1.91 in 2003, with a corresponding exploitation ranging from 63% to 85%. Estimated fishing mortality for 1972 to 1994 is 0.98 for alewife, and except for 1995 and 1997, fishing mortality has ranged from 1.01 in 1998 to 1.86 in 2002, with corresponding exploitations ranging from 64% to 85%. Chowan River blueback herring recruitment averaged 28.9 million age-3 fish per year between 1972 and 1985. However, since 1986 it has only averaged around 3.6 million fish, and in the last five-years, only 552,000 fish. Chowan River alewife recruitment averaged 7.5 million age-3 fish a year between 1972 and 1986. Although, since 1987 it has only averaged around 587,000 fish and in the last five-years, only 317,000 fish. Blueback herring declines in recruitment through the 1990's dramatically reduced SSB to a record low of 89,678 pounds in 2003. Similarly, alewife spawning stock biomass declined rapidly during the early 1990's. From 1994 to 1999, alewife SSB averaged 22,953 pounds, with a record low of 10,862 pounds in 1995. Excessive exploitation combined with poor recruitment has significantly reduced abundance of both river herring species over the last 20 years and has led too much lower catches than were supported historically. Utilizing blueback herring as an indicator species, a Beverton-Holt stock-recruitment model and a stochastic recruitment model were fit and estimated model parameters were used to project population conditions under various management strategies.

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I. Introduction

River herring (alewife *Alosa pseudoharengus* and blueback herring *Alosa aestivalis*) once supported large fisheries in Albemarle Sound, but landings have declined dramatically since the mid 1970's. Concern over reductions in both landings and juvenile survey values led to imposition of seasonal closures and harvest quotas in the early 1990's and initiation of a North Carolina Marine Fisheries Commission (NCMFC) Fishery Management Plan (FMP) to comprehensively manage the fishery (Winslow 1995) in 1999. An updated quantitative analysis of stock status is necessary to determine current conditions and evaluate previous management strategies for the FMP.

Historically, both alewife and blueback herring were harvested by a variety of gears throughout Albemarle Sound, with the largest harvest component being blueback herring in the Chowan River pound net fishery. In the 1970's and early 1980's the bulk of the fisheries were sampled by the North Carolina Division of Marine Fisheries (NCDMF), but the virtual elimination of landings of river herring from the Albemarle Sound and many of its tributaries since the mid-1980's led to a reduction in fishery-dependent sampling efforts after 1993 (Winslow 1995). As a result, only data from the Chowan River pound net fishery was adequate to conduct a population assessment in 2000 (Carmichael 2000), where pound net landings of blueback herring had accounted for 75% of the total river herring landings since 1972 and over 92% of the total since 1994 (Table 1). Since 2000, the proportion of blueback herring in the total river herring landings has dropped steadily to only 41% in 2004, while the proportion of alewife has increased.

As in 2000, only data from the Chowan River pound net fishery was determined to be adequate to conduct a population assessment update for 2005. However, unlike the 2000 assessment, data is available for the 2005 assessment to include species-specific population status estimates for both blueback herring and alewife.

The objectives of this assessment are to estimate fishing mortality and abundance at age of the blueback herring and alewife stocks, evaluate potential biological reference points for the FMP, and project future stock conditions and yields under various management scenarios. This assessment is intended to provide a sound biological basis for the FMP update.

II. The Fishery

Regulations

Two management areas were established in the 2000 Albemarle Sound Area River Herring FMP. The Albemarle Sound River Herring Management Area (ASRHMA) and the Chowan River Herring Management Area (CRHMA) are defined in North Carolina Fisheries Rules for Coastal Waters 2003 rule 15A NCAC 3J. 0209.

An annual quota, or total allowable catch (TAC) of 300,000 pounds was established in 2000 for the ASRHMA and is allocated as follows: 200,000 pounds to the pound net fishery for the CRHMA; 67,000 pounds to the ASRHMA gill net fishery; 33,000 pounds to be allocated at the discretion of the North Carolina Division of Marine Fisheries (NCDMF) Director 15A NCAC 3M.0513. The same rule also grants the Director proclamation authority as it applies to blueback herring, alewife, American and hickory shad fisheries, and also established a 25 fish per person per day (blueback herring and alewife combined) recreational creel limit.

Rule 15A NCAC 3O.0503 outlines the requirements for the Albemarle Sound Management Area River Herring Dealer Permit. To purchase river herring a dealer must obtain an Albemarle Sound Management Area River Herring Dealer Permit. The permit conditions require the dealer to report landings daily to the NCDMF, and allow biological sampling of catches by NCDMF personnel.

Commercial Landings

Blueback herring commercial landings from the Chowan River pound net fishery fluctuated substantially through the mid-1980's, and began a downward trend in 1986 that continued through 2004 (Table 1; Figure 1). From 1972 to 1985, landings averaged 4.4 million pounds and ranged between 2.0 and 8.0 million pounds. Substantially lower landings between 1986 and 1994 resulted in an average for the period of only 1.2 million pounds. Seasonal restrictions were implemented in 1995 and 1997, and TAC's were established for 1996 (250,000 pounds), 1998 (400,000 pounds) and 1999 (450,000 pounds). Landings from 1995 - 1999 have averaged 305,501 pounds with a range between 190,071 and 394,491 pounds. The NC River Herring FMP was adopted in February of 2000 by the NCMFC, establishing a 200,000-pound TAC for river herring (combined alewife and blueback landings) for the Chowan River pound net fishery. The blueback herring landings have declined each year since the adoption of the FMP in 2000. The average harvest from 2000 to 2004 was 81,056 pounds.

Alewife commercial landings from the Chowan River pound net fishery followed the same basic trends as blueback herring landings and fluctuated through the mid-1980's and began a steady decline in 1986 (Table 1; Figure 1). Landings from 1972 to 1985 averaged 1.5 million pounds and ranged from 291,711 to 2.3 million pounds. Landings from 1986 to 1993 averaged only 536,148 pounds and ranged from 99,455 to 1.3 million pounds. Landings reached historical lows in 1994 and averaged only 5,476 pounds from 1994 to 1999. Alewife landings increased slightly in 2000 but remained well below historical level from 2000 to 2004, averaging 43,571 pounds.

The TAC for the Chowan River pound net fishery has not been reached since 2001 when alewife and blueback herring landings totaled 201,467 pounds. From 2002 to 2004, total river herring landings from the Chowan River pound net fishery averaged 79,669 pounds.

Gill net landings for the ASRHMA began a steady increase in 1980 and reached a historical high of 1.8 million pounds in 1984 (Table 2; Figure 2). Landings declined in 1985 and with the exception of a few years, have continued a downward trend through 2004. Since landings restrictions for river herring were implemented in 2000 (67,000 pound TAC), river herring gill net landings have averaged 71,505 pounds. However, gill net landings are not system specific and are therefore not representative of the river herring stock in the CRHMA, thus they will not be used for the stock assessment, which is Chowan River specific.

Commercial Fishery Sampling Intensity

Length, weight, sex, and age samples of the blueback herring and alewife catch from the Chowan River pound net fishery are available from fish house sampling conducted since 1972. The target sampling frequency is to collect unculled samples of at least 30 fish weekly, from at least 3 area commercial fishhouses during the fishing season. This information is combined with total landings to construct the catch-at-age matrix.

Blueback herring catch-at-age has declined across all ages since the 1970's with the 2003 catch-at-age only 1.2% of the average catch-at-age observed during the 1970's (Table 3). Blueback herring sampling intensity has fluctuated over the years and was significantly lower during 1993-1997 (Table 4). However, from 1998 to 2004 samples have averaged 2,227 lengths per 200 metric tons. No individual weight samples were taken from 1973 to 1980, and the weight at age for these years was taken from a length-weight equation fit to data from 1981 to 1997 (Ricker 1958) (Table 5). Age sampling from 1999 to 2003 averaged 1,069 ages per 200 metric tons of landings.

Alewife catch-at-age has also declined across all ages since the 1970's, with the 2003 catch-at-age representing only 3.3% of the average catch-at-age observed during the 1970's (Table 6). Alewife sampling intensity was affected by the decrease in landings in earlier years. In recent years, however, sampling intensity has greatly increased averaging 2,210 lengths per metric ton landed from 2000 to 2004 (Table 7). No individual weight samples were taken from 1973 to 1980, and very few to zero samples were collected in 1990 and 1993 to 1999, due to lack of fish in the harvest (Table 8). The missing weight values from 1973 to 1979 and 1990 were calculated using averages of available weights for the period 1972 to 1993. The missing weight values for 1995 to 1998 were calculated using average weights for 1994 and 1999.

Maintaining adequate sampling has taken considerable effort, since decreased catch rates and trips have made it increasingly difficult to obtain unculled catches from dealers. Sampling frequency was increased in 1998 by establishing contracts with several fishermen to allow direct sampling of catches. The DMF also established biological collection permits with several fishermen that allowed them to continue fishing their nets after the season closed. This program was intended to allow sampling of the population after the season closed for determining the size and age of the population over the entire spawning season and investigate the hypothesis that seasonal restrictions could affect the size and age composition of the harvest. Data analysis indicated that the size and age composition of fish migrating after the season were similar to that of those taken during the season (S. Winslow, pers. comm.). However, since the adoption of the River Herring FMP, and the establishment of a TAC, maintaining sampling intensity has become increasingly easier due to the permit and reporting requirements by the dealers.

Commercial Fishery Effort Chowan River Pound Net Fishery

Aerial surveys during the fishing season were used to estimate total pound net effort for 1977 to 2004 (Rawls 2004) (Table 9). Total effort is recorded as the number of pound nets fished each week summed over the entire season. Since no effort data are available prior to 1977, the average total effort from 1977-1984 was used as an estimate of the effort for 1972 to 1976. While the maximum number of pound nets set in any given week decreased drastically from a high of 624 in 1977 to only 36 in 2004, the total weeks fished has differed little over the years with the exception of 1997 when nets were only set for 5 weeks. Therefore, the overall decrease in total effort is due more to fewer nets set than to a reduction in the length of the fishing season. Since 2001, the number of weeks fished has increased slightly as a result of the TAC not being met, and the season remaining open longer, or nets being set earlier in the fishing season. Effort has decreased considerably since the implementation of a harvest quota in 1995 and has varied without trend since that time, thus CPUE for both blueback herring and alewife has varied in conjunction with harvest trends throughout 2004 (Figure 3; Figure 4).

Recreational Fishery

Although there is some recreational fishing effort directed on the stock in inland waters, the magnitude of recreational landings are unknown at this time. The NCDMF began a Recreational Commercial Gear License (RCGL) Survey in 2002. The RCGL allows recreational fishermen to use limited amounts of commercial gear to harvest finfish for personal consumption. Approximately 22,797 pounds of river herring (blueback herring and alewife) were landed in NC in 2002, and 29,415 pounds were landed in 2003. ASRMHA accounted for 55.7% of the recreational river herring landings in 2002, and 47.8% in 2003. The limited amount of RCGL data prevents it from being a reliable indicator of recreational harvest. However, the continued collection of this data is essential in order to fully assess the recreational harvest of river herring in the ASRHMA.

Research Survey Indices

The NCDMF conducts several fishery-independent surveys to monitor both adult and juvenile anadromous fish in Albemarle Sound. Nursery area sampling with seines and trawls began in 1972 to specifically monitor river herring juvenile abundance. This sampling provides an annual Juvenile Abundance Index (JAI) for alewife and blueback herring that is calculated from the mean CPUE at a set of core seine stations (Table 10). Declining JAI values during 1972-1998 provide the first indication that reduced landings are related to declining population abundance (Winslow 1998)(Figure 5; Figure 6). Although JAI values for blueback herring and alewife differ considerably, the downward trend is apparent for both species.

The overall average for JAI for blueback herring 1972 to 2004 is 59.9 fish-per-seine (fps); however, the average has declined from 135 fps for 1972 to 1985 to only 12.4 fps for 1986 to 1999. The average JAI from 2000 to 2004 is 4.5 fps and ranged from 0.8 fps (2002) to 14.8 fps (2004). The average JAI for alewife has also declined considerably. The overall average from 1972 to 2004 is 2.3 fps. The average has declined from 4.6 fps (1972 to 1985), to 0.73 fps (1986 to 2004). Although the seine is not considered the best gear for sampling juvenile alewife, the JAI's provided continue to reflect the downward trend in adult abundance.

A trawl survey designed to monitor striped bass juveniles, initiated by Dr. W.W. Hassler of NCSU in 1955 and continued through the present by the NCDMF, also captures juvenile blueback herring and alewife (Hassler et al 1981, Winslow 2005)(Table 11). This survey has historically caught fewer river herring, so its value as an indicator of population status is limited in light of the dedicated seine survey and was not used in the stock assessment.

Adult blueback herring and alewife are captured in NCDMF's Albemarle Sound Independent Gill Net Survey (Table 12; Table 13). This survey is similar to the Hassler trawl survey in that it is designed to monitor striped bass (Winslow 2005). Because the gill net survey is conducted throughout the sound, it is likely that those fish captured are from stocks spawning in various tributaries. Therefore, the survey may not accurately represent the Chowan River component of the stock. The broad sampling area and low catch rates greatly limit the usefulness of the gill net survey as an abundance index of the Chowan River spawning stock. The gill net survey was not used in the stock assessment.

III. Estimation Procedures

Catch Curve Analysis

Initial estimates of total mortality (Z, or fishing + natural mortality) were obtained through catch curve analysis. A catch curve is a basic approach to analyzing catches at age wherein a linear regression is fit to the declining limb of log transformed catch-at-age data (Ricker 1958, Ricker 1975, Hilborn and Walters 1992). Catch curves may be applied to annual catches or to individual cohorts. Since annual catch curves assume constant recruitment and it is very unlikely that this assumption is valid in this instance, the catch curve analysis was only applied to individual cohorts. A cohort-based catch curve allows for changes in recruitment, while assuming constant fishing mortality per cohort, and may therefore be more applicable to this stock. Catch curves are a proven method of estimating total mortality, but because they cannot provide estimates of recruitment and abundance at age, more sophisticated models are necessary to meet the assessment objectives.

Catch-at-Age Analysis

A spreadsheet-based catch-at-age analysis incorporating a multinomial error distribution was used to estimate fishing mortality and abundance at age. This flexible approach to analyzing catch-at-age data was initially developed in the late 1980's and has been used extensively for many analytical assessments (Fournier and Archibald 1982, Deriso et al. 1985, Methot 1989, Kimura 1990, Methot 1990). The Solver optimizer of Excel was used to iteratively solve a model based on estimates of both total catch and the proportion of the catch at each age. Maximum likelihood estimates for the model parameters were found by minimizing the following expression developed by Fournier and Archibald (1982) and termed the "multinomial maximum likelihood" model by Kimura (1990):

$$-L = \sum_{ij} n_i \, p_{ij} \log(\hat{p}_{ij}) + \sum_i [\log(c_i) - \log(\hat{c}_i)]^2 / (2\sigma^2) + \text{constant}$$

where

c_i = observed catch in year i
n_i = number aged in year i
p_{ij} = proportion at age_j in year i
σ^2 = variance of catch at age.

The model estimates 69 parameters: 1972-1994 average fishing mortality, 1995-2003 annual fishing mortality, selectivity for ages 3 and 4 (ages 5-7+ assumed fully selected), annual recruitment (estimated as abundance at age-3), and abundance at ages 4-7+ in the initial year (1972). Initial mortality values for the analysis were provided by the catch curves. The actual variance of the catch at age is unknown, so the model is forced to fit predicted catches closely by setting σ^2 at 0.001. Confidence intervals for estimated fishing mortality, recruitment, and selectivity were obtained through 500 bootstrap trials (Hilborn and Walters 1992, Davison and Hinkley 1997).

Although various auxiliary data can be incorporated, in this application of the model the only input data included were annual catches at age and the number of fish aged annually. Fishery effort data and JAI survey values were not used in estimating population parameters. Instead these data were used to investigate effort trends in relation to population abundance and validate the JAI.

Natural Mortality

Past assessments of the blueback herring stock assumed a wide range of natural mortality rates. Crecco and Gibson (1990) used a value of 1.0 in an initial ASMFC assessment of Atlantic Coast river herring stocks. A NC DMF assessment of the Chowan River blueback herring stock by Schaaf (1998) assumed natural mortality was 0.3. Both the Hoenig (1983) and Pauly (1980) methods of estimating natural mortality yielded estimates of 0.51 (Hilborn and Walters 1992) for blueback herring and alewife. The assumed instantaneous rate of natural mortality is 0.5 for blueback herring and alewife.

Maturation Rates

A schedule of maturity rates at age is required to calculate spawning stock biomass from abundance at age estimates. Estimates of maturation rates are typically based on studies and the proportion mature at any given age is calculated from population sampling. This approach is feasible when both mature and immature individuals can be sampled, but estimating maturity is problematic when dealing with an anadromous stock, because it is difficult to obtain unbiased samples of both mature and immature fish. Immature blueback herring and alewife are not available for sampling because they move to offshore waters and migrate along the Atlantic coast. This may explain why there are no published maturity schedules for river herring, while several references to fecundity are available, including Street 1969, Loesch 1987, and Jessup 1983. Although Havey (1961) and Marcy (1969) examined maturation rates by sampling fish on the spawning grounds, their results are presented in terms of the number of times fish of a given age have spawned previously and the number of fish of a given age that are spawning for the first time. The NCDMF surveyed anadromous species offshore between January and April 1971 and obtained 76 scale samples from blueback herring between the ages of 2 and 8. Most bluebacks sampled had not spawned, but of 21 fish that had spawned previously, 33% spawned first at age-3, 62% at age-4, and 5% at age-6 (Holland and Yelverton 1973). Although the results of these various studies indicate that blueback herring mature between the ages of 3 and 5, there is insufficient data for calculating a maturity schedule because there is no information on the abundance of fish of each age in the population. Furthermore, since most of the studies are conducted on the spawning grounds, only mature fish were sampled and there is no way to directly determine how many fish of a given age are immature.

Lacking any published maturity schedules for blueback herring, spawning mark at age data were modeled to estimate maturity at age. Since blueback herring develop a spawning mark when they enter freshwater, it is possible to determine how many times a given fish has spawned previously. If no mark is found on a mature fish, it is assumed to be a virgin spawner. The spawning mark data was combined over all years and corrected for non-random age sampling to generate observed values of the number of fish by the number of spawning marks and age. A maturity schedule for blueback herring was developed using a model fit by least squares to estimate a 2 parameter curvilinear function that predicts the proportion mature-at-age (Table 14). In the absence of a maturity schedule for alewife, the blueback herring maturity schedule will be used as a proxy.

Population Modeling and Stock Projections

Fishery biological reference points are evaluated through several population models, including yield per recruit, stock-recruitment, and stochastic models. A Beverton-Holt stock-recruitment model is fit to estimated SSB and recruitment at age-3 values to generate estimates of model parameters (Beverton and Holt 1957). These parameters are used to calculate recruitment from predicted SSB values so that current and proposed management strategies concerning yield and population trends can be examined. Yield per recruit analysis is used to evaluate growth overfishing and to estimate biological reference points such as F_{max} and $F_{0.1}$ using the Thompson-Bell equilibrium approach (Ricker 1958). Inputs include estimated selectivity-at-age, estimated proportion mature-at-age, mean weight-at-age, and fishing and natural mortality rates.

The age structure and biomass of the population are calculated with standard population equations based on estimated selectivity at age, an estimated maturation schedule, average weight at age, and natural mortality. Two estimates of incoming recruitment are considered: 1) calculated from the stock-recruitment relationship parameters, and 2) chosen stochastically from observed values. The stochastic model projected the population forward 50 years with 50 trials run for each fishing mortality level. Future recruitment is determined through selection from past observed values over a range of SSB levels. To determine appropriate limits on the SSB ranges, observed recruitment and SSB were plotted and then tabulated into three categories: 1) SSB below 2.5 million pounds, 2) SSB 2.5 to 10 million pounds, and 3) SSB greater than 10 million pounds. These values were selected due to the clear thresholds between 2 and 4 and above 10 million pounds of SSB. An Excel spreadsheet macro was used to randomly select recruitment for future years from observed values within the appropriate SSB category.

Management alternatives are evaluated by comparing future fishery yields and stock parameters, such as abundance and spawning stock biomass, for various management strategies. Starting with the 2003 abundance estimates provided by the catch-at-age model, a population model projects changes in abundance for different exploitation levels. Mean weights at age are based on the 1972 to 2003 averages, and selectivity's at age are taken from the catch-at-age model. Estimates of initial abundance at age and the 2003 exploitation rate are based on catch at age model estimates. The exploitation rate for 2004 and 2005 is fixed at the 2000-2003 average of F=1.5 because the fishing season is complete for 2004 and 2005, and any proposed management changes will only impact 2006 and beyond. Recruitment for years 2 and 3 (2004 and 2005) is fixed at the level estimated for 2003. Recruitment estimates after year-3 are provided by either the stochastic stock recruitment selection procedure or the Beverton-Holt stock recruitment model. For the stochastic runs, 25 projections of the stock over a 30-year analysis period were made for each fishing mortality or fixed harvest scenario. Runs incorporating more projections were evaluated but did not offer an increase in precision. Incorporating the stochastic recruitment function only requires assuming that future recruitment will be similar to the observed conditions over the specified ranges of spawning stock biomass, whereas using the stock-recruitment model implies the assumption that any gains in SSB will be reflected as subsequent gains in recruitment.

IV. Results

Catch Curve Total Mortality

Results from the Chowan River blueback herring annual catch curve analysis suggest that total mortality averaged 1.44 from 1972 to 2003 (Figure 7). A test of the slopes of the annual catch curves failed to indicate a significant difference and supports the hypothesis that fishing mortality varied without trend over the period. Cohort based catch curves plotted by fishing year illustrate both the steep decline in abundance and the relative similarity of the slopes of the decline of each cohort (Figure 8). Average 1972 to 2003 total mortality from catch curves applied to cohorts was 1.67 with a 90% confidence interval for the mean of 1.45 – 1.88 (Figure 9). Subtracting natural mortality, the estimated fishing mortality based on catch curve analysis is 1.17 for blueback herring.

Chowan River alewife annual catch curve analysis also suggested a high total mortality, averaging 1.48 from 1972 to 2003 (Figure 10). Cohort based catch curves plotted by fishing year also illustrated both the steep decline in abundance and the relative similarity of the slopes of decline for each alewife cohort (Figure 11). It is important to note that alewife cohorts from 1988 to 1995 exhibited an extreme decline, which corresponded with historic low JAI values for the same period. Even though alewife cohorts have rebounded slightly, the overall trend does not suggest this is indicative of a significant stock recovery. The average 1972 to 2003 total mortality from catch curves applied to the alewife cohorts was 1.77 with a 90% confidence interval for the mean of 1.39 - 2.15 (Figure 12). Subtracting natural mortality, the estimated fishing mortality based on catch curve analysis is 1.27 for alewife.

Catch at age Model Exploitation Rates, Selectivity, and Abundance at Age

The catch-at-age model allows estimation of abundance at age and selectivity in addition to estimates of exploitation. The model is configured to fit the total observed catch fairly closely (Figure 13; Figure 14). Examining annual plots of observed and predicted catch indicates that the model predicts the catch well in most years for both blueback herring and alewife in the Chowan River, with some exception in the 1980's for blueback herring (Figure 15) and the late 1980's and early 1990's for alewife (Figure 16). The exceptions to fit for some model years correspond directly with the transition from a high to low catch during the same respective periods for blueback herring and alewife in the Chowan River.

Recruitment is estimated at age-3 since virtually no fish younger than this appear in the blueback herring or alewife catch and there is no offshore survey data available to estimate the population of the sub-adults. Chowan River blueback herring recruitment averaged 28.9 million age-3 fish a year between 1972 and 1985, but since 1986 it has only averaged around 3.6 million fish (Table 15; Figure 17) and in the last five-years, only 552,000 fish. Strong year classes of the late 1960's sustained the stock through the mid-1970's, then poor 1975-1977 cohorts contributed to the decline in the late 1970's. Exceptional recruitment of the 1978 - 1981 cohorts, averaging 38.0 million fish, allowed the stock to rebuild in the early 1980's, but another series of poor cohorts from 1982 to 1986 combined with sustained high fishing mortality lead to a decline in overall stock abundance. Recruitment has been low over the last 10 years, only averaging 1.8 million fish a year. Moreover, any modest gains in blueback herring recruitment since the early 1980's supported catches over the short term and were quickly removed by high fishing mortality. For example, although the 1987 and 1988 year classes were the best in the last 10 years, these two blueback herring cohorts alone supported over 69% of the catch between 1991 and 1993. Similarly, the 1993 cohort supported nearly 10% of the 1996 catch, nearly 40% of the 1997 catch, and over 50% of the 1998 catch.

Chowan River alewife recruitment averaged 7.5 million age-3 fish a year between 1972 and 1986, but since 1987 it has only averaged around 587,000 fish (Table 16; Figure 18), and in the last five-years, only 317,000 fish. Strong year classes of the late 1960's sustained the stock through the early-1970's, then poor 1972 to 1973 cohorts contributed to the decline in the mid 1970's. High recruitment of the 1978 to 1981 cohorts, averaging 9.5 million fish, allowed the stock to rebuild in the early 1980's. However, another series of poor cohorts from 1985 to 1986, and then extremely poor cohorts from 1989 to 1994, combined with sustained high fishing mortality lead to a drastic decline in overall stock abundance during the mid 1990's. A slight increase in alewife recruitment the last 5 years, averaging 317,000, has occurred. However, any modest gains in alewife recruitment since 1996 has supported catches over the short term and were quickly removed by high fishing mortality. The 1996 cohort supported nearly 58% of the 2000 catch, nearly 53% of the 2001 catch, and over 21% of the 2002 catch.

A catch-at-age model estimating annual fishing mortality rates suggested that fishing mortality varied without trend between 1972 and 1994 for blueback herring and alewife; this conclusion is also supported by the respective catch curve analyses above. The final model configurations imposed a constant F for 1972 to 1994 to reduce the number of parameters estimated and provide a long-term average F that is more robust than would be obtained from averaging annual estimates. Predicted catches are similar to observed catches in most years (Figure 15; Figure 16). Fishing mortality was estimated annually for 1995 to 2003 to account for changes in exploitation rate related to regulatory changes since 1995.

Estimated fishing mortality for 1972 to 1994 is 0.90 for blueback herring, equivalent to an annual exploitation rate attributable to fishing of 59% (Table 17). Except for 1995 and 1997, fishing mortality has ranged from 0.98 in 1998 to 1.91 in 2003, with a corresponding exploitation ranging from 63% to 85%. A separability assumption is included in the catch at age model that allows separation of exploitation into year and age effects. Selectivity is fixed at 1 for ages 5-7+ and estimated by the model at 0.02 for age 3 and 0.44 for age 4.

Estimated fishing mortality for 1972-1994 is 0.98 for alewife, with an annual exploitation rate attributable to fishing of 62% (Table 18). Except for 1995 and 1997, fishing mortality has ranged from 1.01 in 1998 to 1.86 in 2002, with corresponding exploitations ranging from 64% to 85%. A separability assumption is included in the catch-at-age model that allows separation of exploitation into year and age effects. Selectivity is fixed at 1 for ages 5-7+ and estimated by the model at 0.01 for age-3 and 0.29 for age-4.

Spawning stock biomass (SSB) based on 1972-2003 mean weights-at-age, the estimated maturity schedule, and estimated numbers-at-age shows a rapidly decreasing trend for both blueback herring (Figure 19) and alewife (Figure 20). Blueback herring spawning stock biomass varied between 4.43 and 14.5 million pounds and averaged 8.3 million pounds from 1972 to 1986. Blueback herring SSB then dropped to just 1.0 million pounds in 1994 corresponding with a decline in recruitment (Table 19). Continued blueback herring declines in recruitment through the 1990's further reduced SSB to a record low of 89,678 pounds in 2003. Alewife spawning stock biomass varied from 1.1 million to 3.1 million from 1971 to 1988, but then declined rapidly during the early 1990's. From 1994 to 1999, alewife SSB averaged 22,953 pounds, with a record low of 10,862 pounds in 1995. This dramatic drop in alewife SSB corresponds with historically low recruitment values in the early 1990's (Table 20). A slight increase in alewife SSB has been observed since 2000, however, the 2003 SSB value (92,442 pounds) was only 7.5% of the 1972 to 2003 SSB average.

Validation of the Juvenile Abundance Index

An objective of the original assessment was to determine whether the blueback herring and alewife juvenile abundance index is a valid indicator of cohort strength. A linear regression was used to establish the relationship between JAI values and the predicted abundance of a given cohort at age-3. The JAI value for 1981 is an apparent outlier and was not used in this analysis. Drought conditions during 1981 are suspected of adversely affecting survey values (S. Winslow pers. comm.). Comparing the low 1981 JAI value to the high estimated recruitment of the 1981 cohort further justifies its classification as an outlier. Age-3 abundance and the JAI were highly correlated ($r = 0.77$), and the linear regression indicates that 60% of the variation in age-3 abundance can be explained by the JAI ($r^2 = 0.65$, $p < .001$)(Figure 21). This analysis suggested that the JAI is a valid indicator of cohort strength and has potential value as a management tool and stock indicator.

Indicator Species Designation

The goals of the river herring FMP include evaluating the impact of future management changes. However, due to the nature of the fishery, it is not possible to develop management measures that are stock specific. The Chowan River blueback herring stock has historically been significantly greater in population size, SSB, and catch. The River Herring Plan Development Team (PDT) recommended that management plans be developed for the river herring FMP by using blueback herring as the indicator species for the entire river herring stock.

Stock Recruitment Relationship

There are multiple means of predicting future recruitment for inclusion in population modeling and projections. A common approach is to fit a deterministic stock-recruitment relationship that can be used to predict recruitment from spawning stock biomass. There are a variety of models available to describe the relationship between spawning biomass and recruitment, and the first step in selecting an appropriate model is to observe the potential relationship graphically (Vaughan 1993). A spawning stock and recruitment plot indicates that strong year classes are much more likely when SSB is above 4 million pounds and poor year classes are likely when SSB is below 2.5 million pounds (Figure 22). This potential relationship between spawning stock and recruitment can be further evaluated by modeling. Two of the most commonly used stock-recruitment models are those of Ricker and Beverton-Holt. The models differ primarily in their recruitment expectation at maximum spawning stock levels, with the Ricker model predicting that recruitment will decline and the Beverton-Holt model predicting that recruitment will reach an asymptote.

The Chowan River blueback herring stock shows no indication of declining recruitment at larger stock sizes, so a Beverton-Holt model incorporating an arithmetic error assumption was used to quantify the relationship between spawning stock and recruitment (Table 19; Figure 23). Initially, both arithmetic and logarithmic error assumptions were considered. The difference in the alternative assumptions relates to how observed recruitment points are distributed relative to SSB and the predicted curve, with the logarithmic model allowing less influence by very high recruitment observations.

Many stocks exhibit lognormal variation and there is a strong theoretical basis for such an assumption (Hilborn and Walters 1992), but the plot of blueback herring recruits vs. SSB (Figure 22) suggests that the variation in recruitment is as great for lower stock sizes as it is for higher stock sizes over the 4 to 10 million pounds of SSB range of most of the observations. Moreover, the logarithmic model failed to account for occasional high recruitment events, observed in 1972 to 1973, 1978, and 1980 to 1981, that may be important to the productivity of the stock. Recruitment predicted by the arithmetic model is about 40% higher than that of lognormal model. This increase occurs because the arithmetic error assumption allows the highest recruitment observations equal influence on the predicted relationship. There is some risk in relying on the arithmetic model's higher predicted recruitment, since a bias that overestimates recruitment will result in overestimates of stock growth. Conversely, occasional exceptional recruitment events may be a characteristic of the stock and failing to account for their influence will underestimate stock growth.

V. Biological Reference Points

Yield per Recruit

A yield-per-recruit (YPR) analysis is one method of estimating appropriate fishing mortality levels. Such models can be used to illustrate how a stock changes in response to different levels of exploitation and changes in selectivity. The reference points provided by YPR are related to growth overfishing and include F_{max} (the level of exploitation at which yield per recruit is maximized) and $F_{0.1}$. YPR models are often extended to examine spawning potential ratios (SPR) and calculate $F_{\%SPR}$, which is a class of references related to the proportion of the maximum spawning biomass per recruit that is retained. No stock-recruitment information is necessary since YPR models are based solely on exploitation rates and size-at-age. This is a benefit when analyzing stocks for which there is no clear relationship between spawning stock and recruitment, but it is a disadvantage when considering stocks such as this that exhibit a strong stock-recruitment relationship (Deriso 1987). According to Hilborn and Walters (1992), one of the major drawbacks associated with YPR models is that they cannot account for recruitment effects and cannot reflect recruitment overfishing. Another difficulty with YPR models arises with stocks having growth, selectivity, and maturity patterns that prevent yield from reaching a maximum. All of these factors affect this YPR analysis, suggesting that the results are not useful for management (Table 21; Figure 24). F_{max} is undefined since the yield never reaches a clear asymptote, while values of other references appear excessive with $F_{0.1}$ estimated at F=1.0 and $F_{40\%SPR}$ at F=1.6. Given that this stock declined sharply when fishing mortality was sustained at around F=1.0, these reference values provide little real guidance in establishing management targets and clearly fail to account for the poor recruitment observed from the current truncated age structure and low stock sizes.

Spawning Potential Ratios

One approach to integrating the stock-recruitment information with a YPR analysis is presented in Gabriel et al (1985). The YPR analysis provides spawning stock biomass per recruit value (SSB/R) that can be produced at any given level of exploitation. The SSB/R can then be plotted on the stock recruitment plot as a straight line that goes through the origin and has a slope of R/SSB. The line represents the level of recruitment that is necessary to sustain the stock at the particular fishing mortality rate. Any recruitment values above the line represent years in which recruitment exceeds that needed for replacement; the excess production can be taken as harvest or protected for stock growth. Any values below the line represent years in which recruitment fails to provide replacement. Several lines can be plotted to examine potential exploitation rates relative to the recruitment history of the stock. A line with recruitment points equally distributed above and below represents the R/SSB necessary to replace the stock at the observed recruitment (F_{REP}=0.1) (Sissenwine and Shepherd 1987; Maguire and Mace 1993). Years in which recruitment failed to replace losses from natural mortality fall below a line corresponding to F=0. Applying these principles to the YPR and recruitment information from this stock indicates that fishing mortality below F=0.1 was necessary to sustain the stock given the observed 1972-2003 recruitment patterns (Figure 25). Age-3 abundance for 1976-1977 and 1982-1986 falls below the F=0 line and was therefore insufficient to sustain the stock even if there had been no fishing mortality.

VI. Stock projections

The goal of stock projection is to determine how a stock may respond to management changes by projecting population growth and catches in future years using standard population models. Future recruitment is based on both the stochastic model and the deterministic estimates provided by the Beverton-Holt stock-recruitment model. It cannot be stressed enough that the assumed or estimated future recruitment values will greatly influence the results, especially in later years. Generally, short-term projections are fairly reliable since the first few years of any projection are based on estimated initial abundances at age. Results of longer-term projections become increasingly dominated by assumed recruitments and therefore increasingly uncertain. This basic tenet of stock projections is especially important for this stock. The catch is typically dominated by 4 and 5 year old fish, yet age-3 is the first age that can be estimated. Virtually no fish older than age-7 appear in the catch. Therefore, once a projection has been extended out 5 years, the abundance of every age in the population is directly dependent on the assumed recruitment value. Also, once the projection is extended 3 years, the abundance of the dominant ages (ages 4 and 5) is directly dependent on the assumed recruitment value. Clearly, for this stock, the accuracy of even relatively short-term projections is heavily dependent on the accuracy of future recruitment assumptions. Although it makes presentation and interpretation of the projection results more difficult, the strong influence of the recruitment assumption on projection results necessitates considering more than one option.

The PDT suggested evaluating two different management scenarios. The first considered a constant harvest strategy that maintained a minimal harvest of 10,000 pounds. These were chosen after preliminary analysis indicated harvest levels greater than 10,000 pounds would not achieve a minimum SSB threshold of four million pounds in 30 years. Next, a fixed exploitation rate strategy was explored for F_{REP} (F=0.1). Finally, a strategy of no harvest, or fishing moratorium, was examined. Given the reduced biomass of this stock, consideration of other alternatives such as fixed harvest levels at or greater than the current quota are not appropriate. Each alternative scenario is analyzed using both the stock-recruitment model and the stochastic recruitment model to select future recruitment. Results from both recruitment model assumptions are presented separately and then comparisons are made for the two approaches.

It is necessary to establish a time frame over which to project the stock. Although it is common to base management plans on a 10-year schedule for rebuilding age structure and spawning stock biomass, for some stocks this is an unreasonable goal and other alternatives must be considered. One approach is to estimate a minimum rebuilding time (T_{min}) based on the time it takes the stock to rebuild to some predetermined level if fishing mortality is eliminated. Projections based on the stock-recruitment relationship indicate that the stock could reach 4 million pounds in 25 years. The stochastic approach indicated that 4 million pounds will not be reached, largely because the average observed recruitment of 303,121 fish at the current low SSB levels (below 2.5 million pounds) is not sufficient to rebuild the stock. Results from these alternative methods of estimating future recruitment clearly illustrate how the recruitment assumption affects projection outcomes. While the stochastic approach may best represent short-term changes in the population, it does not appear to represent long-term trends very well. A subdivision of the General Assembly of North Carolina House Bill 1429 (G.S. 113-182.1(b)(4)) specifies a time period, not to exceed 10 years (T_{max}), from the date of the adoption of a FMP, for ending overfishing and achieving sustainable harvest. The bill also states that it shall not apply to a plan for a fishery where the biology of the fish or environmental conditions make ending overfishing and achieving a sustainable harvest within 10 years impracticable. For blueback herring, the 10-year maximum rebuilding time (T_{max}), is impracticable. An alternative suggested in Restrepo et al (1998) is to base the rebuilding period on the 10-year T_{max} plus one mean generation time. Based on applying an equation developed by Goodyear (1995), the mean generation time for Chowan River blueback herring is six-years. Added to the mandated T_{max} of 10 years, a practicable T_{max} value for this stock is 16 years. Projection scenarios are presented over a 30-year period to encompass these time frames. If management measures are changed before the 2006 fishing season, the projected target year for full recovery of the blueback herring stock would be 2021.

Proposed management alternatives were first examined by predicting future recruitment from the Beverton-Holt stock-recruitment relationship. Projections are grouped by the overall management approach of either fixed harvest or fixed exploitation, with results for each level of harvest or exploitation rate combined on a single graph to facilitate comparisons. Summaries of the years it will take to reach potential biomass targets of four, six, and eight million pounds are provided in (Table 22). None of the management strategies evaluated reached the minimum SSB threshold of four million pounds within 16 years (by 2021). Projections indicate that for the fixed harvest level of 10,000 pounds, it will take 26 years for the spawning stock biomass to reach the initial threshold of four million pounds, and 30+ years to reach six and eight million pounds (Figure 26). Growth in SSB under the fixed harvest option is extremely slow in the first few years because recent poor cohorts dominate the population. Fishing mortality will decrease significantly under the 10,000-pound harvest option (Figure 27). A constant exploitation rate would allow harvest to increase as stock abundance increases, at the cost of a delayed rebuilding of 28 years to reach the SSB threshold (Figure 28). The poor cohorts now in the population result in decreased catches over a long timeframe for the fixed F rate (F=0.1) considered (Figure 29). Recruitment values predicted by the Beverton-Holt model are higher than those observed over the last few years; this potential bias is reflected by increased SSB and allowable harvest after around 2007 and the ability of the population to eventually reach the SSB threshold, though after 2021. A moratorium would not allow harvest, and would rebuild SSB to the 4 million pound SSB threshold within 25 years (Figure 28).

The outlook for the stock is quite a bit different when based on the stochastic recruitment model. Whereas the stock-recruitment relationship predicts increased recruitment from any slight increase in SSB, the preponderance of poor recruitment events at the current low SSB prevents the stochastic model from predicting any real improvements in the stock. At least one recruitment event close to the long-term average of 14.6 million fish is needed before the stock will begin to recover. Fixing the harvest at 10,000 pounds allows SSB to stabilize at less than 900,000 pounds in a few years (Figure 30). Trends in SSB observed by projecting fixed exploitation rates are similar to those for fixed harvest rates; SSB stabilizes below 800,000 pounds at F=0.1 (Figure 31). Additionally, poor cohorts now in the population result in catches no greater than 55,000 pounds after 2012 (Figure 32). Implementation of a fishing moratorium (F=0.0) results in SSB stabilizing below 900,000 pounds in a few years but failing to increase further (Figure 31).

The harvest that this stock can sustain is overwhelmingly dependent on future recruitment. Projections based on the stock-recruitment relationship suggest that SSB could improve, but these results are potentially biased and should be viewed with caution since recruitment over the last 10 years has been less than that predicted by the stock recruitment model. Therefore, the stochastic model may provide a more realistic representation of the conditions that can be expected. Results from the stochastic model clearly indicate that recruitment must improve considerably before the stock will improve. The only insight available regarding recruitment over the next few years is provided by the JAI. The JAI value for the 2004 cohort is the highest since 1996, however, substantial increases in recruitment over multiple years are needed before any significant increases in SSB and stock size can be expected.

VII. Discussion

Recruitment through much of the 1970's and early 1980's sustained the Chowan River stock of river herring in spite of very high fishing mortality. Much of the variability in landings, population abundance, and spawning stock biomass can be attributed to trends in recruitment. A succession of poor year-classes during the mid-1980's could not support the high fishing mortality at that time, so subsequently the stock declined to historic low levels. Spawning stock biomass and recruitment of blueback herring and alewife declined dramatically during the mid to late 1980's and has never recovered. Although blueback herring from Albemarle Sound are reported to reach age-10 (Kornegay 1978), in recent years the age structure is becoming increasingly truncated (Figure 33; Figure 34). Until the mid-1980's an occasional age-9 fish appeared in the catch and age-8 fish were fairly common, but since 1983 the oldest fish observed has been 7 years old, and in several years the maximum observed age was 6. This analysis suggests that the long-term decline in landings, overall and species specific, are related to a decline in population abundance and that current fishing mortality rates are not sustainable. Sustained high exploitation over the last 25 years have reduced SSB to the extent that current levels are insufficient to produce even moderate recruitment for either blueback herring or alewife. Current management measures have inadvertently increased exploitation rates and average mortality remains above the long-term stock replacement rate. Although regulatory changes likely restricted catches between 1995 and 1998, mortality remained high as stock abundance continued to decline. Further, the attempt to decrease fishing mortality over the last 5 years has failed to reverse the trend of declining SSB and poor recruitment. One reason for the lack of improvement is that relatively strong year classes, such as that of 1996 for both blueback herring and alewife, are supporting a disproportionate share of current catches and are harvested before contributing significantly to population growth.

Excessive harvest of river herring by offshore fisheries is often implicated in the decline of Albemarle Sound stocks since the 1980's. Harris and Rulifson (1991) compared ocean landings of river herring to total domestic river herring landings from coastal rivers by attempting to separate riverine and state territorial seas landings from true offshore harvest. Results, reviewed for the NC MFC in Carmichael (1998; 1999), indicate that total 1978 to 1987 ocean landings of river herring ranged between 688 and 66,000 pounds, accounting for 0.5 to 11 % of total combined river herring landings. Ocean landings in most years were around 2% of the total, with the unusually high value of 11% observed in 1978 attributed to unusually low coastwide riverine landings and unusually high ocean landings in Massachusetts. States reporting significant ocean bycatch of river herring are Massachusetts, Virginia, New York, and North Carolina. Reported offshore landings of river herring are relatively insignificant, but other known sources of blueback herring harvest are not included in the coastal statistics. For example, blueback herring migrate as far North as the Bay of Fundy, and are vulnerable to harvest by Canadian fisheries. Both joint-venture and directed foreign vessel fisheries also harvest some blueback herring as bycatch, mostly in Atlantic Mackerel fisheries. Joint-venture and foreign fisheries were limited to 220,000 pounds of river herring at the time of the Harris and Rulifson report, and recent data indicate that between 1981 and 1989 bycatch in these fisheries ranged between 16 and 220 thousand pounds. There is evidence to suggest that some of the decline in river herring stocks along the Atlantic Coast during the 1970's can be attributed to offshore fisheries (Street and Davis 1976, Rulifson et al. 1987, Crecco and Gibson 1990, Hightower et al. 1996). However, given that since the 1980's, landings by directed fisheries have far exceeded those of offshore fisheries and that offshore fisheries harvest both alewife and blueback herring from many different stocks, it seems unlikely that ocean landings of river herring contributed significantly to the harvest of Chowan River blueback herring during the 1980's. Moreover, in light of sustained excessive exploitation by directed fisheries within Albemarle Sound, it seems unlikely that offshore fisheries are contributing significantly to the continued low abundance of Chowan River blueback herring since the 1980's.

Total harvest is a major source of uncertainty in this assessment. The harvest used to construct the catches at age includes only landings in the Chowan River pound net fishery. Landings from other fisheries that harvest river herring from this stock, such as the gill net fishery in Albemarle Sound and the recreational fishery in inland waters, are not included. Because pound nets are a non-selective gear and the pound net fishery accounts for 95% of the total known harvest, estimates of mortality rate should not be especially biased by the omission of some landings. However, indicators of absolute abundance, such as recruitment and spawning stock biomass, may be underestimated to some unknown extent. This bias will also be reflected in estimates of fishing mortality. Again, since the pound net fishery has dominated the harvest of the river herring stock, the amount of bias should be fairly low and the trend would remain the same.

Previous assessments of the blueback herring stock, also based on landings from the Chowan River pound net fishery, reported exploitation rates similar to those in this analysis. Crecco and Gibson (1990) used models based on stock-recruitment parameters to estimate an average F=1.1 for 1983 to 1987. In a CAGEAN catch at age model covering 1972-1995, Schaaf (1998) reported an average F for 1972-1995 of 1.17. That report also noted a truncated age structure, substantial declines in both SSB and recruitment since the 1970's, and fishing mortality exceeding F_{msy} jeopardized the stock. Schaaf reported a drop in fishing mortality for 1995 attributal to season restrictions and harvest quotas. According to that analysis, the trend continued through 1998, but has since reversed, and fishing mortality has increased.

Management measures for the river herring fishery cannot be partitioned out by species due to the nature of the fishery and species intermixing. Correspondingly, to adequately quantify and rebuild the river herring fishery as a whole, management must utilize an indicator species to project the adequacy of any chosen measure. Blueback herring, which has historically dominated the landings and population estimates, was chosen by the PDT as the indicator species for management measures to be developed, projected, and monitored.

Results of the yield-per-recruit analysis do not appear especially useful, primarily due to F_{max} being undefined, and the excessive exploitation rates associated with $F_{0.1}$ and SPR references such as $F_{40\%}$ and $F_{30\%}$. There are several possible explanations for the high YPR reference point estimates. Weight-at-age increases little between the ages of 3 and 9, so the reduced abundance of older ages is not offset by an increase in biomass and much of the stock biomass is represented by younger ages that have low selectivity (and thus are not fully exploited by the fishery). As a result, high exploitation rates remove most of the older fish but do not result in a large decline in SSB per recruit. The relatively high natural mortality is another consideration, as it prevents most recruits from reaching the older ages even if F=0 and contributes to a low virgin (conditions in the absence of fishing) spawning stock biomass. The combination of low virgin spawning stock biomass, low selectivity of younger, immature fish, and little increase in weight at age for older ages prevents increasing mortality rates from drastically reducing overall SSB. Ultimately, these factors give the false indication that the stock would be able to support high levels of fishing mortality without a significant decline in biomass. Yield-per-recruit results would perhaps differ if the calculation of maximum spawning potential was based on fecundity, rather than biomass. Crecco and Gibson (1990) suggested that the high fecundity of blueback herring may enable them to support much higher fishing mortality than American shad. As support of this theory, they cite the fact that American shad and blueback herring have roughly the same lifetime fecundity, yet shad outweigh herring by an order of magnitude. The Thompson-Bell YPR analysis presented by Crecco and Gibson (1990) shows that both YPR and biomass per recruit fail to reach clear asymptotes. Another difficulty with YPR analysis for this stock is the clear presence of a stock-recruitment relationship. When there is a strong relationship between recruitment and stock abundance, F_{max} can be much larger than F_{msy} (Deriso 1987). The stock assessment indicates that recruitment overfishing is occurring, yet F_{max} is undefined since the yield never reaches a clear asymptote, while values of other references appear excessive with $F_{0.1}$ estimated at F=1.0 and $F_{40\%SPR}$ at F=1.6. When fishing mortality was sustained around F=1.0, this stock sharply declined. Thus, these reference values do not provide real guidance in establishing management targets, and clearly fail to account for the recruitment failures observed from the current truncated age structure and low stock sizes.

Combining stock-recruitment information with the YPR results suggests that, if future management strategies are based on YPR estimated growth overfishing reference points, the stock could be overexploited. Given the past recruitment history, fishing mortality must be held below 0.1 to achieve replacement. Furthermore, this value is based on the entire series of observed recruitment values, so if the current trend of lower than expected recruitment continues, even F=0.1 may be excessive.

Projections of future fishing mortality and catch levels clearly indicate that little improvement in the stock can be expected until recruitment improves. Also, regardless of the level of harvest or exploitation, a series of poor cohorts will move through the population in the next few years. How SSB responds in 2006 and beyond will depend on the level of exploitation and whether future recruitment improves or stays at the current average. Comparing the two alternative approaches to predicting future recruitment shows that the stock-recruitment model predicts steady increases in recruitment and SSB if the exploitation does not exceed F=0.1 or the harvest does not exceed 10,000 pounds. Conversely, the stochastic model based on observed recruitment suggests that neither recruitment nor SSB will improve until a year class of at least average strength occurs. For harvest levels greater than 10,000 pounds and exploitation rates greater than F=0, it is possible that the long-term SSB could decline further, and push an already heavily exploited stock to collapse. The key factor in examining the alternative approaches to predicting future recruitment and SSB is that neither model, even under a moratorium, rebuilds the stock to the minimum SSB threshold level of 4 million pounds by 2021, the target year.

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Table 1. Chowan River (CR) blueback herring and alewife landings and pound net landings, 1972 to 2004.

Year	Total CR River Herring Landings (lb)	Percent of CR River Herring: Blueback Landings (%)	Total CR Blueback Landings (lb)	Percent of CR River Herring: Alewife Landings (%)	Total CR Alewife Landings (lb)	Percent of CR Landings: Pound Net Landings (%)	Total CR Pound Net Landings (lb)	Total CR Pound Net Blueback Landings (lb)	Total CR Pound Net Alewife Landings (lb)	Blueback Mean Weight Pounds (lb)	Total CR Catch Blueback Numbers (#)	Alewife Mean Weight Pounds (lb)	Total CR Catch Alewife Numbers (#)
1972	10,594,117	78%	8,263,411	22%	2,330,706	98%	10,338,274	8,063,853	2,274,421	0.404	20,443,867	0.551	4,229,956
1973	7,350,578	79%	5,806,957	21%	1,543,621	99%	7,308,578	5,773,776	1,534,802	0.417	13,918,880	0.513	3,009,594
1974	5,736,905	84%	4,819,000	16%	917,805	98%	5,637,262	4,735,300	901,962	0.397	12,141,597	0.513	1,789,442
1975	5,031,756	53%	2,666,831	47%	2,364,925	99%	4,968,795	2,633,461	2,335,334	0.366	7,286,423	0.513	4,610,889
1976	5,734,776	84%	4,817,212	16%	917,564	100%	5,704,034	4,791,388	912,646	0.397	12,121,822	0.513	1,788,972
1977	7,418,218	96%	7,121,489	4%	296,729	98%	7,292,770	7,001,059	291,711	0.423	16,831,692	0.513	578,532
1978	5,615,113	77%	4,323,637	23%	1,291,476	94%	5,260,737	4,050,767	1,209,970	0.443	9,762,107	0.513	2,517,988
1979	4,303,663	51%	2,194,868	49%	2,108,795	97%	4,154,720	2,118,907	2,035,813	0.446	4,921,229	0.513	4,111,513
1980	5,382,954	65%	3,498,920	35%	1,884,034	97%	5,213,820	3,388,983	1,824,837	0.459	7,617,940	0.523	3,602,359
1981	3,314,447	63%	2,088,102	37%	1,226,345	98%	3,240,189	2,041,319	1,198,870	0.479	4,360,204	0.533	2,302,563
1982	7,549,968	73%	5,511,477	27%	2,038,491	98%	7,380,980	5,388,115	1,992,865	0.435	12,658,422	0.494	4,130,681
1983	4,405,915	55%	2,423,253	45%	1,982,662	98%	4,327,749	2,380,261	1,947,488	0.407	5,955,402	0.506	3,919,854
1984	4,561,503	71%	3,238,667	29%	1,322,836	99%	4,501,994	3,196,416	1,305,578	0.359	9,023,870	0.565	2,341,717
1985	8,871,391	78%	6,919,685	22%	1,951,706	99%	8,776,370	6,845,568	1,930,802	0.377	18,364,344	0.449	4,343,881
1986	5,767,874	76%	4,383,584	24%	1,384,289	97%	5,584,579	4,244,280	1,340,299	0.399	10,997,451	0.411	3,368,919
1987	2,334,719	58%	1,354,137	42%	980,582	100%	2,333,795	1,353,601	980,194	0.370	3,664,782	0.468	2,093,918
1988	2,259,888	64%	1,446,328	36%	813,560	99%	2,234,554	1,430,114	804,440	0.348	4,162,095	0.418	1,947,247
1989	908,145	69%	626,620	31%	281,525	100%	907,569	626,222	281,347	0.354	1,772,115	0.398	706,816
1990	710,849	86%	611,330	14%	99,519	100%	710,386	610,931	99,455	0.379	1,612,157	0.513	194,032
1991	1,202,535	71%	853,799	29%	348,735	84%	1,014,392	720,218	294,174	0.335	2,545,614	0.533	654,655
1992	1,135,340	71%	806,091	29%	329,249	100%	1,135,340	806,091	329,249	0.353	2,281,605	0.469	701,425
1993	801,115	80%	640,892	20%	160,223	100%	800,115	640,092	160,023	0.364	1,763,114	0.513	312,386
1994	390,852	98%	383,035	2%	7,817	99%	385,437	377,728	7,709	0.277	1,380,804	0.427	18,311
1995	280,681	98%	275,067	2%	5,613	96%	268,534	263,163	5,371	0.338	814,048	0.427	13,148
1996	404,884	99%	400,835	1%	4,049	98%	398,476	394,491	3,985	0.384	1,043,026	0.427	9,485
1997	201,929	99%	199,909	1%	2,019	95%	191,991	190,071	1,920	0.426	468,830	0.427	4,729
1998	377,312	98%	369,766	2%	7,546	98%	368,658	361,285	7,373	0.334	1,105,760	0.427	17,676
1999	332,466	98%	325,815	2%	6,649	98%	324,995	318,495	6,500	0.343	948,791	0.320	20,804
2000	184,741	80%	146,126	20%	36,531	99%	182,658	146,126	36,532	0.335	436,067	0.401	91,168
2001	201,716	68%	137,167	32%	64,549	100%	201,468	136,998	64,470	0.378	363,260	0.443	145,676
2002	93,047	55%	51,138	45%	41,840	92%	85,883	47,235	38,648	0.383	133,659	0.458	91,394
2003	84,590	56%	47,371	44%	37,220	96%	80,940	45,326	35,614	0.331	143,201	0.395	94,204
2004	77,177	41%	31,642	59%	45,535	94%	72,184	29,595	42,589	0.309	102,534	0.441	103,277

Table 2. ASRHMA river herring gill net landings, 1972 to 2004.

Year	Pounds
1972	48,111
1973	17,740
1974	75,632
1975	343,834
1976	234,453
1977	275,800
1978	997,577
1979	679,773
1980	776,748
1981	1,065,035
1982	1,668,276
1983	1,333,447
1984	1,891,977
1985	877,311
1986	871,371
1987	761,598
1988	1,523,240
1989	560,872
1990	362,384
1991	533,268
1992	220,175
1993	111,580
1994	174,869
1995	155,154
1996	119,697
1997	125,397
1998	144,358
1999	103,856
2000	83,358
2001	71,078
2002	65,920
2003	65,764
2004	71,406

Table 3. Blueback herring catch-at-age (numbers) landed in the Chowan River pound net fishery, 1972 to 2003.

YEAR \ AGE	3	4	5	6	7+	Sum (3-9)
1972	3,557,634	7,716,558	6,614,192	2,304,945	250,538	20,443,867
1973	760,839	5,191,608	4,744,056	2,774,825	447,552	13,918,880
1974	157,003	5,390,450	4,082,089	2,250,382	261,672	12,141,597
1975	281,601	4,928,015	1,760,006	246,401	70,400	7,286,423
1976	438,952	6,618,042	4,186,924	709,076	168,828	12,121,822
1977	0	3,152,602	11,381,430	1,816,754	480,906	16,831,692
1978	260,322	3,384,197	5,076,296	824,356	216,936	9,762,107
1979	192,737	1,117,877	2,235,754	1,117,877	256,984	4,921,229
1980	35,025	1,716,226	2,889,563	1,926,376	1,050,750	7,617,940
1981	19,582	959,506	1,651,394	1,044,360	685,362	4,360,204
1982	570,666	6,381,091	3,216,484	1,608,242	881,939	12,658,422
1983	408,704	3,075,011	2,082,444	350,318	38,925	5,955,402
1984	1,032,392	3,976,621	3,288,359	726,498	0	9,023,870
1985	437,246	2,361,130	10,843,708	4,547,362	174,898	18,364,344
1986	277,714	2,554,963	4,887,756	2,888,219	388,799	10,997,451
1987	209,416	2,024,356	994,727	349,027	87,256	3,664,782
1988	611,573	2,497,257	849,407	152,893	50,965	4,162,095
1989	232,590	974,663	487,332	77,530	0	1,772,115
1990	515,890	741,592	282,127	72,548	0	1,612,157
1991	596,462	1,171,621	628,415	117,162	31,954	2,545,614
1992	77,606	1,327,056	698,450	170,732	7,761	2,281,605
1993	68,872	289,261	1,033,075	316,809	55,097	1,763,114
1994	266,179	632,175	365,996	99,817	16,637	1,380,804
1995	19,537	319,107	442,842	19,537	13,025	814,048
1996	96,576	347,675	424,936	135,207	38,632	1,043,026
1997	66,976	184,183	138,137	71,162	8,372	468,830
1998	36,294	355,682	585,545	100,413	27,826	1,105,760
1999	15,194	254,924	492,966	172,201	13,506	948,791
2000	6,584	193,661	183,561	43,036	9,222	436,067
2001	2,471	149,505	164,332	43,863	3,089	363,260
2002	831	47,735	70,150	14,528	415	133,659
2003	4,792	49,508	68,672	17,035	3,194	143,201

Table 4. CRPN blueback herring sampling intensity, 1972 to 2004.

Year	Ages Collected (#)	Lengths Collected (#)	Landings (lb)	Weights Collected (#)	Length /200mt	Age /200mt
1972	412	862	8,063,853	862	47	23
1973	333	806	5,773,776	0	62	25
1974	232	579	4,735,300	0	54	22
1975	148	501	2,633,461	0	84	25
1976	217	467	4,791,388	0	43	20
1977	118	421	7,001,059	0	27	7
1978	200	379	4,050,767	0	41	22
1979	331	434	2,118,907	0	90	69
1980	371	455	3,388,983	0	59	48
1981	345	668	2,041,319	668	144	75
1982	141	245	5,388,115	244	20	12
1983	171	299	2,380,261	299	55	32
1984	133	240	3,196,416	240	33	18
1985	129	210	6,845,568	210	14	8
1986	118	198	4,244,280	198	21	12
1987	132	210	1,353,601	210	68	43
1988	136	247	1,430,114	247	76	42
1989	77	131	626,222	131	92	54
1990	133	205	610,931	205	148	96
1991	127	209	720,218	209	128	78
1992	164	293	806,091	293	160	90
1993	82	130	640,092	130	90	56
1994	71	84	377,728	84	98	83
1995	79	125	263,163	125	209	132
1996	82	109	394,491	109	122	92
1997	75	114	190,071	114	264	174
1998	464	911	361,285	911	1112	566
1999	295	562	318,495	562	778	408
2000	512	996	146,126	996	3005	1545
2001	315	592	136,998	592	1905	1014
2002	176	333	47,235	333	3108	1643
2003	149	274	45,326	274	2665	1449
2004	150	245	29,595	245	3650	2235

Table 5. CRPN blueback herring average weight-at-age in pounds, 1972 to 2003.

AGE/ YEAR	2	3	4	5	6	7	8	9	Annual
1972		0.3787	0.3940	0.4211	0.4259	0.4337			0.4042
1973		0.3228	0.3735	0.4285	0.4708	0.4797	0.4746		0.4172
1974		0.3164	0.3569	0.4080	0.4476	0.5011			0.3969
1975		0.3229	0.3477	0.4061	0.4610	0.5678	0.5678	0.5678	0.3660
1976		0.3626	0.3686	0.4126	0.5145	0.5487			0.3974
1977			0.3825	0.4285	0.4909	0.5223	0.5853		0.4261
1978		0.4043	0.4314	0.4558	0.4533	0.5600			0.4429
1979		0.3552	0.4041	0.4519	0.4779	0.4948	0.5779		0.4460
1980		0.4044	0.4106	0.4431	0.4828	0.5374	0.5759		0.4593
1981		0.2728	0.4141	0.4603	0.5059	0.5567	0.5995	0.6655	0.4789
1982		0.3459	0.3987	0.4493	0.5084	0.5585	0.5831	0.7496	0.4354
1983		0.3446	0.3839	0.4291	0.5284	0.5530	0.6944		0.4069
1984		0.2972	0.3345	0.3898	0.4528				0.3589
1985		0.3036	0.3432	0.3724	0.4094	0.5115			0.3768
1986		0.3019	0.3475	0.4055	0.4293	0.5101			0.3986
1987		0.3121	0.3383	0.3978	0.4546	0.4826			0.3695
1988	0.2646	0.2996	0.3332	0.3865	0.4749	0.5051			0.3475
1989		0.2850	0.3214	0.3968	0.4503				0.3536
1990	0.2260	0.3401	0.3859	0.4043	0.5006	0.6173			0.3792
1991		0.2804	0.3276	0.4134	0.5374	0.6327			0.3354
1992		0.2860	0.3365	0.3763	0.4101	0.4722			0.3533
1993		0.2972	0.3361	0.3611	0.3986	0.4353			0.3635
1994		0.2390	0.2556	0.2839	0.4533	0.4905			0.2774
1995		0.3126	0.3156	0.3442	0.4401	0.5420			0.3379
1996		0.2602	0.3474	0.4120	0.4651	0.4815			0.3843
1997		0.2710	0.3407	0.5232	0.5572	0.7165			0.4264
1998		0.2762	0.3009	0.3392	0.4127	0.4886			0.3344
1999		0.2677	0.3149	0.3502	0.3604	0.4188			0.3434
2000		0.2155	0.3069	0.3546	0.4029	0.4787			0.3351
2001		0.2645	0.3324	0.3897	0.4991	0.6007			0.3776
2002		0.3086	0.3291	0.3999	0.4666	0.485			0.3826
2003		0.2498	0.2904	0.3614	0.4056	0.3968			0.3308
Mean	0.2453	0.3064	0.3504	0.4018	0.4609	0.5193	0.5823	0.661	0.3825

Table 6. Alewife catch-at-age (numbers) landed in the Chowan River pound net fishery,1972 to 2003.

YEAR \ AGE	3	4	5	6	7+	Sum (3-9)
1972	711,582	1,568,114	1,291,388	448,033	210,839	4,229,956
1973	276,109	1,560,019	676,468	358,942	138,056	3,009,594
1974	255,634	1,267,947	184,057	61,352	20,452	1,789,442
1975	249,851	2,135,091	1,476,393	635,985	113,569	4,610,889
1976	9,567	707,935	841,869	200,900	28,701	1,788,972
1977	11,867	246,247	284,816	23,735	11,867	578,532
1978	166,021	1,840,068	387,383	110,681	13,835	2,517,988
1979	264,377	2,470,554	1,157,787	209,678	9,117	4,111,513
1980	0	388,490	1,765,862	1,212,559	235,448	3,602,359
1981	0	458,943	1,321,914	380,493	141,213	2,302,563
1982	40,300	2,377,661	1,289,578	402,993	20,149	4,130,681
1983	493,063	2,021,561	961,473	443,757	0	3,919,854
1984	18,439	1,272,271	682,233	295,019	73,755	2,341,717
1985	186,833	2,055,171	1,868,336	233,541	0	4,343,881
1986	190,693	1,144,161	1,652,677	381,388	0	3,368,919
1987	129,077	1,305,113	631,044	14,342	14,342	2,093,918
1988	413,790	973,623	389,449	170,385	0	1,947,247
1989	121,864	389,967	170,612	24,373	0	706,816
1990	15,663	71,318	76,183	23,721	7,147	194,032
1991	18,704	93,523	374,088	168,340	0	654,655
1992	0	131,517	409,164	102,292	58,452	701,425
1993	25,216	114,819	122,653	38,191	11,507	312,386
1994	1,015	7,997	6,569	2,602	128	18,311
1995	729	5,742	4,717	1,868	92	13,148
1996	526	4,142	3,403	1,348	66	9,485
1997	262	2,065	1,696	672	34	4,729
1998	980	7,720	6,341	2,512	123	17,676
1999	1,154	9,086	7,463	2,956	145	20,804
2000	9,597	52,781	22,552	5,278	960	91,168
2001	1,457	52,929	77,694	13,596	0	145,676
2002	3,723	20,987	47,728	18,956	0	91,394
2003	2,298	68,470	12,407	10,110	919	94,204

Table 7. CRPN alewife sampling intensity, 1972 to 2004.

Year	Ages Collected (#)	Lengths Collected (#)	Landings (lb)	Weights Collected (#)	Length /200mt	Age /200mt
1972	298	589	2,274,421	578	114	58
1973	172	499	1,534,802	0	143	49
1974	177	262	901,962	0	128	87
1975	175	585	2,335,334	0	110	33
1976	187	417	912,646	0	201	90
1977	59	129	291,711	0	195	89
1978	232	269	1,209,970	0	98	85
1979	503	669	2,035,813	0	145	109
1980	248	286	1,824,837	0	69	60
1981	302	584	1,198,870	584	215	111
1982	123	210	1,992,865	181	46	27
1983	101	163	1,947,488	163	37	23
1984	90	125	1,305,578	125	42	30
1985	81	94	1,930,802	94	21	18
1986	53	53	1,340,299	53	17	17
1987	73	90	980,194	90	40	33
1988	64	82	804,440	82	45	35
1989	29	29	281,347	29	45	45
1990	0	0	99,455	0	0	0
1991	30	30	294,174	30	45	45
1992	48	48	329,249	48	64	64
1993	3	3	160,023	3	8	8
1994	2	2	7,709	2	114	114
1995	0	0	5,371	0	0	0
1996	0	0	3,985	0	0	0
1997	0	1	1,920	1	230	0
1998	0	0	7,373	0	0	0
1999	4	4	6,500	4	271	271
2000	111	190	36,532	190	2,293	1,340
2001	131	242	64,470	242	1,655	896
2002	166	276	38,648	276	3,149	1,894
2003	108	181	35,614	181	2,241	1,337
2004	212	212	42,589	212	2,195	2,195

Table 8. CRPN alewife average weight-at-age in pounds, 1972 to 2003.

AGE/ YEAR	3	4	5	6	7	Annual
1972	0.4605	0.5315	0.5975	0.6442	0.7558	0.5510
1973	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1974	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1975	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1976	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1977	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1978	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1979	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1980		0.4757	0.5301	0.5853	0.7129	0.5230
1981		0.4823	0.5251	0.5471	0.6680	0.5326
1982		0.4734	0.5401	0.5748	0.8377	0.4935
1983	0.3784	0.4781	0.5778	0.6424		0.5058
1984	0.4188	0.5238	0.5673	0.6540	0.7826	0.5649
1985	0.3196	0.4270	0.4837	0.6084		0.4493
1986	0.2866	0.3919	0.4290	0.4519		0.4109
1987	0.3282	0.4371	0.5397	0.5511	0.9258	0.4683
1988	0.3212	0.4049	0.4835	0.5196		0.4178
1989	0.2645	0.3871	0.5007	0.5291		0.3983
1990	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1991		0.4409	0.5082	0.6123		0.5327
1992		0.3830	0.4508	0.5322	0.6668	0.4694
1993	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129
1994	0.2976	0.3767	0.4648	0.5264	0.6288	0.4269
1995	0.2976	0.3767	0.4648	0.5264	0.6288	0.4269
1996	0.2976	0.3767	0.4648	0.5264	0.6288	0.4269
1997	0.2976	0.3767	0.4648	0.5264	0.6288	0.4269
1998	0.2976	0.3767	0.4648	0.5264	0.6288	0.4269
1999	0.2314	0.3306	0.3306	0.3968		0.3196
2000	0.3289	0.3797	0.4432	0.5004	0.5401	0.4007
2001	0.3196	0.4137	0.4605	0.5188		0.4431
2002	0.2685	0.3669	0.4805	0.5174		0.4578
2003	0.2976	0.3540	0.4568	0.5711	0.7054	0.3951
Mean	0.3974	0.4757	0.5301	0.5853	0.7129	0.5129

Table 9. Chowan River pound net effort, 1972 to 2004.

YEAR	Maximum Number of Pound Nets	Weeks Fished	Total Effort in Pound Nets (weeks)	Pound Net Blueback Catch	CPUE Blueback Pounds (lb) per Pound Net Week	Pound Net Alewife Catch	CPUE Alewife Pounds (lb) per Pound Net Week
1972			4,387	8,063,853	1,838	2,274,421	518
1973			4,387	5,773,776	1,316	1,534,802	350
1974			4,387	4,735,300	1,079	901,962	205
1975			4,387	2,633,461	600	2,335,334	532
1976			4,387	4,791,388	1,092	912,646	208
1977	624	9	4,854	7,001,059	1,442	291,711	60
1978	383	10	3,645	4,050,767	1,111	1,209,970	332
1979	502	12	4,996	2,118,907	424	2,035,813	407
1980	500	9	3,090	3,388,983	1,096	1,824,837	590
1981	525	10	4,120	2,041,319	495	1,198,870	291
1982	480	11	4,461	5,388,115	1,207	1,992,865	446
1983	486	12	4,895	2,380,261	486	1,947,488	398
1984	480	12	5,040	3,196,416	634	1,305,578	259
1985	421	12	3,708	6,845,568	1,846	1,930,802	520
1986	451	12	4,241	4,244,280	1,000	1,340,299	316
1987	501	11	4,969	1,353,601	272	980,194	197
1988	506	12	4,689	1,430,114	305	804,440	171
1989	348	9	3,063	626,222	204	281,347	92
1990	360	11	3,077	610,931	198	99,455	32
1991	226	11	2,037	720,218	353	294,174	144
1992	180	12	1,669	806,091	483	329,249	197
1993	197	11	1,729	640,092	370	160,023	92
1994	175	8	1,173	377,728	322	7,709	6
1995	73	8	484	263,163	543	5,371	11
1996	95	10	555	394,491	711	3,985	7
1997	102	5	461	190,071	412	1,920	4
1998	75	11	463	361,285	780	7,373	16
1999	68	8	471	318,495	676	6,500	14
2000	51	9	445	146,126	328	36,532	82
2001	63	7	385	136,998	356	64,470	167
2002	62	12	648	47,235	73	38,648	60
2003	50	10	419	45,326	108	35,614	85
2004	36	12	376	29,595	79	42,589	113

Table 10. Blueback herring and alewife JAI (fish per seine) from alosid core seine sites, Albemarle Sound area, 1972 to 2004.

Year	Blueback JAI	Alewife JAI
1972	320.5	4.92
1973	362.9	4.68
1974	83.3	0.8
1975	123.4	7.6
1976	157.4	1.2
1977	103.2	6.8
1978	77.3	8.9
1979	174.1	3.9
1980	222.6	12.4
1981	1.0	5.2
1982	68.9	0.5
1983	228.7	2.1
1984	18.9	0.7
1985	139.7	3.9
1986	13.8	2.3
1987	25.1	0
1988	11.0	0.2
1989	0.0	0.05
1990	9.2	0.04
1991	21.8	0
1992	0.9	0.02
1993	67.3	0
1994	0.0	0
1995	1.2	0.1
1996	14.9	3.2
1997	7.2	0.44
1998	0.4	1.2
1999	1.8	1.3
2000	1.5	0.3
2001	4.5	0.9
2002	0.8	0.1
2003	1.3	1.5
2004	14.8	2.1

Table 11. Hassler trawl survey CPUE of blueback herring and alewife, western Albemarle Sound area, 1972-2004.

Year	Blueback Trawl Survey Catch per Tow JAI	Alewife Trawl Survey Catch per Tow JAI
1972	10.8	2.2
1973	37.9	0.2
1974	7.1	0.2
1975	37.3	1.3
1976	11.4	0.1
1977	11.8	5.2
1978	43.0	5.9
1979	2.0	2.7
1980	16.0	1.5
1981	0.0	0
1982	38.9	2.3
1983	13.9	0.5
1984	3.8	2.1
1985	0.2	0.01
1986	8.9	0.6
1987	14.7	0.01
1988	1.9	0.9
1989	0.2	0.09
1990	27.6	0.5
1991	4.9	0.07
1992	0.1	0.11
1993	39.1	0.05
1994	0.4	0
1995	0.1	0.04
1996	107.8	3
1997	90.5	0.7
1998	0.1	0
1999	0.0	0.05
2000	22.9	0.87
2001	8.4	8.6
2002	0.2	2.08
2003	15.9	4.96
2004	60.0	1.28

Table 12. ASRHMA independent gill net survey CPUE for 2.5-inch stretch mesh, 1991 to 2003.

2.5" Gillnet		Blueback Herring		Alewife	
Year	Sets	**Total fish**	CPUE	**Total fish**	CPUE
1991	229	3,946	17.2	95	0.41
1992	248	2,756	11.1	753	3
1993	260	1,667	6.4	115	0.44
1994	234	637	2.7	84	0.36
1995	254	2,561	10.1	89	0.35
1996	248	1,449	5.8	118	0.47
1997	256	3,261	12.7	35	0.14
1998	257	2,308	8.9	27	0.1
1999	270	2,489	9.2	260	0.96
2000	261	3,741	14.3	648	2.48
2001	246	2,275	9.2	852	3.46
2002	249	1,366	5.5	105	0.42
2003	276	1,943	7	152	0.55

Table 13. ASRHMA independent gill net survey CPUE for 3.0-inch stretch mesh, 1991 to 2003.

3.0" Gillnet		Blueback Herring		Alewife	
Year	Sets	**Total fish**	CPUE	**Total fish**	CPUE
1991	239	871	3.6	127	0.53
1992	248	441	1.8	303	1.22
1993	263	171	0.65	24	0.09
1994	233	1	0.004	9	0.03
1995	252	111	0.44	118	0.46
1996	248	65	0.26	32	0.12
1997	257	77	0.3	29	0.11
1998	257	56	0.21	37	0.14
1999	272	111	0.4	21	0.07
2000	261	284	1	278	1.06
2001	248	204	0.82	528	2.12
2002	249	91	0.36	216	0.86
2003	276	364	1.31	158	0.57

Table 14. Estimated male, female, and combined maturation schedules. Based on analysis of spawning marks data.

Age	Male Maturation Proportion	Female Maturation Proportion	Combined Sexes Maturation Proportion
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.06	0.06	0.13
4	0.26	0.62	0.48
5	0.67	0.98	0.84
6	0.92	1.00	0.97
7	1.00	1.00	1.00
8	1.00	1.00	1.00

Table 15. Estimated blueback herring abundance at age in numbers, 1972 to 2003.

			AGE			
Year	3	4	5	6	7+	Sum (3-9)
1972	39,865,477	28,225,684	16,332,859	4,596,699	621,741	89,642,459
1973	23,506,889	23,640,276	11,438,335	3,895,696	1,244,697	63,725,893
1974	22,284,834	13,939,614	9,580,119	2,728,260	1,226,081	49,758,906
1975	51,118,274	13,214,933	5,648,968	2,285,040	943,185	73,210,400
1976	44,515,997	30,313,198	5,355,294	1,347,386	769,993	82,301,868
1977	21,013,218	26,398,040	12,284,291	1,277,339	505,035	61,477,923
1978	15,591,527	12,460,863	10,697,691	2,930,036	425,130	42,105,247
1979	16,829,710	9,245,795	5,049,710	2,551,602	800,271	34,477,088
1980	10,028,049	9,980,038	3,746,818	1,204,452	799,485	25,758,842
1981	38,857,247	5,946,645	4,044,367	893,687	477,977	50,219,923
1982	15,254,203	23,042,394	2,409,852	964,658	327,168	41,998,275
1983	38,099,778	9,045,761	9,337,830	574,795	308,125	57,366,289
1984	59,696,182	22,593,214	3,665,755	2,227,249	210,593	88,392,994
1985	7,987,989	35,399,908	9,155,801	874,352	581,472	53,999,523
1986	9,165,666	4,736,887	14,345,658	2,183,832	347,242	30,779,285
1987	8,969,447	5,435,251	1,919,603	3,421,711	603,709	20,349,721
1988	3,049,336	5,318,893	2,202,612	457,862	960,139	11,988,842
1989	5,103,808	1,808,260	2,155,458	525,365	338,220	9,931,111
1990	9,036,148	3,026,565	732,790	514,118	205,981	13,515,601
1991	7,797,123	5,358,447	1,226,502	174,784	171,757	14,728,613
1992	2,628,602	4,623,703	2,171,487	292,544	82,657	9,798,993
1993	4,380,587	1,558,764	1,873,736	517,941	89,492	8,420,520
1994	3,030,564	2,597,693	631,682	446,921	144,884	6,851,746
1995	1,864,735	1,797,128	1,052,704	150,668	141,157	5,006,392
1996	3,366,597	1,115,027	845,037	354,232	98,198	5,779,091
1997	2,476,938	1,994,012	442,309	191,834	102,708	5,207,801
1998	1,517,985	1,487,570	1,013,639	178,267	118,711	4,316,172
1999	1,055,377	898,507	583,264	223,995	65,627	2,826,769
2000	622,571	616,654	279,542	75,459	37,470	1,631,696
2001	343,726	367,029	225,051	52,326	21,138	1,009,270
2002	273,119	200,321	109,047	26,171	8,543	617,201
2003	467,359	161,699	78,877	24,334	7,746	740,016

Table 16. Estimated alewife abundance at age in numbers, 1972 to 2003.

	AGE					
Year	3	4	5	6	7+	Sum (3-9)
1972	5,806,398	4,393,737	2,330,191	756,163	359,588	13,646,078
1973	6,792,805	3,452,490	1,546,674	212,489	101,745	12,106,203
1974	10,243,653	4,039,009	1,215,339	141,040	28,655	15,667,695
1975	1,524,166	6,090,886	1,421,804	110,826	15,474	9,163,156
1976	1,027,837	906,270	2,144,101	129,653	11,517	4,219,379
1977	10,412,192	611,153	319,023	195,519	12,873	11,550,760
1978	12,893,819	6,191,099	215,137	29,092	19,003	19,348,150
1979	6,485,611	7,666,677	2,179,378	19,618	4,386	16,355,670
1980	4,224,186	3,856,351	2,698,808	198,736	2,189	10,980,270
1981	14,429,980	2,511,705	1,357,505	246,102	18,322	18,563,615
1982	6,312,971	8,580,080	884,165	123,790	24,113	15,925,119
1983	6,863,865	3,753,699	3,020,342	80,626	13,487	13,732,019
1984	13,661,915	4,081,261	1,321,369	275,423	8,582	19,348,550
1985	5,047,520	8,123,388	1,436,677	120,495	25,898	14,753,978
1986	6,187,074	3,001,260	2,859,578	131,010	13,349	12,192,272
1987	3,179,568	3,678,840	1,056,498	260,763	13,164	8,188,833
1988	595,544	1,890,574	1,295,018	96,341	24,979	3,902,456
1989	448,161	354,111	665,516	118,092	11,063	1,596,942
1990	2,483,113	266,477	124,653	60,688	11,778	2,946,709
1991	1,176,496	1,476,462	93,805	11,367	6,608	2,764,737
1992	25,082	699,546	519,741	8,554	1,639	1,254,562
1993	18,843	14,914	246,253	47,395	930	328,334
1994	38,198	11,204	5,250	22,456	4,407	81,514
1995	36,853	22,712	3,944	479	2,450	66,438
1996	41,260	21,934	8,206	394	292	72,085
1997	66,988	24,769	10,036	1,865	156	103,814
1998	137,422	40,486	13,628	4,335	873	196,745
1999	436,220	82,473	18,377	3,012	1,151	541,233
2000	356,773	262,945	42,208	6,169	1,398	669,494
2001	102,284	213,909	116,234	8,507	1,525	442,460
2002	475,838	61,066	84,173	15,623	1,348	638,049
2003	214,737	283,542	22,798	9,420	1,899	532,397

Table 17. Estimated blueback herring fishing mortality rate and confidence intervals, 1972 and 1994 to 2003.

Year	F	90% Confidence Interval	Total Annual Exploitation Rate	Fishing Annual Exploitation Rate
1972	0.90	0.89 – 0.91	75%	59%
1973	0.90			
1974	0.90			
1975	0.90			
1976	0.90			
1977	0.90			
1978	0.90			
1979	0.90			
1980	0.90			
1981	0.90			
1982	0.90			
1983	0.90			
1984	0.90			
1985	0.90			
1986	0.90			
1987	0.90			
1988	0.90			
1989	0.90			
1990	0.90			
1991	0.90			
1992	0.90			
1993	0.90			
1994	1.06	1.03 – 1.10	79%	65%
1995	0.69	0.67 – 0.71	70%	50%
1996	1.02	1.00 – 1.05	78%	64%
1997	0.40	0.39 – 0.41	59%	33%
1998	0.98	0.97 – 1.00	77%	63%
1999	1.47	1.43 – 1.50	86%	77%
2000	1.16	1.13 – 1.19	81%	69%
2001	1.59	1.56 – 1.63	88%	80%
2002	1.24	1.16 – 1.32	82%	71%
2003	1.91	1.85 – 1.98	91%	85%

Table 18. Estimated alewife fishing mortality rate and confidence intervals, 1972 and 1994 to 2003.

Year	F	90% Confidence Interval	Total Annual Exploitation Rate	Fishing Annual Exploitation Rate
1972	0.98	0.96 – 1.00	77%	62%
1973	0.98			
1974	0.98			
1975	0.98			
1976	0.98			
1977	0.98			
1978	0.98			
1979	0.98			
1980	0.98			
1981	0.98			
1982	0.98			
1983	0.98			
1984	0.98			
1985	0.98			
1986	0.98			
1987	0.98			
1988	0.98			
1989	0.98			
1990	0.98			
1991	0.98			
1992	0.98			
1993	0.98			
1994	1.06	1.01-1.11	79%	65%
1995	0.78	0.72-0.83	72%	54%
1996	0.98	0.97-0.98	77%	62%
1997	0.54	0.50-0.59	65%	42%
1998	1.01	1.01-1.01	78%	64%
1999	1.36	1.30-1.42	84%	74%
2000	1.05	1.01-1.08	79%	65%
2001	1.40	1.36-1.45	85%	75%
2002	1.86	1.84-1.89	91%	85%
2003	1.39	1.35-1.42	85%	75%

Table 19. Blueback herring spawning stock biomass and recruitment by cohort based on catch at age analysis.

Year	SSB (lb)	Recruits by cohort (est. numbers at age-3)
1969		39,865,477
1970		23,506,889
1971		22,284,834
1972	14,522,222	51,118,274
1973	11,425,556	44,515,997
1974	8,548,280	21,013,218
1975	7,911,119	15,591,527
1976	9,911,718	16,829,710
1977	10,459,987	10,028,049
1978	8,022,784	38,857,247
1979	5,635,462	15,254,203
1980	4,417,303	38,099,778
1981	4,709,277	59,696,182
1982	6,008,350	7,987,989
1983	6,779,751	9,165,666
1984	8,723,894	8,969,447
1985	10,231,393	3,049,336
1986	7,313,002	5,103,808
1987	3,862,501	9,036,148
1988	2,559,345	7,797,123
1989	1,698,050	2,628,602
1990	1,497,323	4,380,587
1991	1,837,518	3,030,564
1992	1,822,752	1,864,735
1993	1,379,160	3,366,597
1994	1,072,525	2,476,938
1995	896,214	1,517,985
1996	838,699	1,055,377
1997	741,427	622,571
1998	815,045	343,726
1999	537,244	273,119
2000	283,041	467,359
2001	190,190	
2002	99,797	
2003	89,678	

Table 20. Alewife spawning stock biomass and recruitment by cohort based on catch at age analysis.

Year	SSB (lb)	Recruits by cohort (est. numbers at age-3)
1969		5,806,398
1970		6,792,805
1971		10,243,653
1972	3,027,835	1,524,166
1973	2,024,871	1,027,837
1974	2,099,253	10,412,192
1975	2,169,714	12,893,819
1976	1,300,120	6,485,611
1977	950,638	4,224,186
1978	2,208,861	14,429,980
1979	3,067,599	6,312,971
1980	2,417,636	6,863,865
1981	2,090,113	13,661,915
1982	2,759,259	5,047,520
1983	2,618,448	6,187,074
1984	2,398,657	3,179,568
1985	2,835,526	595,544
1986	2,368,913	448,161
1987	1,630,842	2,483,113
1988	1,111,173	1,176,496
1989	476,350	25,082
1990	289,931	18,843
1991	449,585	38,198
1992	398,218	36,853
1993	142,058	41,260
1994	22,772	66,988
1995	10,862	137,422
1996	11,246	436,220
1997	14,802	356,773
1998	25,596	102,284
1999	52,443	475,838
2000	101,751	214,737
2001	111,738	
2002	86,407	
2003	92,442	

Table 21. Yield-per-recruit analysis for blueback herring.

Based on the Thompson-Bell method, M=0.5, 1972 to 2003 mean weights, catch at age estimated selectivity, and maturation estimated from spawning marks.

F	Yield	SSB	Biomass	YPR	SSB/R	B/R	% MSP (SPR)	Reference point
0	0.00	517.3	920.57	0.000	0.517	0.921	100.0%	
0.05	18.05	485.1	887.48	0.018	0.485	0.887	93.8%	
0.1	33.22	456.9	858.42	0.033	0.457	0.858	88.3%	
0.2	57.02	410.2	810.13	0.057	0.410	0.810	79.3%	
0.3	74.61	373.6	771.97	0.075	0.374	0.772	72.2%	F70%
0.4	87.99	344.3	741.32	0.088	0.344	0.741	66.6%	
0.5	98.48	320.7	716.31	0.098	0.321	0.716	62.0%	
0.6	106.92	301.3	695.59	0.107	0.301	0.696	58.2%	F60%
0.7	113.87	285.1	678.17	0.114	0.285	0.678	55.1%	
0.8	119.72	271.4	663.34	0.120	0.271	0.663	52.5%	
0.9	124.73	259.7	650.55	0.125	0.260	0.651	50.2%	F50%
1	129.09	249.6	639.41	0.129	0.250	0.639	48.3%	
1.1	132.94	240.8	629.59	0.133	0.241	0.630	46.6%	$F_{0.1}$
1.2	136.36	233.1	620.86	0.136	0.233	0.621	45.1%	
1.3	139.44	226.2	613.04	0.139	0.226	0.613	43.7%	
1.4	142.24	220.0	605.98	0.142	0.220	0.606	42.5%	
1.5	144.80	214.5	599.57	0.145	0.214	0.600	41.5%	
1.6	147.15	209.4	593.70	0.147	0.209	0.594	40.5%	F40%
1.7	149.32	204.8	588.31	0.149	0.205	0.588	39.6%	
1.8	151.34	200.6	583.33	0.151	0.201	0.583	38.8%	
1.9	153.23	196.7	578.71	0.153	0.197	0.579	38.0%	
2	155.00	193.2	574.41	0.155	0.193	0.574	37.3%	
2.5	162.45	178.6	556.57	0.162	0.179	0.557	34.5%	
3	168.27	167.8	543.02	0.168	0.168	0.543	32.4%	
3.5	173.04	159.5	532.27	0.173	0.160	0.532	30.8%	F30%

Table 22. Management strategy and target timetable.

Management Strategy	**Measures**	**2003**	**Time in years to Reach Management Targets (if management implemented by January 1st, 2006)**					
	Target Harvest or F	F or Harvest	Stock-Recruitment Projections			Stochastic Projections		
			4 mpds	6 mpds	8 mpds	4 mpds	6 mpds	8 mpds
Status quo	Allowable Harvest	F rate						
2003 Harvest	Quota = 300,000	F=1.28	**	**	**	**	**	**
Fixed Harvest	10,000	Initial F=0.16	26	**	**	**	**	**
Fixed Exploitation Rate	F rate	Allowable Harvest						
$F_{2000\text{-}03\ average}$	F=1.5	lb = 300,000	**	**	**	**	**	**
$F_{replacement}$	F=0.1	Initial lb =6,500	28	**	**	**	**	**
Moratorium	F=0	lb = 0	25	**	**	**	**	**

** - indicates that the management benchmark is not reached within 30-year projection period.

Figure 1. River herring landings from Chowan River pound nets, 1972-2004.

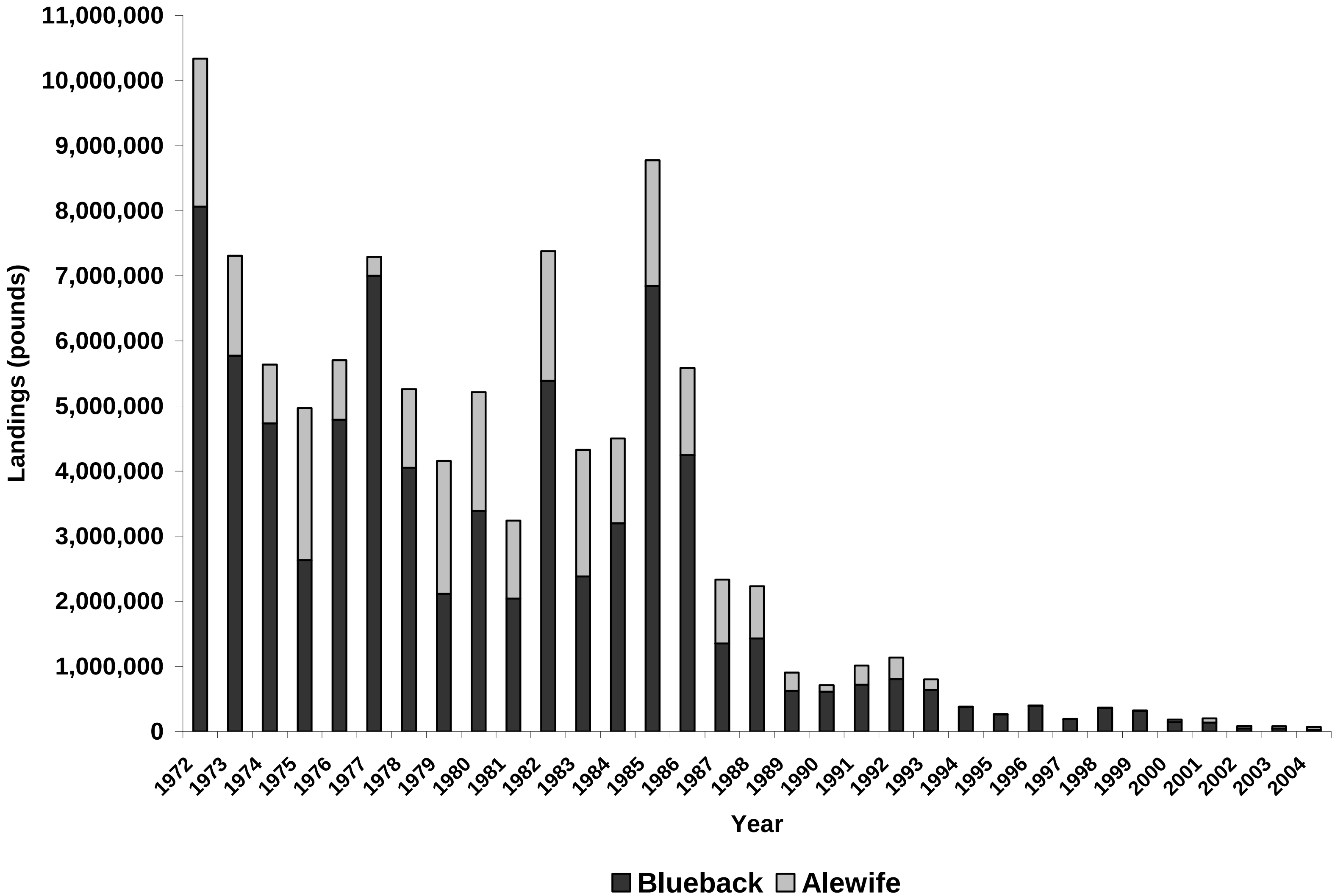


Figure 2. River herring landings from the ASRHMA gill net fishery, 1972-2004.

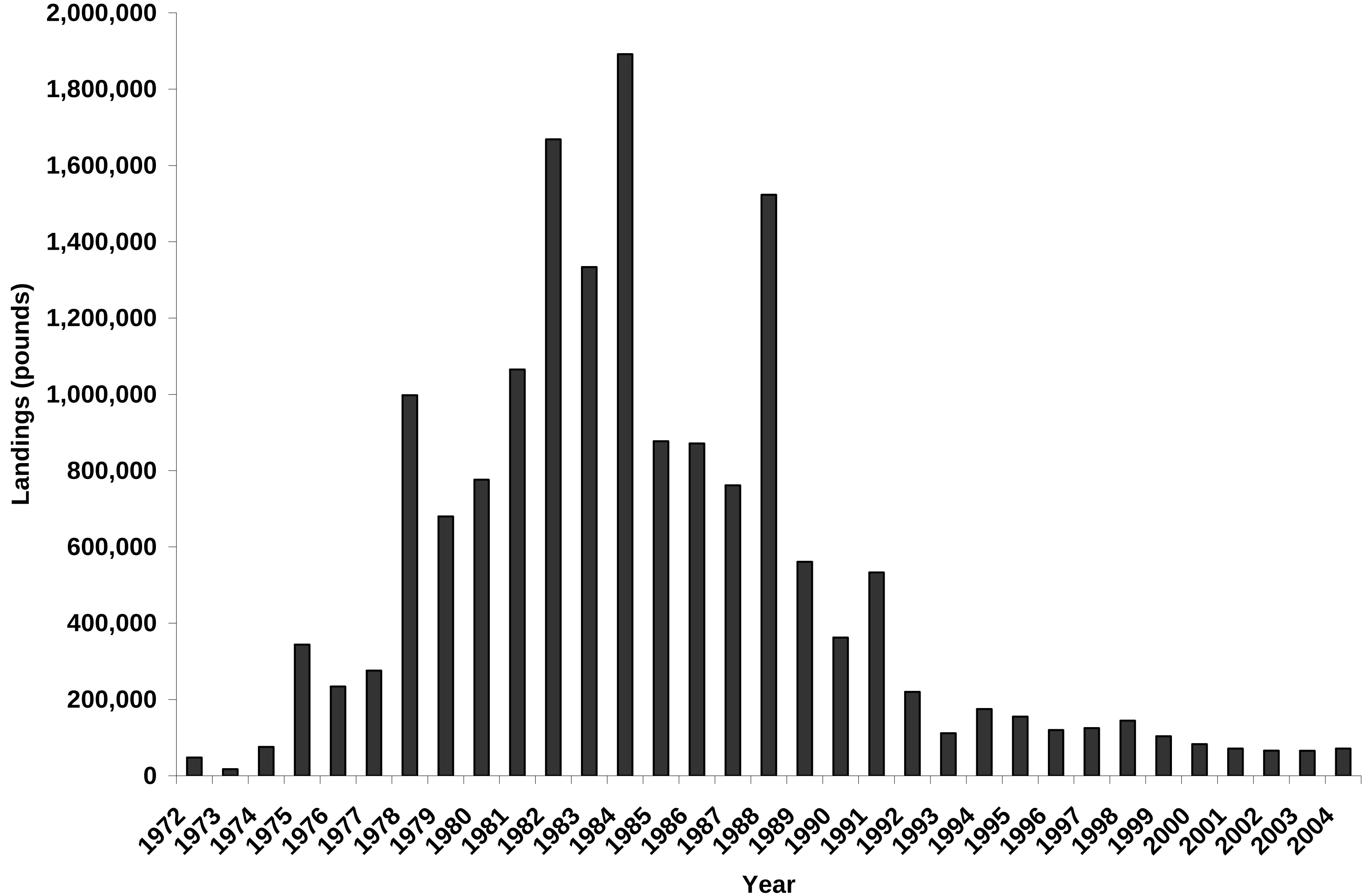


Figure 3. Blueback herring Chowan River pound net fishery catch, effort, and CPUE, 1972 to 2004.

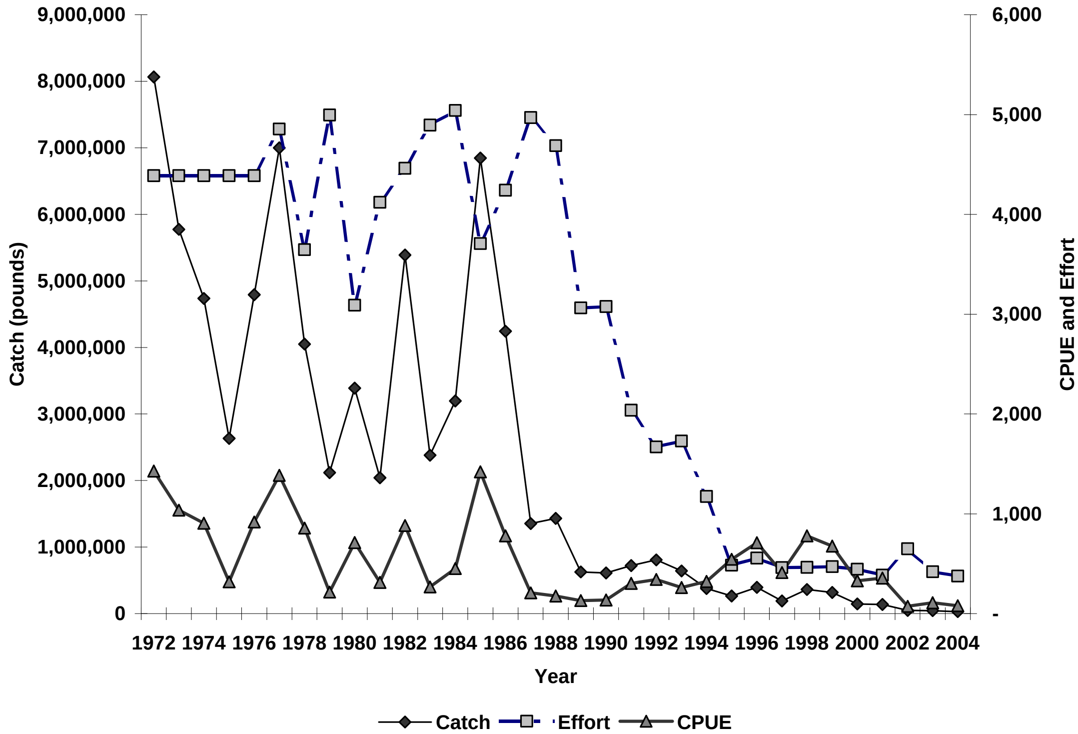


Figure 4. Alewife Chowan River pound net fishery catch, effort, and CPUE, 1972 to 2004.

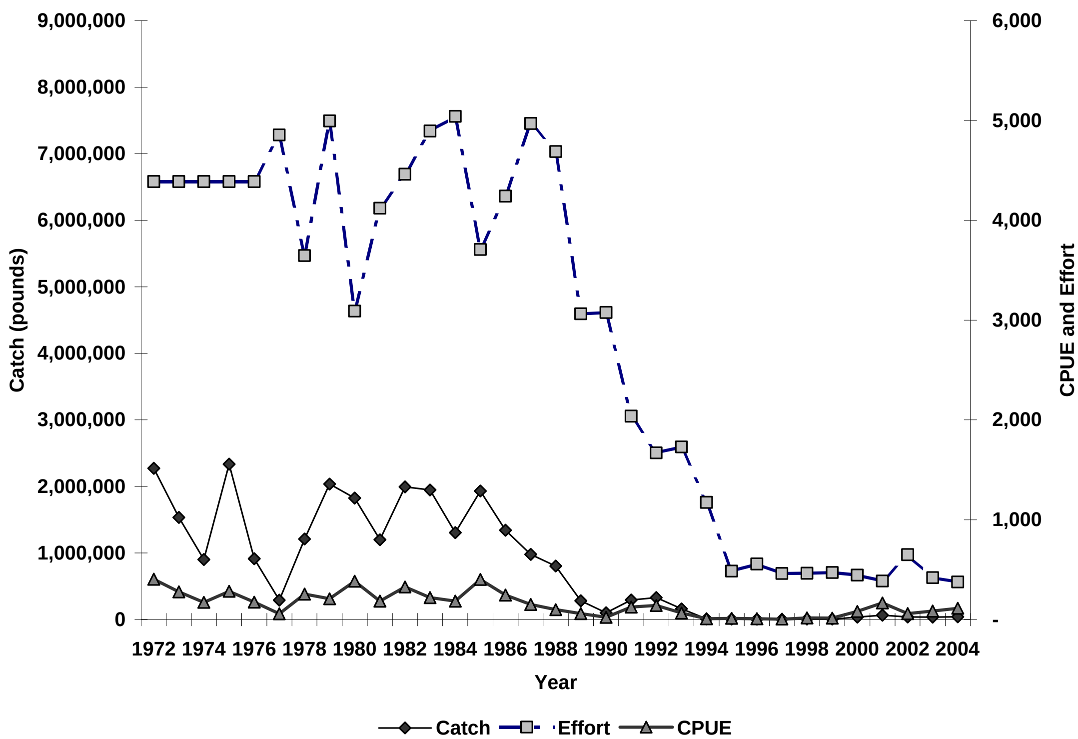


Figure 5. Blueback herring JAI, Albemarle Sound core alosid seine sites, 1972 to 2004.

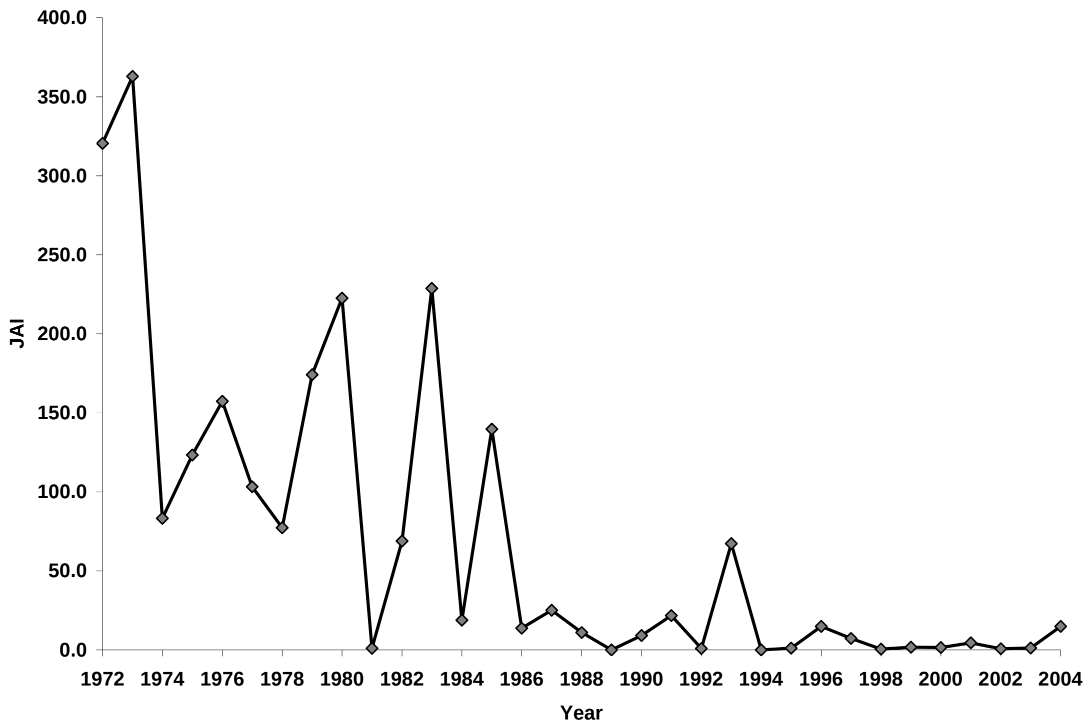


Figure 6. Alewife JAI, Albemarle Sound core alosid seine sites, 1972 to 2004.

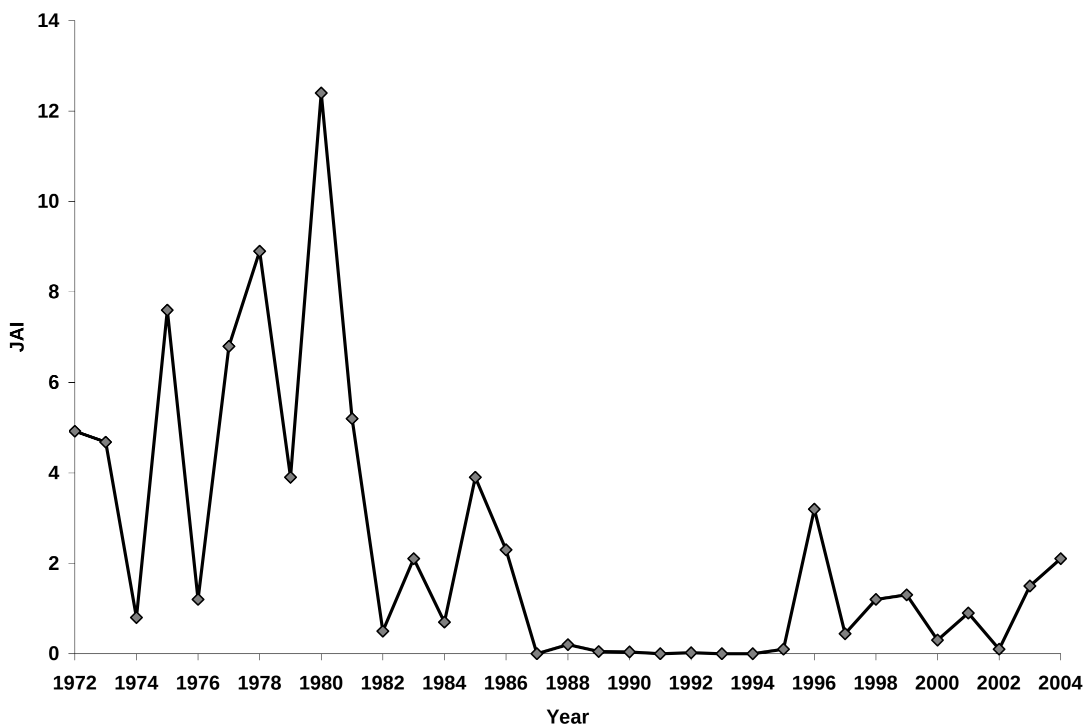


Figure 7. Total mortality (Z) estimates from blueback herring annual catch curves.

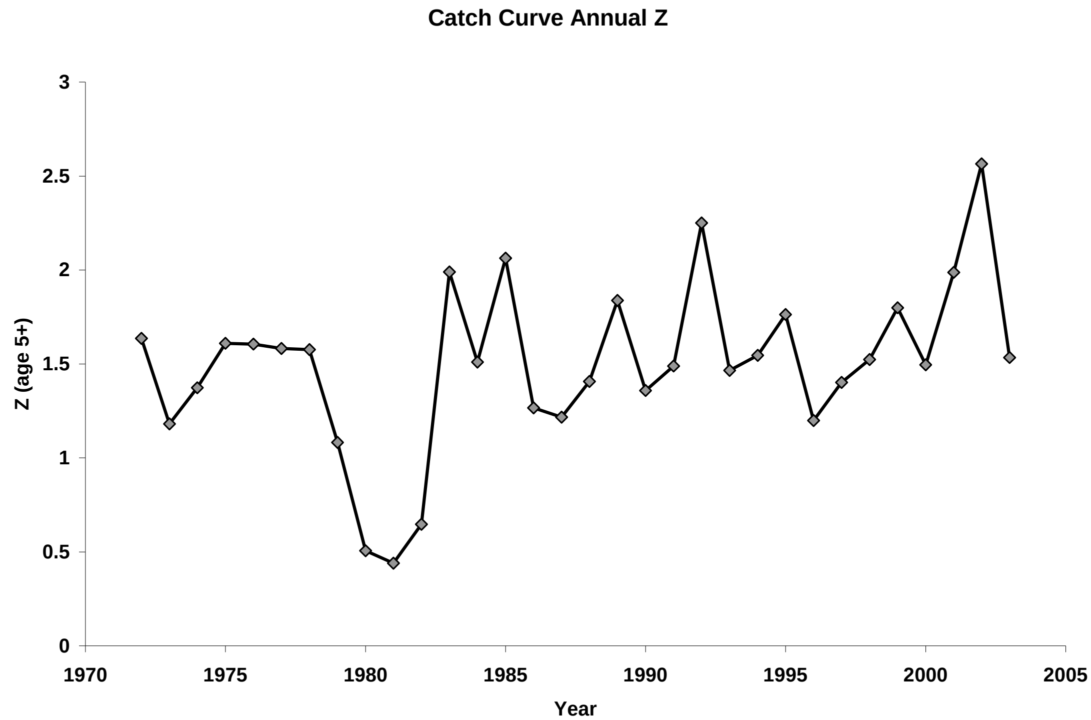


Figure 8. Plot by fishing year of cohort based catch curves for blueback herring. Each curve follows an individual cohort from recruitment to elimination from the population.

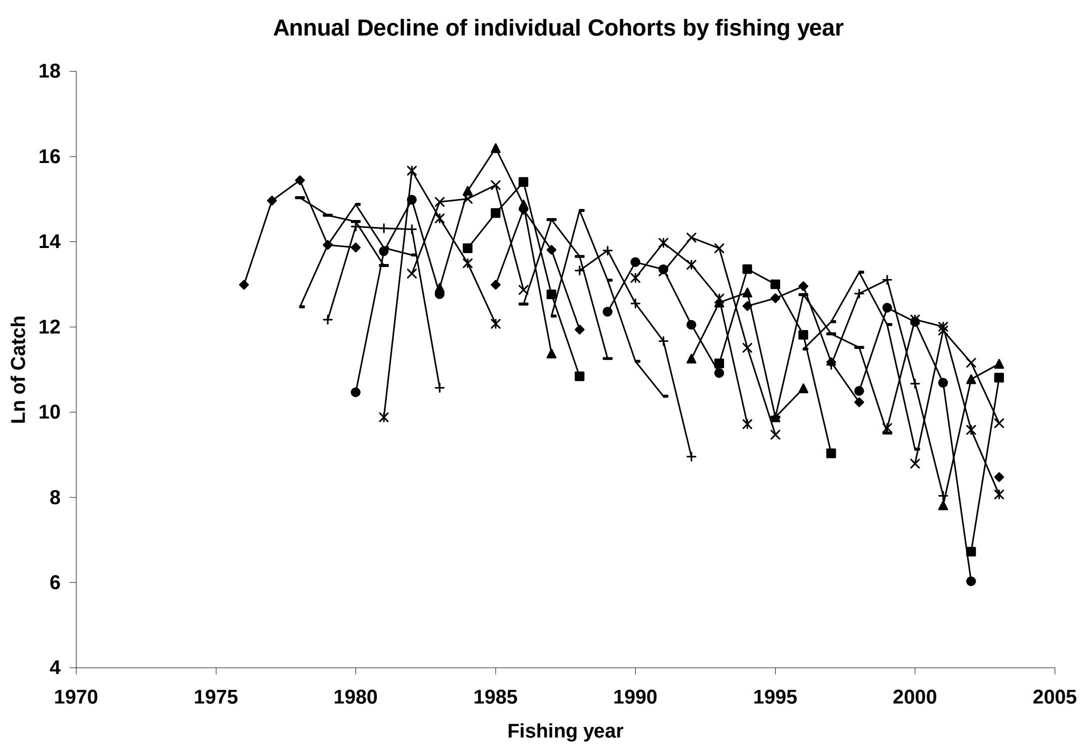


Figure 9. Blueback herring mean and annual total mortality (Z) estimates from cohort catch curves.

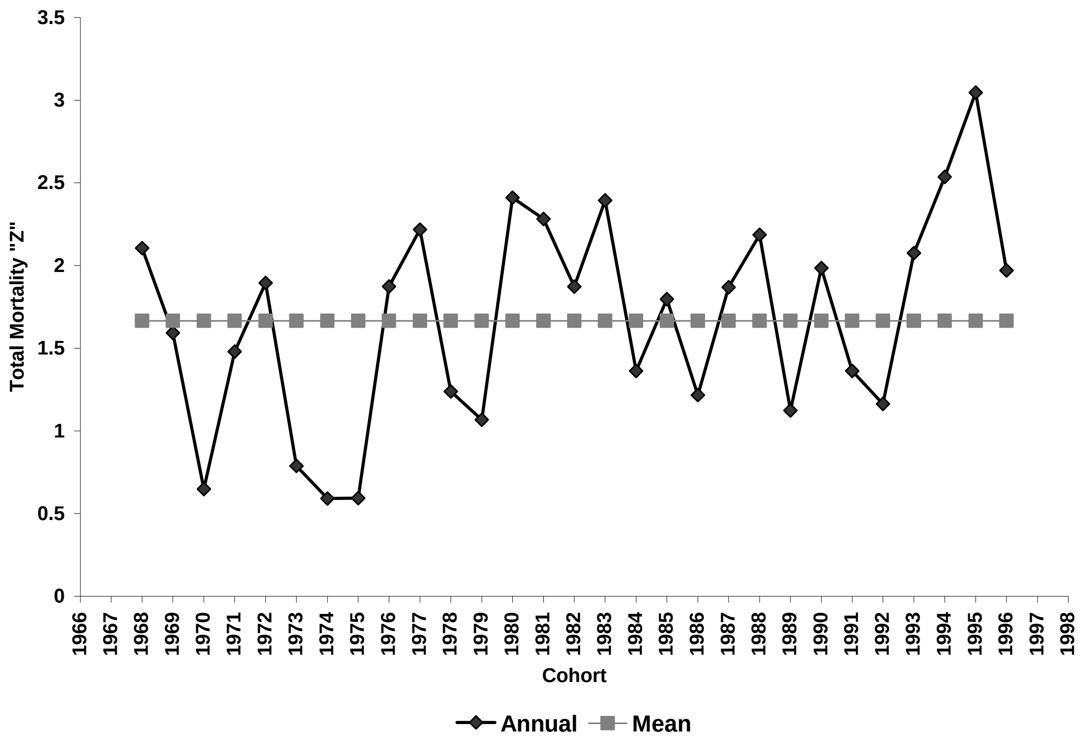


Figure 10. Total mortality (Z) estimates alewife annual catch curves.

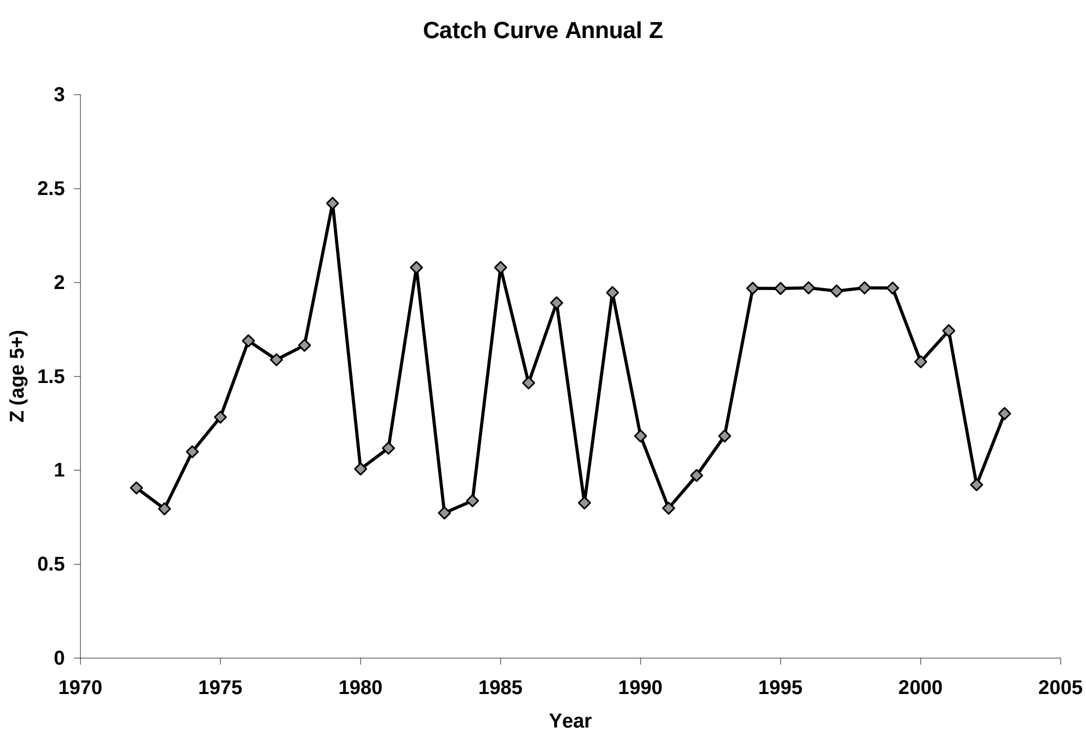


Figure 11. Plot by fishing year of cohort based catch curves for alewife. Each curve follows an individual cohort from recruitment to elimination from the population.

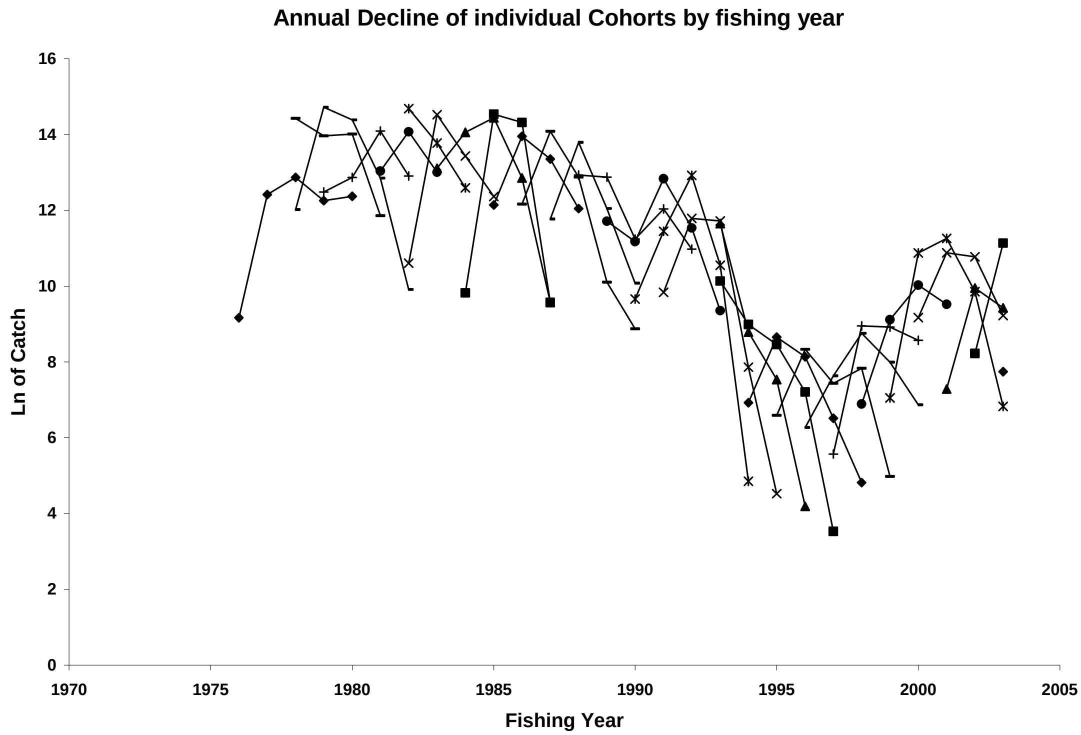


Figure 12. Alewife mean and annual total mortality (Z) estimates from cohort catch curves

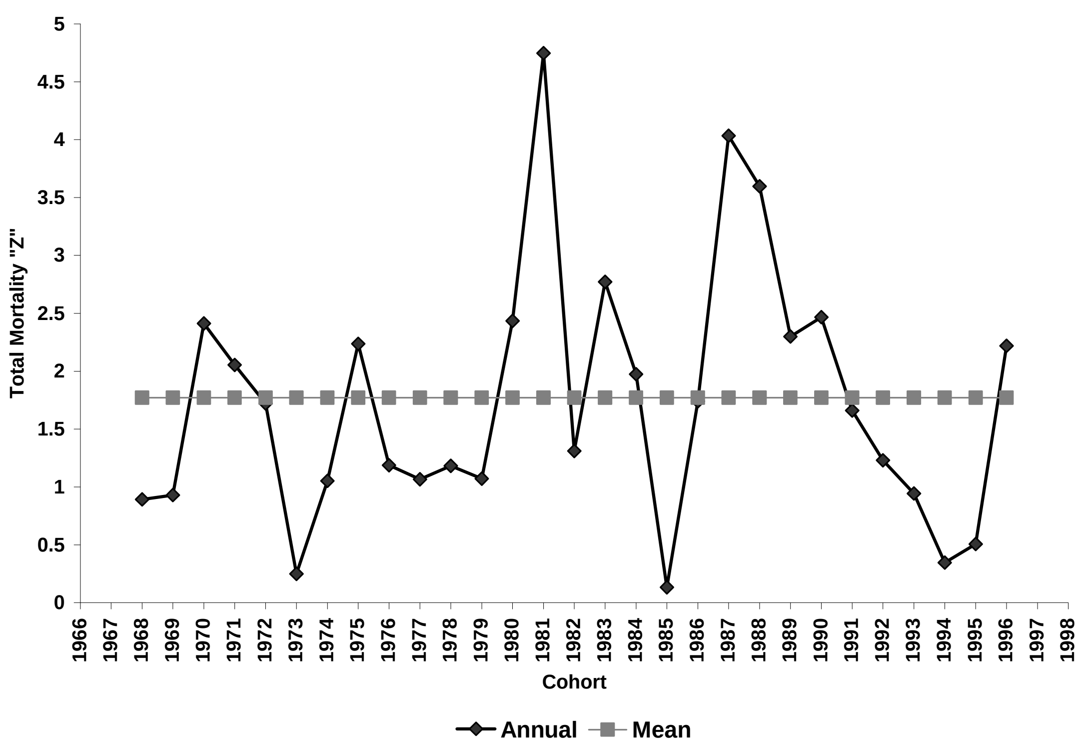


Figure 13. Blueback herring observed and predicted catch-at-age model predicted catch in numbers for 1972 to 2003.

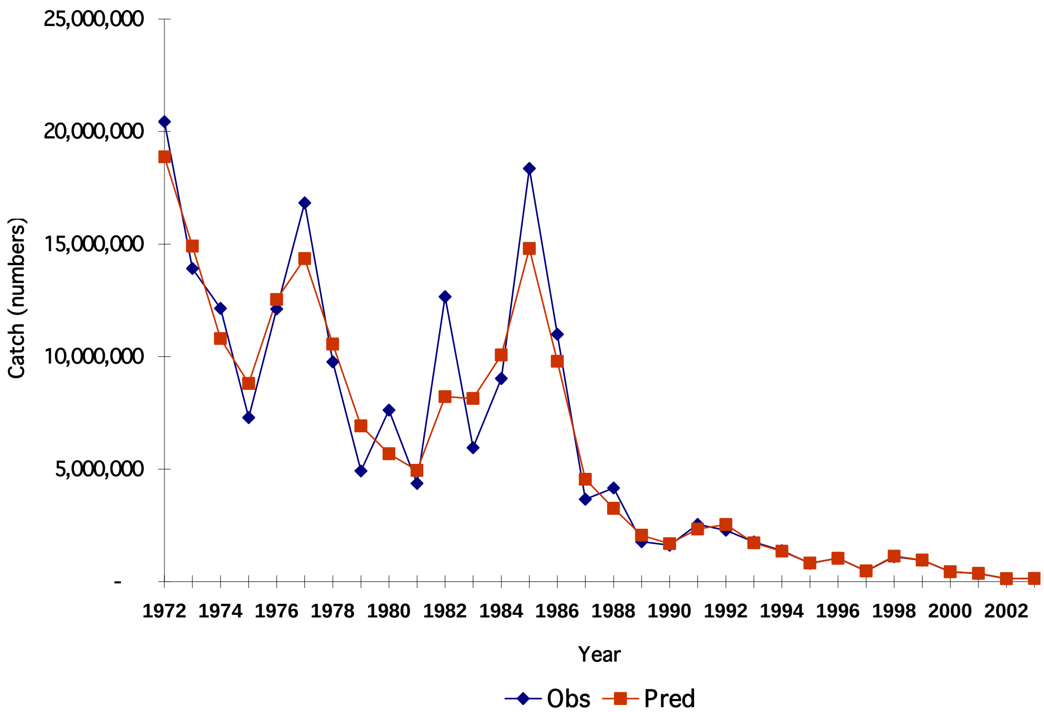


Figure 14. Alewife observed and predicted catch-at-age model predicted catch in numbers for 1972 to 2003.

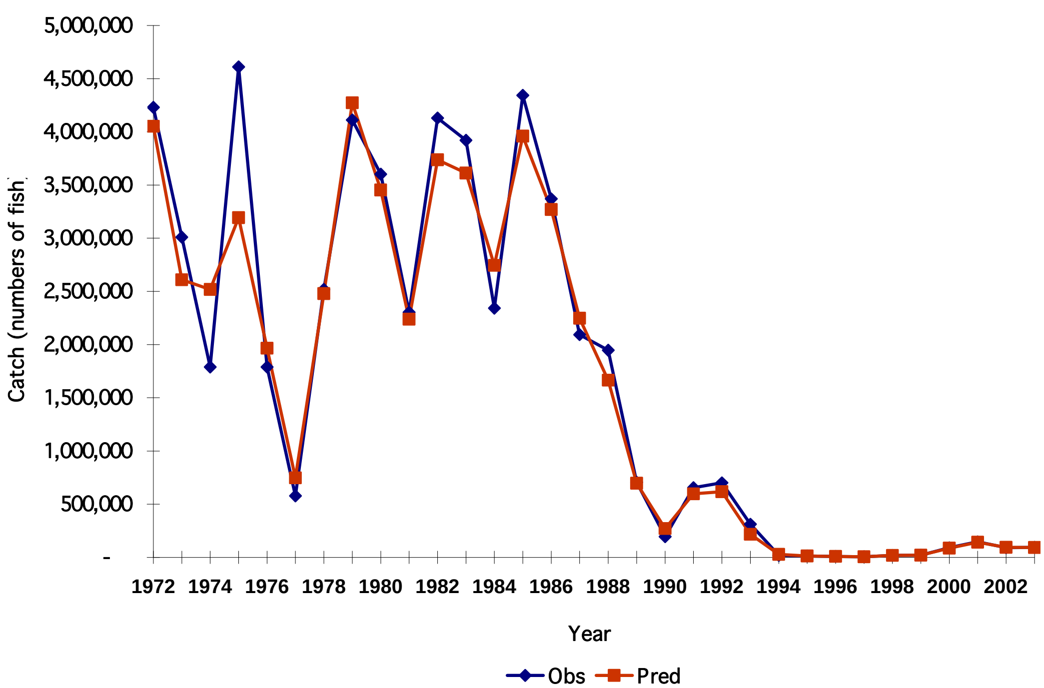


Figure 15. Annual plots of blueback herring observed and predicted catch, 1972 to 2003.

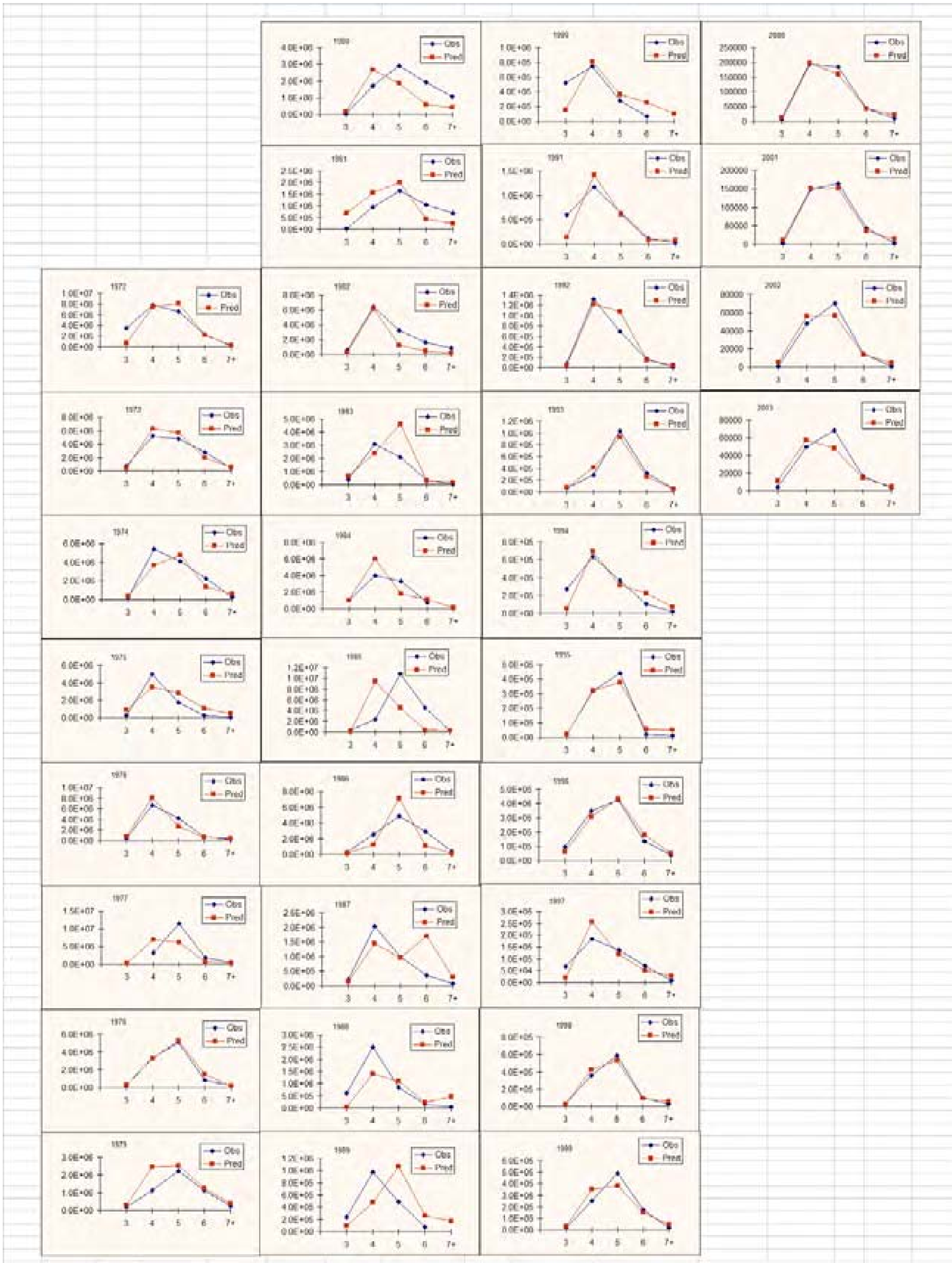


Figure 16. Annual plots of alewife observed and predicted catch, 1972 to 2003.

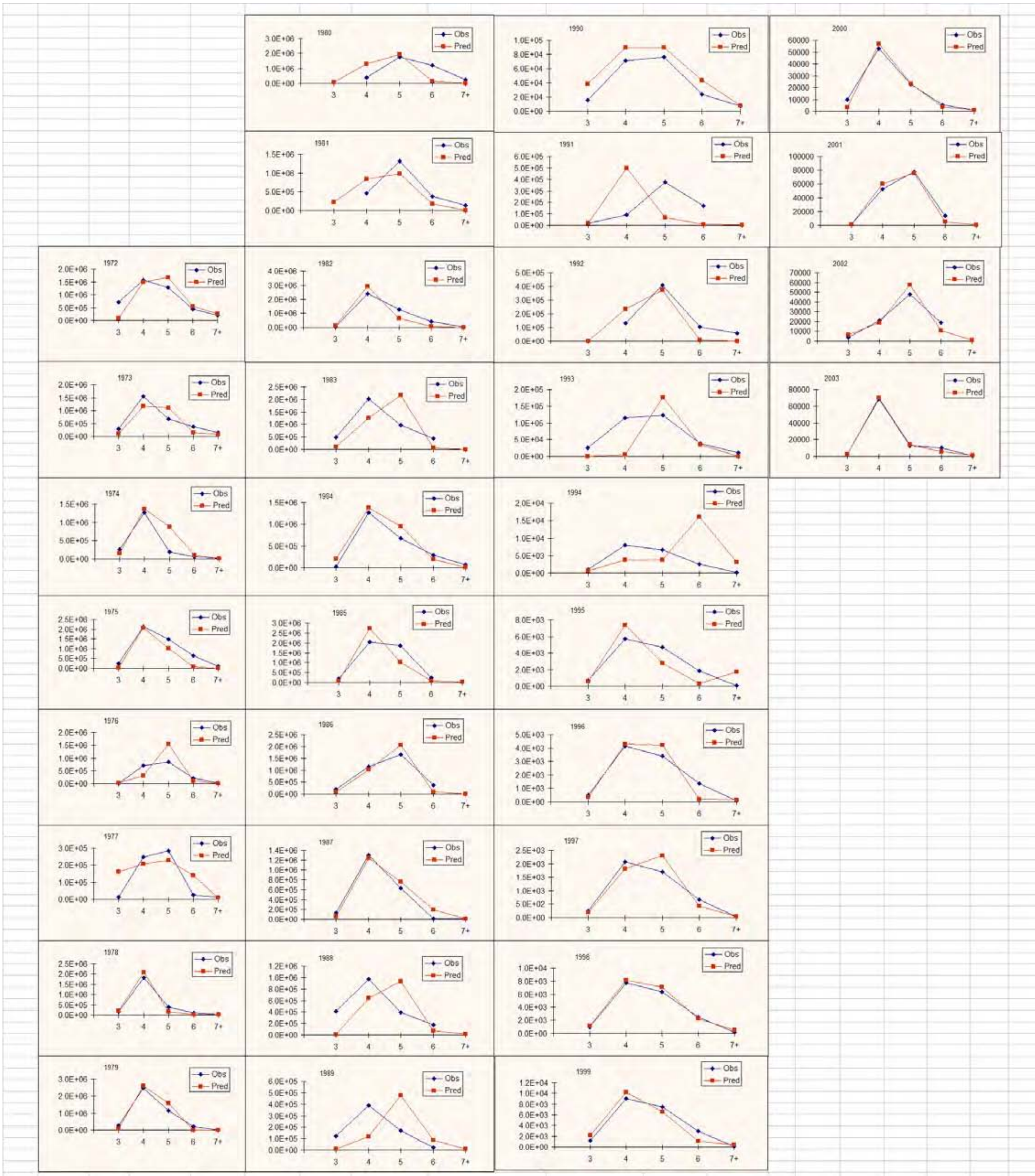


Figure 17. Blueback herring annual estimates of recruitment, 1972 to 2003.

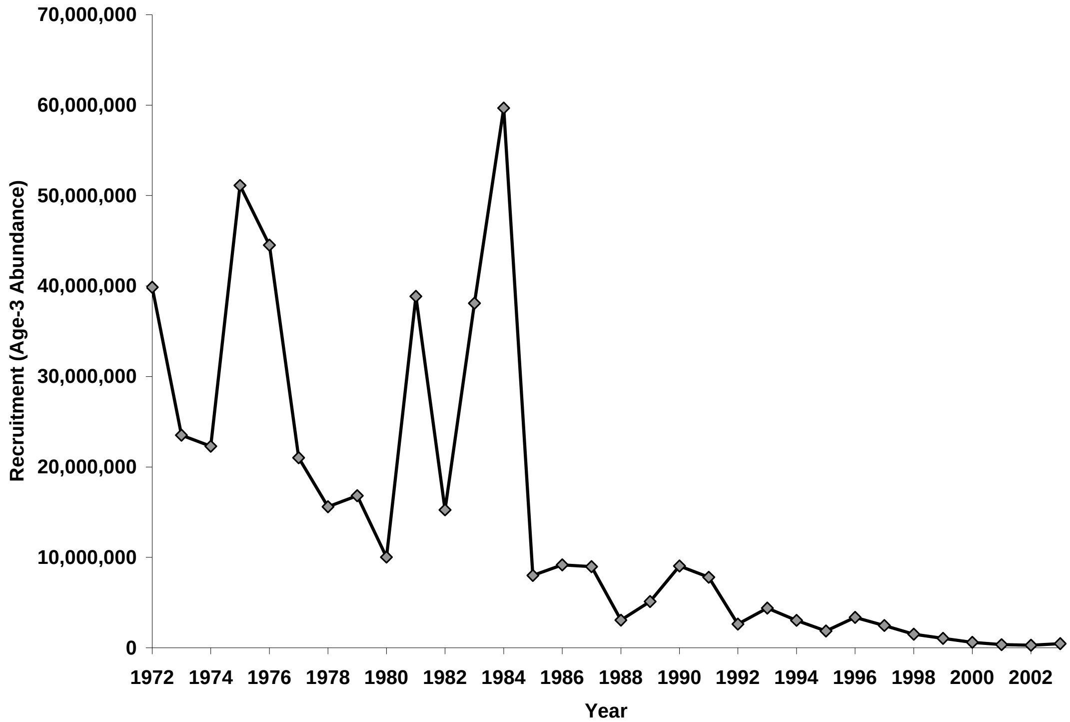


Figure 18. Alewife annual estimates of recruitment, 1972 to 2003.

Figure 19. Blueback herring annual estimates of spawning stock biomass, 1972 to 2003.

Figure 20. Alewife annual estimates of spawning stock biomass, 1972 to 2003.

Figure 21. Blueback herring age-3 abundance vs. JAI values and fitted regression line.

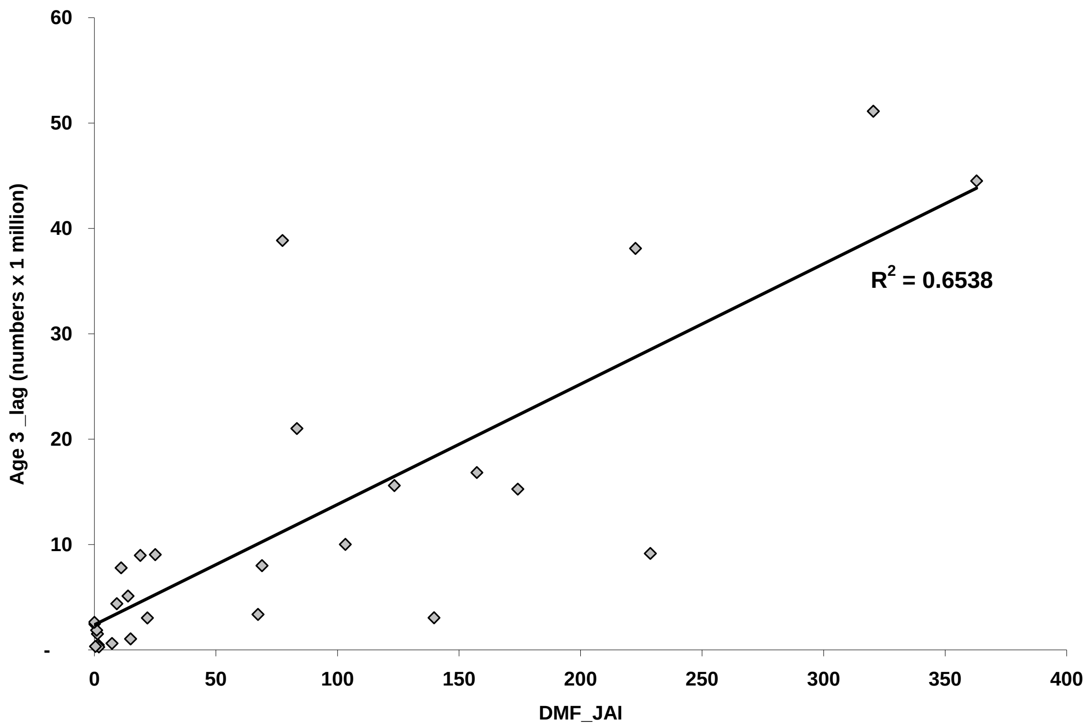


Figure 22. Blueback herring number of recruits at age-3 vs. spawning stock biomass.

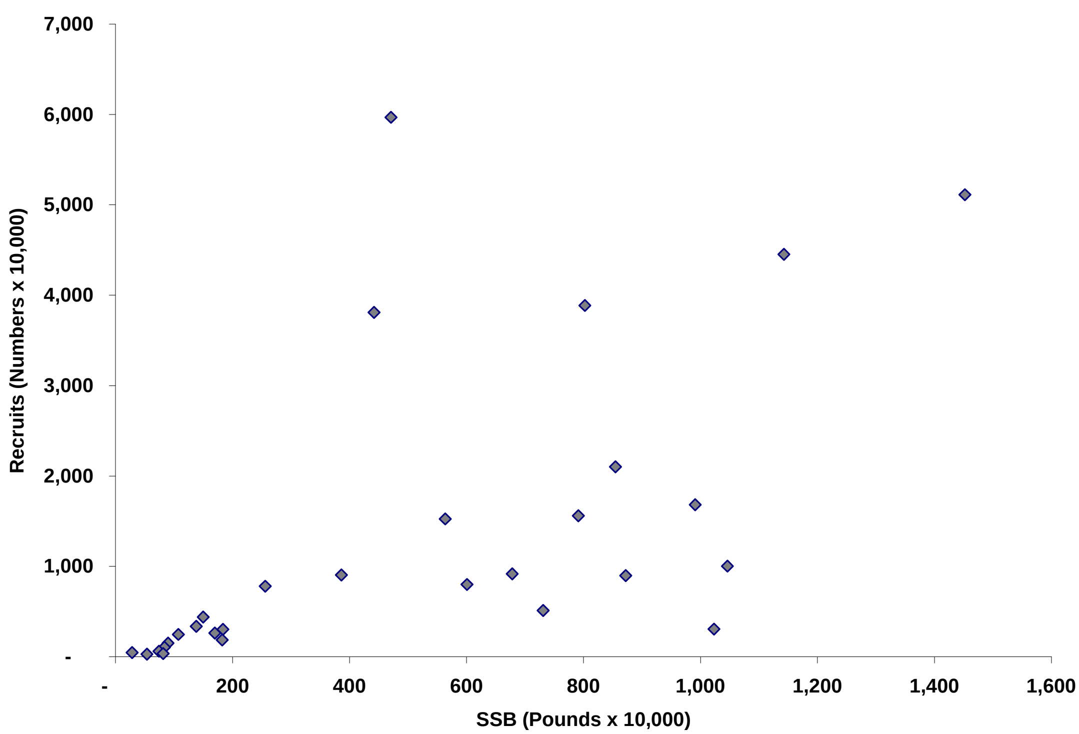


Figure 23. Blueback herring observed recruitment and fitted stock-recruitment relationship. Circles represent observed recruitment values and solid line represents fitted stock-recruitment relationship.

Figure 24. Blueback herring yield and spawners-per-recruit (SPR) for various fishing mortality levels.

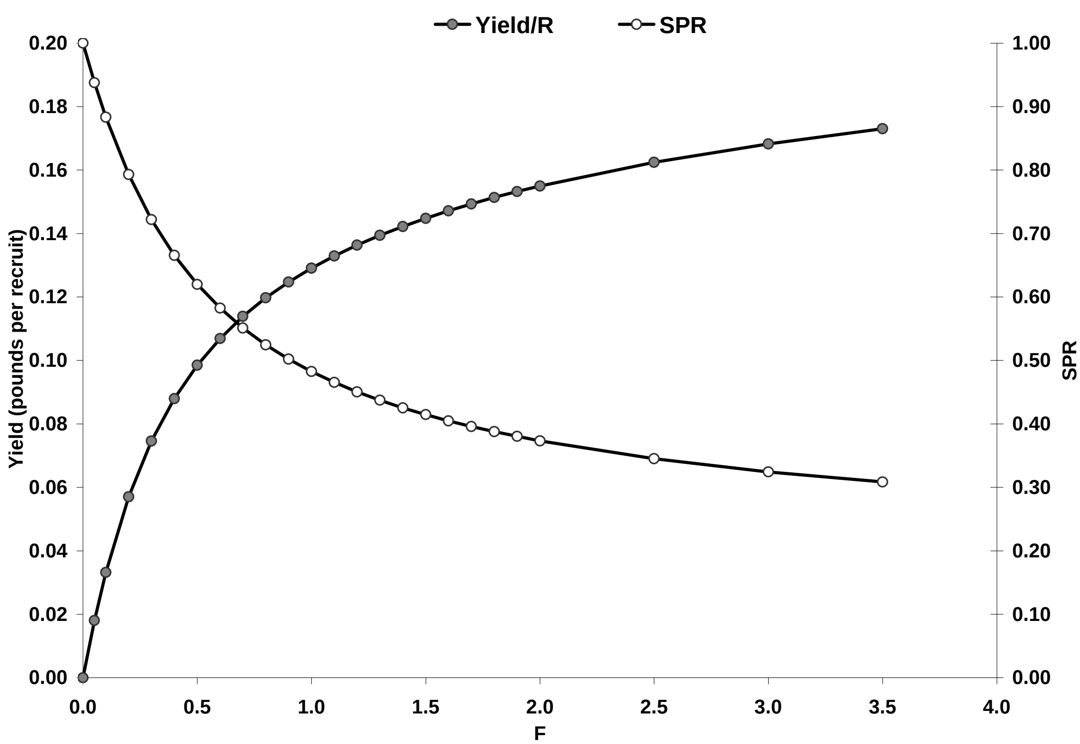


Figure 25. Blueback herring stock-recruitment plot combined with spawning stock biomass per recruit levels.

Solid line represents the replacement R/SSB, dashed lines represent R/SSB for 2003 and F=0, circles represent observed recruitment, and labels refer to cohorts.

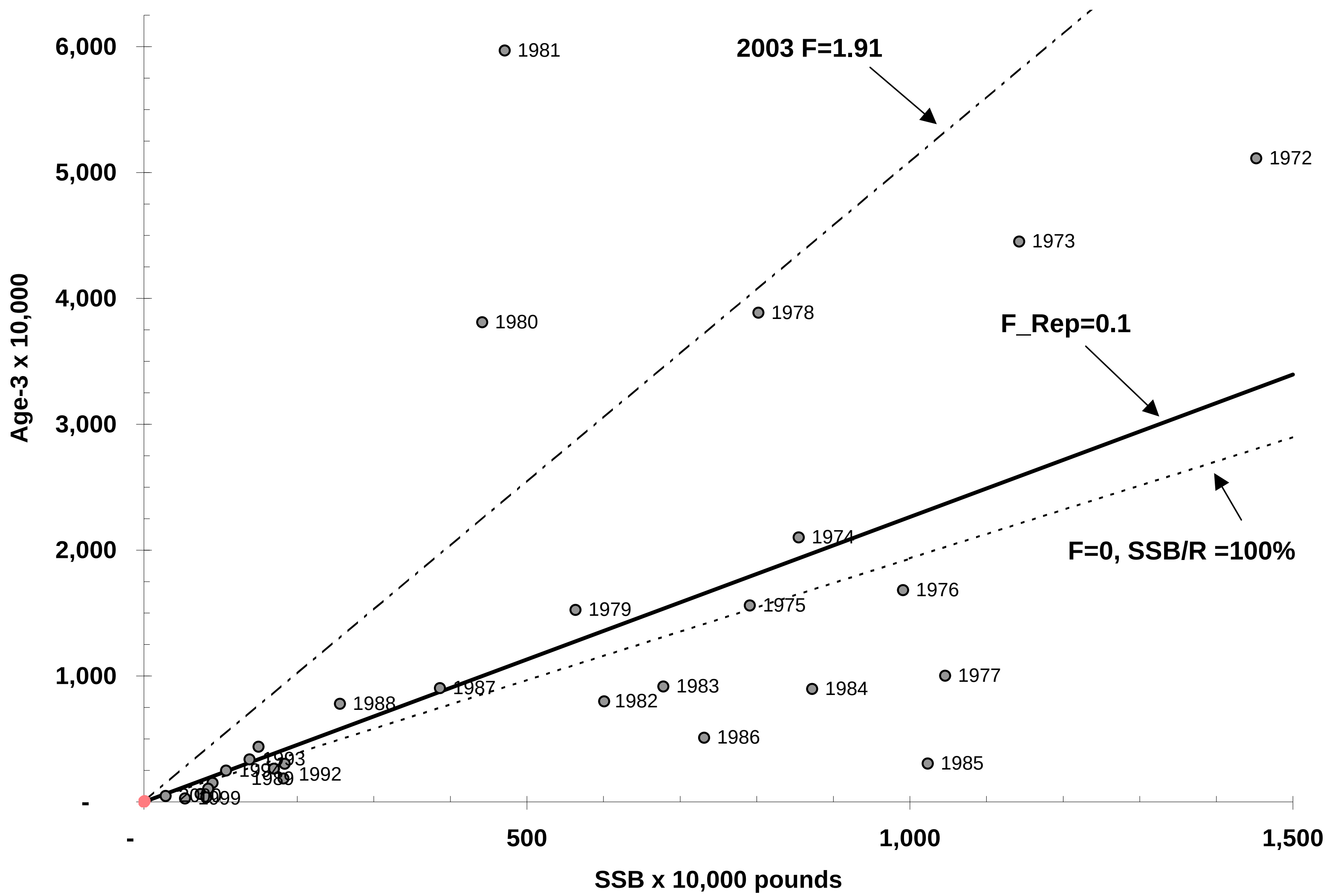


Figure 26. Blueback herring 30-year projection of SSB for fixed quota of 10,000 pounds, based on SRR predicted recruitment. Dotted lines indicate target year (2021) and minimum threshold for SSB.

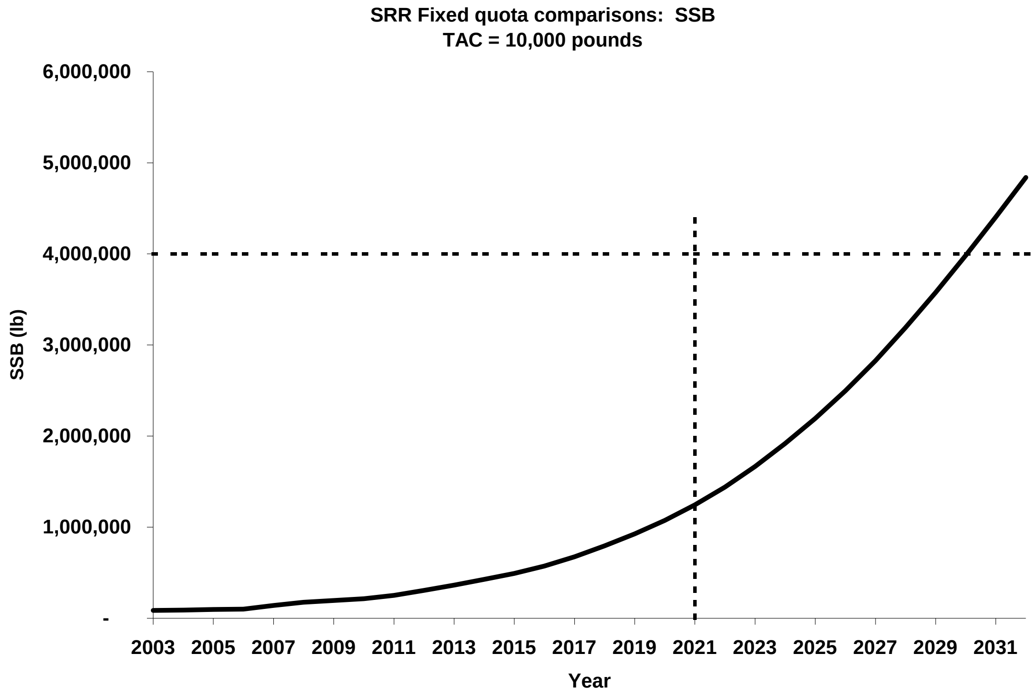


Figure 27. Blueback herring 30-year projection of F for fixed quota scenarios, based on SRR predicted recruitment.

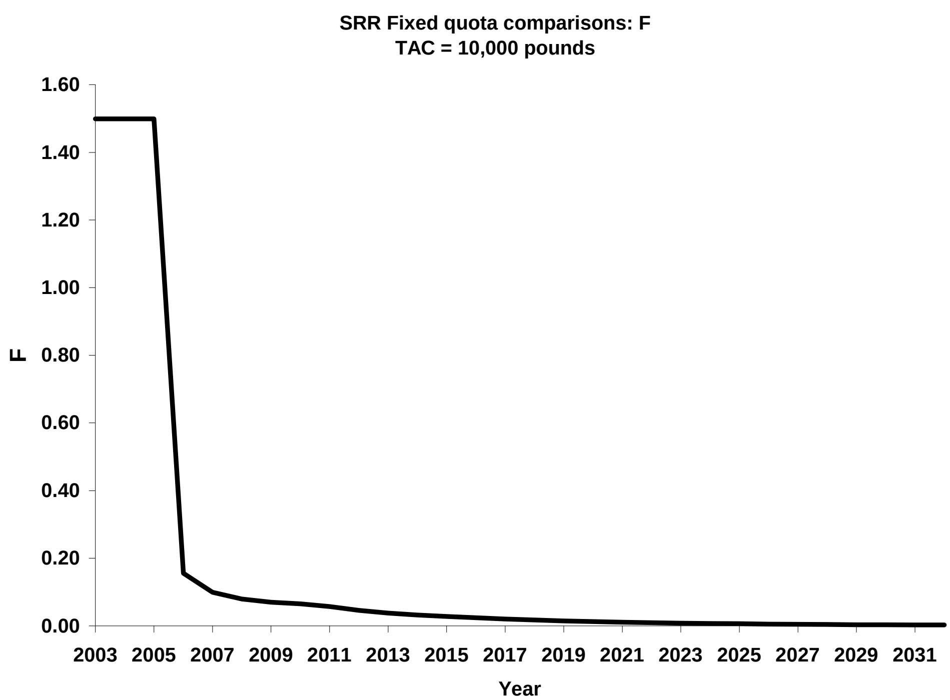


Figure 28. Blueback herring 30-year projection of SSB for fixed exploitation rate scenarios, based on SRR predicted recruitment. Dotted lines indicate target year (2021) and minimum threshold for SSB.

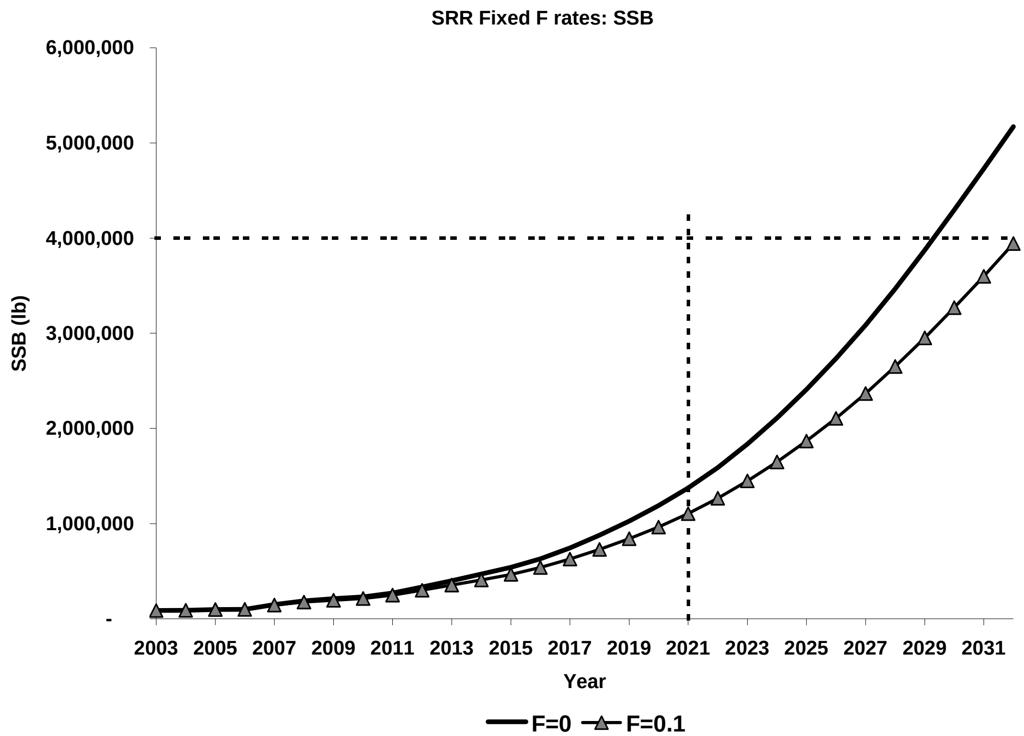


Figure 29. Blueback herring 30-year projection of catch for fixed exploitation rate scenarios, based on SRR predicted recruitment.

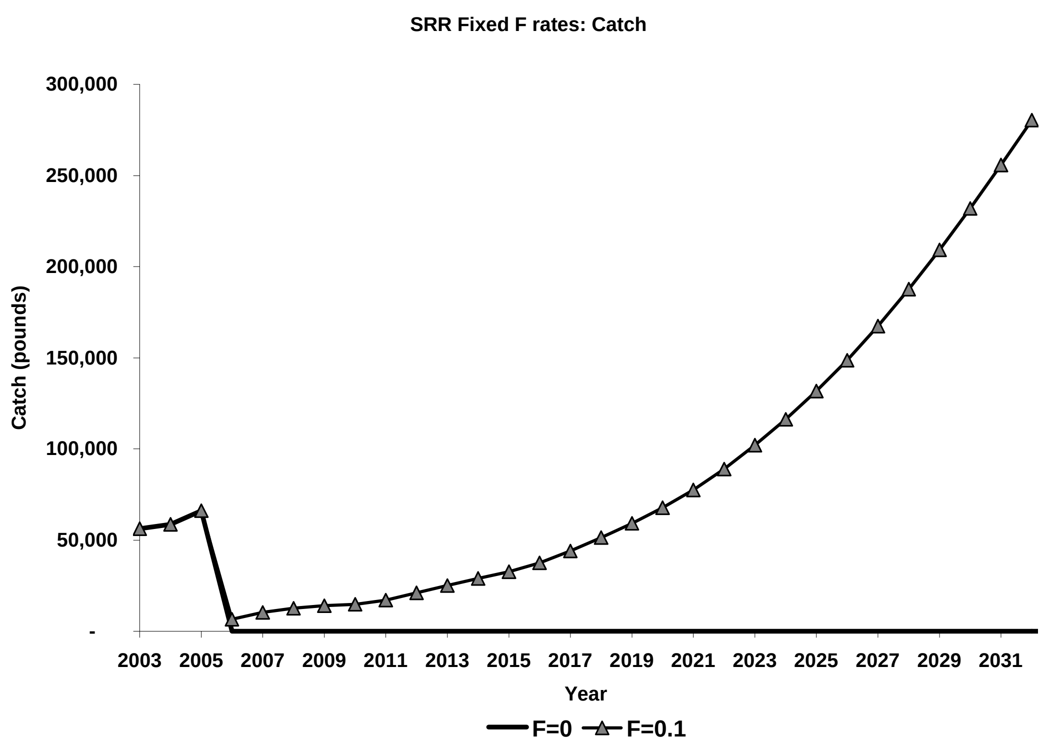


Figure 30. Blueback herring 30-year projection of SSB for fixed quota of 10,000 pounds, based on stochastic recruitment model. Dotted lines indicate target year (2021) and minimum threshold for SSB.

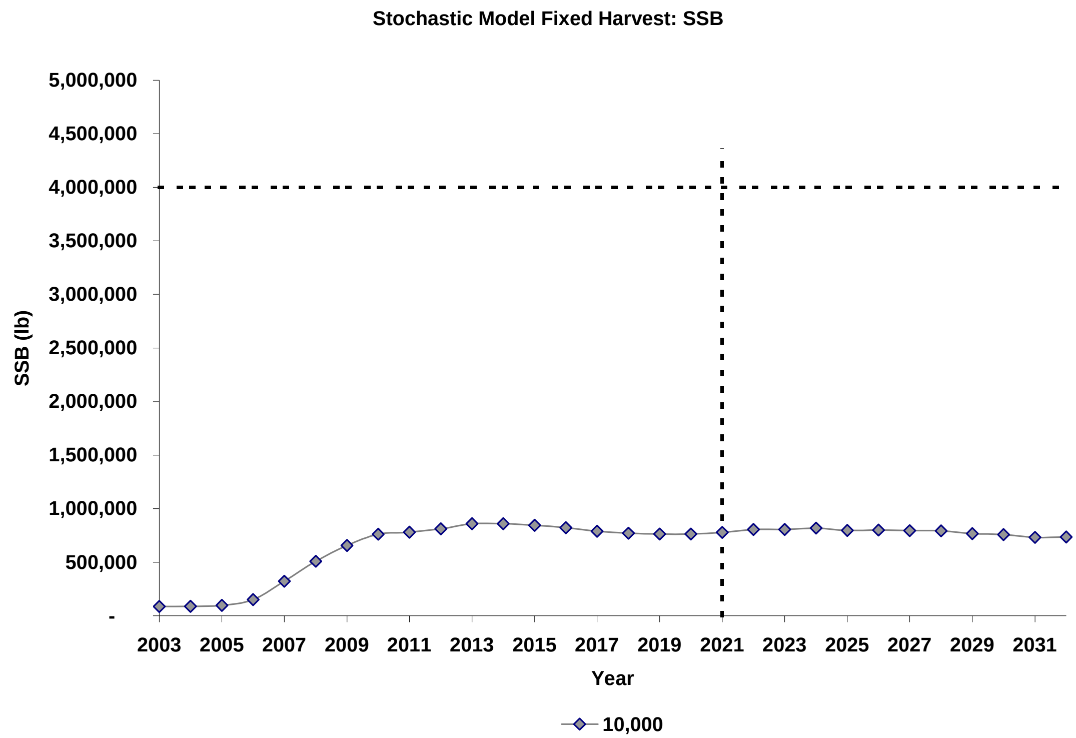


Figure 31. Blueback herring 30-year projection of SSB for fixed exploitation rate scenario, based on stochastic recruitment model. Dotted lines indicate target year (2021) and minimum threshold for SSB.

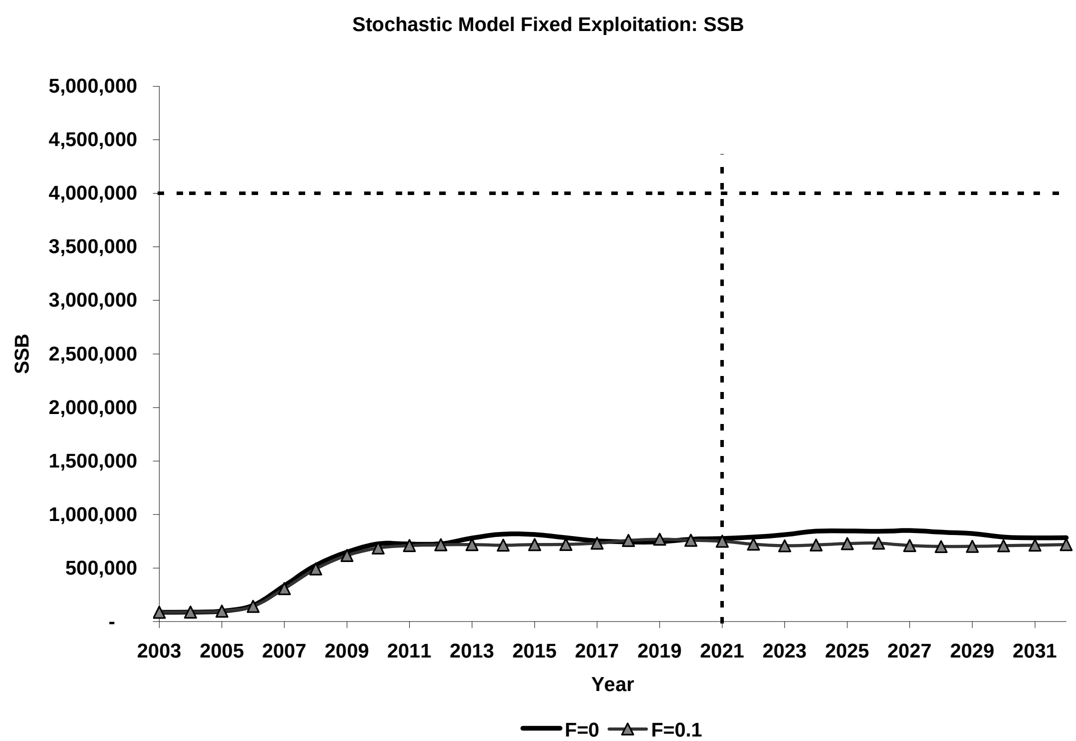


Figure 32. Blueback herring 30-year projection of catch for fixed exploitation rate scenarios, based on stochastic recruitment model.

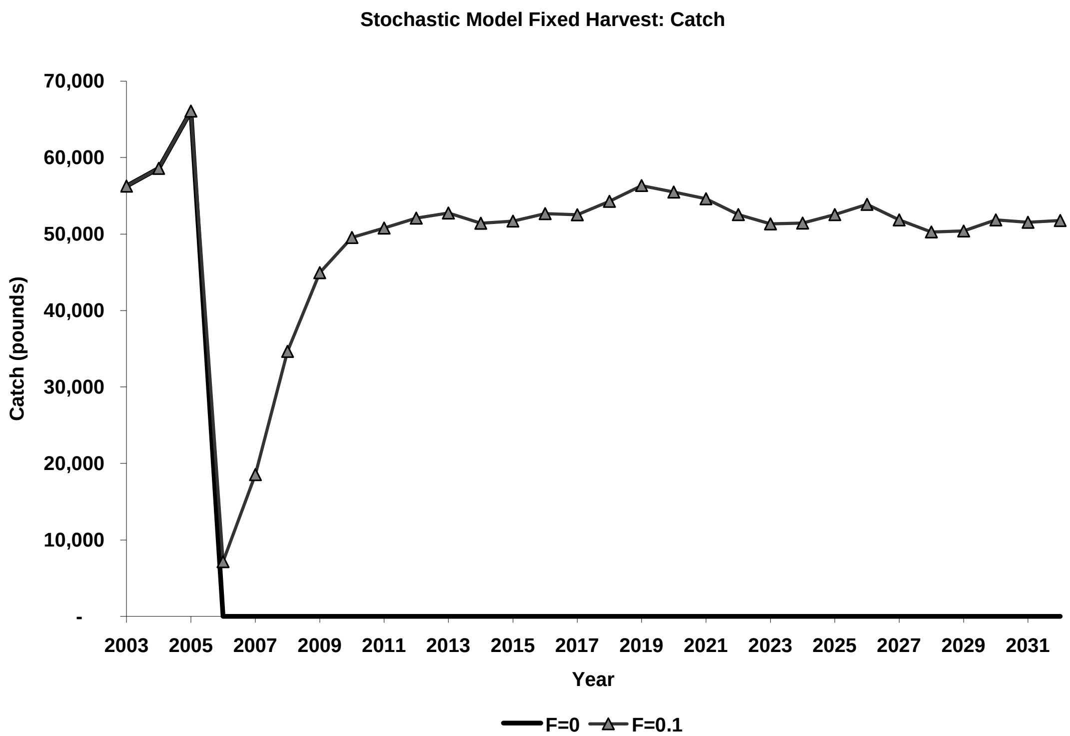


Figure 33. Blueback herring population age-structure for ages 3-7, 1972 to 2003.

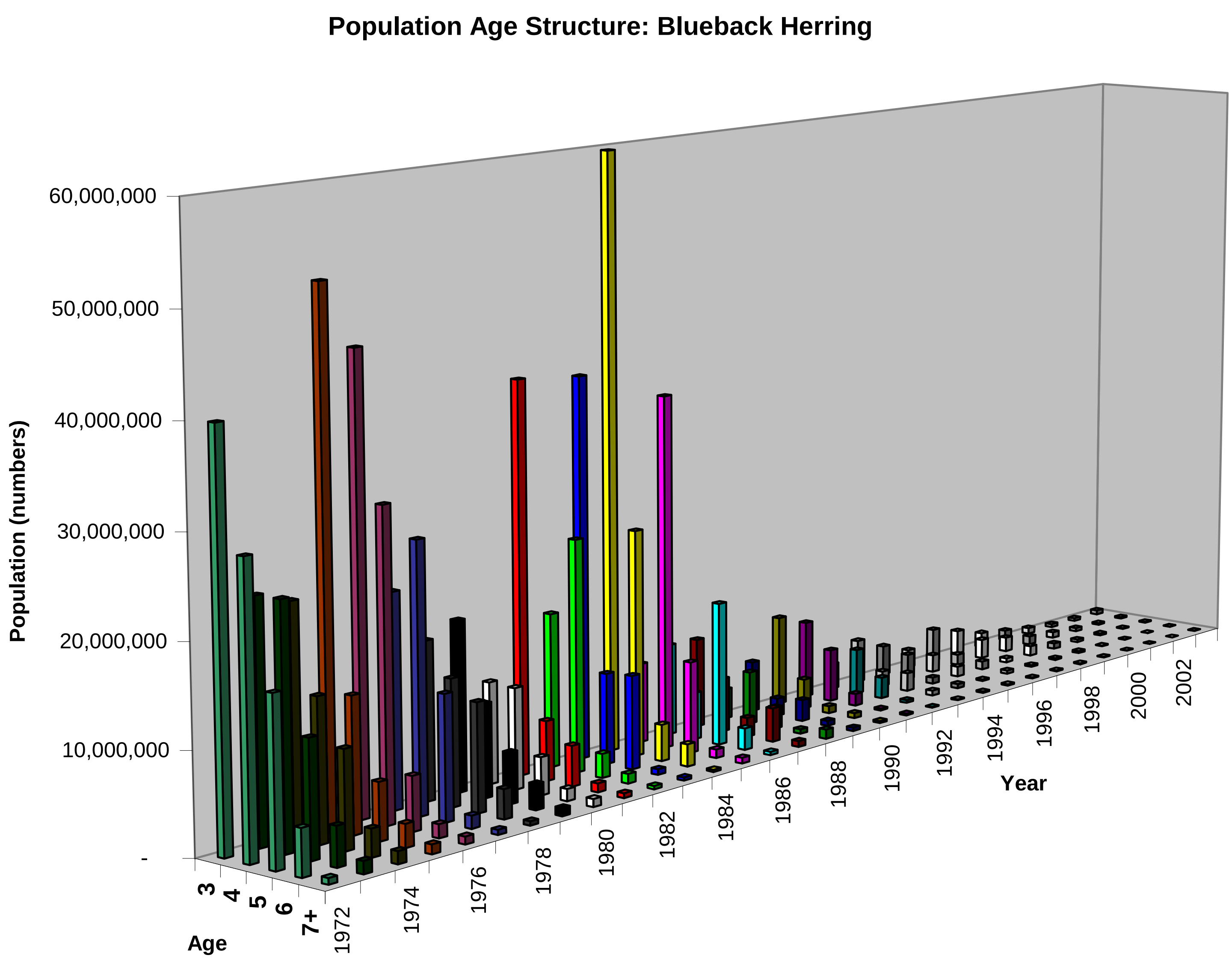
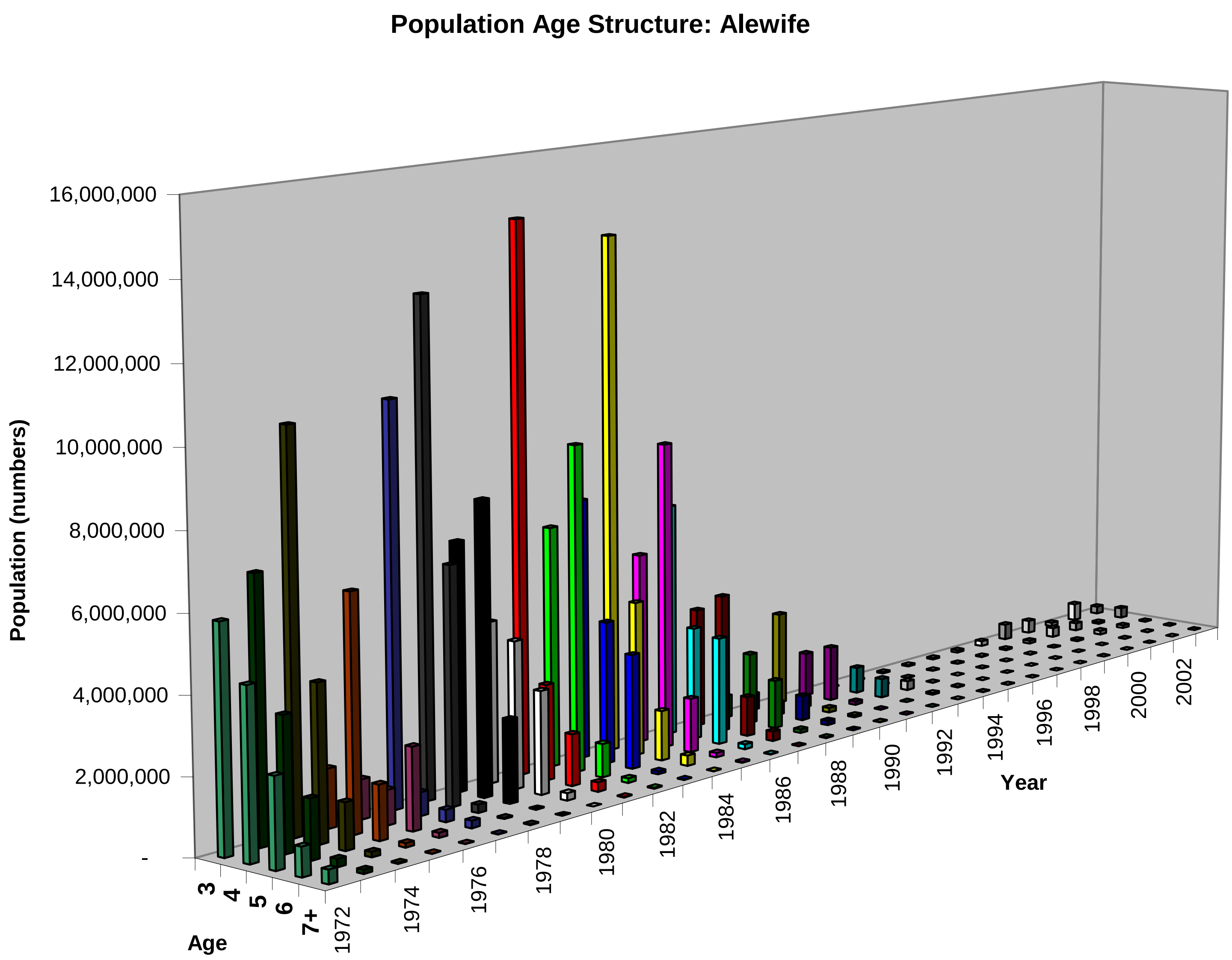


Figure 34. Alewife population age-structure for ages 3-7, 1972 to 2003.



Section 12.3 Appendix 3- River Herring Regulations by State

Commercial

State	**Season**	**Limit**	**Gear restrictions**	**Comments**
Maine	Closed 3 or 4 days per week	Harvest limit determined by town and MDMR		Towns hold fishing rights, competitive bid, allowed set amount of harvest
New Hampshire	May and June		Nets and pots	Coastal harvest permit and mandatory monthly logbooks; harvest mostly lobster bait- personal use
Massachusetts	No fishery			
Rhode Island	None	None	None	Changes proposed in 2006
Connecticut	Closed			Closed harvest since 2003
New York	March 15 – June 15		Primarily Gill net and scap net	Area closures, no gill nets from 6:00 am Friday to 6:00 pm Saturday
New Jersey	None	None	None	
Pennsylvania	Closed			
Delaware	None	None	None	Limited entry fishery and gill net restrictions that impact herring, areas in rivers only dip nets
Maryland	Closed- Jun 6-Dec 31	N/A	N/A	

State	Season	Limit	Gear restrictions	Comments
Virginia	Feb 15 – May 31- James, Mattaponi, Pamunkey, Rappahannock		Gill net mesh size no less than 2”	
South Carolina	Winyah Bay rivers – Feb 15 – Apr 15 open (84 hr lift period weekly) Santee River – Feb 15 – May 1 Rediversion Canal Santee and Tailrace Cooper – Mar 1 – May 1	10 US bushels per boat per day	Gill nets-300 yds max. Since 1998-daily catch and effort must be reported daily	Closed-Ashley, Edisto, Combahee, Coosawhatchie and Savannah rivers and ocean

Recreational

State	**Season**	**Limit**	**Gear restrictions**	**Comments**
Maine	Closed 3 days per week		Permit- hook and line, gill net, dip net	Only few areas open to public
New Hampshire	None			
Massachusetts	Closed Tues, Thurs, and Sun.	25 (2006- 12 fish)	Only- hand held dip net	Towns and cities control local runs
Rhode Island	Closed Sun, Mon, and Tues	12		
Connecticut	Closed			Closed harvest since 2003
New York	No info			
New Jersey	None	35	None	
Pennsylvania	Susquehanna – closed Delaware – open	Closed 35	 Hook and line only	
Delaware	None	25		Can not be sold
Maryland	Closed- Jun 6- Dec 31	N/A	N/A	
Virginia	James, Meherrin, Chickahominy, Appomatox, and Rappahannock rivers- above the fall line Meherrin, Nottoway, Blackwater, North Landing and Northwest rivers and Back Bay	No Possession No limit or minimum size limit	Catch and Release- only	
South Carolina	No closed season	1 US bushel per person	Hook and line and cast nets – no sale	

Canada

Gaspereau- Prince Edward Island

- Gear- dip net, gill net, trap/box net (no more than 4 per license holder)
- Limited number of commercial license holders- 23
- Authorized to fish- 25 trap nets, 9 dip nets and 15 gill nets
- Limited number bait license holders- 923- limited to only one gear type and 1,000 lbs. per day
- Season- May 1 – June 30 (closed Friday – Sunday)
- 1989 – 1999 115,103 – 689,176 lbs., value $19,069 – 92,608
- No processors
- No recreational harvest
- Areas that runs have totally disappeared
- Overfishing in some systems jeopardized local populations

Eastern New Brunswick

- Number of licenses and amount of gear limited
- 2000 – 164 licenses (1987 – 2000 179 – 132)
  - 328 box nets (2 per license)
  - 3,600 ft. of gill net (3 – 3 ½”)
- Closed season varies by waterbody:
  - June 16 – May 14
  - July 1 – May 14
  - July 1 – December 31

  Weekend closure throughout
- Logbook required since 2001
- No recreational harvest

Maritime Provinces- Bay of Fundy, Southern Gulf of St. Lawrence, Coast of Nova Scotia

- Limit number of license, season, gear, logbooks required
- Fisheries generally small- less than 224,000 lbs. annually
- St. John and Miramichi rivers- larger harvest- greater than 2.2 million lbs.
- Harvest in Maritimes peaked 1980- 25 million lbs., down to 11.2 million lbs. by 1996
- Resource exploited at or above reference levels
- Disproportionately harvest alewife and older blueback herring

St. John River- New Brunswick (Jessop 2001)

- Declining mean age, length and weight for blueback herring and alewife due to effects of fishery exploitation.

12.4 Appendix 4- Research Needs

Research needs identified during the development of the North Carolina River Herring Fishery Management Plan.

Stocking/Restoration Program

Adult Relocation

- Conduct Watershed Surveys to Determine:
  - Areas of viable and non-viable spawning runs
  - Areas with the greatest probability of brood stock yield
  - Watershed with most viable environmental conditions

- Establish a plan for stocking via adult relocation
  - Determine hours and staff requirements
  - Identify equipment and facilities needed
  - Procure necessary funds

- Collection/Transportation/Relocation of Adult Herring
  - Collection of a predetermined amount of adult river herring
  - Transportation of adults from a viable spawning run to the area of concern within the closest possible proximity

- Monitoring
  - Conduct monitoring and analysis to determine the impact of adult relocation

Larval Stocking

- Conduct Watershed Surveys
  - Determine areas of viable and non-viable spawning runs
  - Determine areas with the greatest probability of brood stock yield

- Establish a plan for larval stocking program
  - Create partnerships with other agencies
  - Determine hours and staff requirements
  - Identify equipment and facilities needed
  - Procure necessary funds

- Collection of Brood stock
  - Collection of a predetermined amount of adult river herring brood stock
  - Remove eggs from a predetermined amount of female river herring for a target number of river herring larvae
  - Fertilize eggs with milt from an equal amount of male river herring
  - Transport fertilized eggs to partnership agency for incubation and hatching

- Stocking of Larval Herring
    Collection of larval staged river herring from partnership agency
    Transport and stock larval herring to the watershed of concern

- Monitoring
    Conduct monitoring and analysis to determine the impact of larval stocking

Habitat

- Update the spawning and nursery area surveys conducted previously in all areas.

- Identify potential incentives to landowners for protection of riparian buffers in the management area.

- Develop, identify and clarify what critical habitat actions are needed to protect, enhance and restore habitats and water quality affecting river herring.

Water Quality

- Membrane Water Treatment Plants: Evaluate the impacts/effects of reverse osmosis plants on receiving waters and aquatic resources.

- Water quantity: Evaluate the effects of existing and future water withdrawals on water quality and quantity and fisheries habitat in coastal watersheds.

- Contaminants: Determine if contaminants are present and identify those that are potentially detrimental to various life history stages of river herring. Specific areas of concern include the lower Neuse, Pamlico, Chowan and Roanoke rivers.

Blockages to Spawning Habitat

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

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

- **Neuse River**
  Investigate the feasibility of removing Milburnie Dam in Wake County.

Entrainment and Impingement

- The magnitude and seasonal timing of agricultural water withdrawals from coastal rivers is unknown. Division of Water Resources and Division of Water Quality should require documentation of these withdrawals, so that the extent of entrainment of river herring eggs, fry, and juveniles can be estimated.

- Comprehensive list of industrial and municipal water withdrawals and their intake specifications by river system coast-wide.

- Data on the density and distribution of river herring eggs, fry, and juveniles in coastal rivers are needed so that potential losses can be estimated.

- Identify effective engineering solutions to prevent entrainment and impingement of river herring eggs, fry, and juveniles.

- Research is needed to determine the fate of river herring eggs, fry, and juveniles that are impinged, and then released through screen cleaning operations.

Socioeconomic

- A socioeconomic impact analysis of the cumulative effects of reduced stock availability and harvest restrictions put in place over time needs to be conducted to assess the overall impact on fishermen who have traditionally relied on the fishery for economic opportunity.

- A detailed and directed survey of all recreational harvest of river herring in coastal, joint, and inland waters needs to be conducted to determine not only harvest levels, but also the economic and social importance of the fishery.

12.5 Appendix 5- Proposed Rule Changes

PROPOSED RIVER HERRING FMP RULES

10.1 Actions to Restore Abundance of North Carolina River Herring

15A NCAC 03M .0513 RIVER HERRING AND SHAD

(a) It is unlawful to possess river herring taken from coastal fishing waters unless the season is open.

(b) The take of river herring ~~in the Albemarle Sound and Chowan River Herring Management Area 300,000 pounds to be allocated as follows:~~

~~(1) 200,000 pounds to the pound net fishery for the Chowan River Herring Management Area;~~

~~(2) 67,000 pounds to the Albemarle Sound Herring Management Area gill net fishery; and~~

~~(3) 33,000 pounds to be allocated at the discretion of the Fisheries Director.~~

shall be set forth in the North Carolina River Herring Fishery Management Plan for implementation under Paragraph (c) of this Rule.

~~(a)~~(c) The Fisheries Director may, by proclamation, based on variability in environmental and local stock conditions, take any or all of the following actions in the commercial and recreational blueback herring, alewife, American shad and hickory shad fisheries:

(1) Specify size;

(2) Specify season;

(3) Specify area;

(4) Specify quantity;

(5) Specify means/methods; and

(6) Require submission of statistical and biological data.

~~(c) For the purpose of this rule, the Albemarle Sound Herring Management Area and the Chowan River Herring Management Area are defined in 15A NCAC 03J .0209.~~

~~(d) It is unlawful to possess more than 25 blueback herring or alewife, in the aggregate, per person per day taken for recreational purposes.~~

~~(e)~~(d) It is unlawful to take American shad and hickory shad by any method except hook and-line from April 15 through December 31.

~~(f)~~(e) It is unlawful to possess more than 10 American shad or hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes.

History Note: *Authority G.S. 113-134; 113-182; 113-221; 143B-289.52;*
Eff. March 1, 1995;
A/mended Eff. August 1, 1998;
Temporary Amendment Eff. May 1, 2000; August 1, 1999; July 1, 1999; March 1, 1999;
Amended Eff. April 1, 2001

15A NCAC 03J .0107 POUND NET SETS

(a) All initial, renewal or transfer applications for Pound Net Set Permits, and the operation of such pound net sets, shall comply with the general rules governing all permits <u>as provided</u> in 15A NCAC 03O ~~.0500.~~ <u>.0500 et seq.</u> The procedures and requirements for obtaining permits are ~~also found~~ <u>set forth</u> in 15A NCAC 03O .0500.

(b) It is unlawful to ~~use~~ <u>hold a</u> ~~pound net sets~~ <u>Pound Net Set Permit</u> in coastal fishing waters without the permittee's identification being clearly printed on a sign no less than six inches square, securely attached to <u>a stake at</u> the ~~outermost stake of each end~~ <u>permitted ends</u> of each ~~set.~~ <u>set at all times</u>. For pound net sets in the Atlantic Ocean using anchors instead of stakes, the set ~~must~~ <u>shall</u> be identified with a yellow buoy, which shall be of solid foam or other solid buoyant material no less than five inches in diameter and no less than 11 inches in length. The permittee's identification shall be clearly printed on the buoy. Such identification on signs or buoys ~~must~~ <u>shall</u> include the pound net set permit number and the permittee's last name and initials.

(c) It is unlawful to use <u>a</u> pound net ~~sets,~~ <u>set,</u> or any part thereof, except for one location identification stake or identification buoy for <u>a</u> pound ~~nets~~ <u>net</u> used in the Atlantic Ocean at each end of <u>a</u> proposed new ~~locations,~~ <u>location,</u> without first obtaining a Pound Net Set Permit from the Fisheries Director. The applicant ~~must~~ <u>shall</u> indicate on a base map provided by the Division the proposed set including an inset vicinity map showing the location of the proposed set with detail sufficient to permit on-site identification and location. The applicant ~~must~~ <u>shall</u> specify the type(s) of pound net set(s) requested and possess proper valid ~~licenses~~ <u>license(s)</u> and ~~permits~~ <u>permit(s)</u> necessary to fish those type(s) of net. A pound net set shall be deemed a flounder pound net set when the catch consists of 50 percent or more flounder by weight of the entire landed catch, excluding blue crabs. The type "other finfish pound net set" is for sciaenid (Atlantic croaker, red drum, weakfish, spotted seatrout, spot, for example) and other finfish, except flounder, herring, or shad, taken for human consumption. Following are the type(s) of pound net fisheries that may be specified:

(1) Flounder pound net set;
(2) Herring/shad pound net set;
(3) Bait pound net set;
(4) Shrimp pound net set;
(5) Blue crab pound net set;
(6) Other finfish pound net set.

(d) For proposed new ~~locations,~~ <u>location(s)</u> the Fisheries Director shall issue a public notice of intent to consider issuance of a Pound Net Set Permit allowing for public ~~comments~~ <u>comment</u> for 20 days, and after the comment period, may hold public meetings to take comments on the proposed pound net set. If the Director does not approve or deny the application within 90 days of receipt of a complete and verified application, the application shall be deemed denied. The applicant shall be notified of ~~such~~ denial in writing. For new locations, transfers and renewals, the Fisheries Director may deny the permit application if the Director determines that granting the permit ~~will~~ <u>shall</u> be inconsistent with one or more of the following permitting criteria, as determined by the Fisheries Director:

(1) The application ~~must~~ shall be in the name of an individual and shall not be granted to a corporation, partnership, organization or other entity;

(2) The proposed pound net set, either alone or when considered cumulatively with other existing pound net sets in the area, ~~will~~ shall not interfere with public navigation or with existing, traditional uses of the area other than navigation, and ~~will~~ shall not violate 15A NCAC 03J.0101 and .0102;

(3) The proposed pound net set ~~will~~ shall not interfere with the rights of any riparian or littoral landowner, including the construction or use of piers;

(4) The proposed pound net set ~~will~~ shall not, by its proximate location, interfere with existing pound net sets in the area. Except in Chowan River as referenced in 15A NCAC 03J .0203, proposed new pound net set locations shall be a minimum of 1,000 yards as measured in a perpendicular direction from any point on a line following the permitted location of existing pound net sets;

(5) The applicant has in the past complied with fisheries rules and laws and does not currently have any licenses or privileges under suspension or revocation. In addition, a history of habitual fisheries violations evidenced by eight or more convictions in ten years shall be grounds for denial of a ~~pound net set permit~~ Pound Net Set Permit;

(6) The proposed pound net set is in the public interest; ~~and~~

(7) The operation of the proposed pound net set is not in compliance with management measures adopted in fishery management plans; and

~~(7)~~(8) The applicant has in the past complied with all permit conditions, rules and laws related to pound nets.

Approval shall be conditional based upon the applicant's continuing compliance with specific conditions contained on the Pound Net Set Permit and the conditions set out in Subparagraphs (1) through ~~(7)~~ (8) of this Paragraph. The final decision to approve or deny the Pound Net Set Permit application may be appealed by the applicant by filing a petition for a contested case hearing, in writing, within 60 days from the date of mailing notice of such final decision to the applicant, with the Office of Administrative Hearings.

(e) An application for renewal of an existing Pound Net Set Permit shall be filed not less than 30 days prior to the date of expiration of the existing permit, and shall not be processed unless filed by the permittee. The Fisheries Director shall review the renewal application under the criteria for issuance of a new Pound Net Set Permit, except that pound net sets approved prior to January 1, ~~2003~~ 2003, do not have to meet the 1,000 yard minimum distance requirement specified in Subparagraph (d)(4) of this Rule. The Fisheries Director may hold public meetings and ~~may~~ conduct such investigations necessary to determine if the permit should be renewed.

(f) A Pound Net Set Permit, whether a new or renewal permit, shall expire one year from the date of issuance. The expiration date shall be stated on the permit.

(g) ~~Pound net sets~~, Except for herring/shad pound net sets in the Chowan River, it is unlawful to fail to have a pound net set ~~shall be~~ operational for a minimum ~~period~~ of 30 consecutive days during the permit period unless a season for the fishery for which the pound net set is permitted is ended earlier due to a quota being met. For purposes of this Rule, operational means with net attached to stakes or anchors for the lead and pound, including only a single pound in a multi-pound set, and a non-restricted opening leading into the pound such that the set is able to catch and hold fish. The permittee, including permittees of operational herring/shad pound net sets in the Chowan River, shall notify the Marine Patrol Communications Center by phone within 72 hours after the pound net set is operational. Notification shall include name of permittee, ~~pound net set permit~~ Pound Net Set Permit number, county where located, a specific location site, and how many pounds are in the set. It is unlawful to fail to notify the Marine Patrol Communications Center within 72 hours after the pound net set is operational or to make false notification when said pound net set is not operational. Failure to comply with this Paragraph shall be grounds for the Fisheries Director to revoke ~~this and~~ any ~~other~~ and all ~~pound net set permits~~ Pound Net Set Permits held by the permittee and for denial of any future ~~pound net set permits.~~ applications for Pound Net Set Permits.

(h) It is unlawful to transfer a ~~pound net set permit~~ Pound Net Set Permit without a completed application for transfer being submitted to the Division ~~of Marine Fisheries~~ not less than 45 days before the date of the transfer. Such application shall be made by the proposed new permittee in writing and shall be accompanied by a copy of the current permittee's permit and an application for a ~~pound net set permit~~ Pound Net Set Permit in the new permittee's name. The Fisheries Director may hold a public meeting and ~~may~~ conduct such investigations necessary to determine if the permit should be transferred. The transferred permit shall expire on the same date as the initial permit. Upon death of the permittee, the permit may be transferred to the Administrator/Executor of the estate of the permittee if transferred within six months of the Administrator/Executor's qualification under ~~G.S. 28A.~~ Chapter 28A of the N.C. General Statutes. The Administrator/Executor ~~must~~ shall provide a copy of the deceased permittee's death certificate, a copy of ~~the certificate of administration~~ letters of administration/letters testamentary and a list of eligible immediate family members as defined in G.S. 113-168 to the Morehead City Office of the ~~Division of Marine Fisheries.~~ Division. Once transferred to the Administrator/Executor, the Administrator/Executor may transfer the permit(s) to eligible immediate family members of the deceased permittee. No transfer is effective until approved and processed by the Division.

(i) Every pound net set in coastal fishing waters shall have yellow light reflective tape or yellow light reflective devices on each pound. The yellow light reflective tape or yellow light reflective devices shall be affixed to a stake of at least three inches in diameter on any outside corner of each pound, shall cover a vertical distance of not less than 12 inches, and shall be visible from all directions. In addition, every pound net set shall have a marked navigational opening ~~of~~ at least 25 feet ~~in width~~ wide at the end of every third pound. Such opening shall be marked with yellow light reflective tape or yellow light reflective devices on each side of the opening. The yellow light reflective tape or yellow light reflective devices shall be affixed to a stake of at least three inches in diameter, shall cover a vertical distance of not less than 12 inches, and shall be visible from all directions. If a permittee notified of a violation under this Paragraph fails or refuses to take corrective action sufficient to remedy the violation within 10 days of receiving notice of the violation, the Fisheries Director shall revoke the permit.

(j) In Core Sound, it is unlawful to use a pound net ~~sets~~ set in the pound net ~~sets~~ set prohibited areas designated in 15A NCAC 03R .0113 except that only those ~~pound net set permits~~ Pound Net Set Permits valid within the specified area as of March 1, 1994, may be renewed or transferred subject to the requirements of this Rule.

(k) Escape Panels:

(1) The Fisheries Director may, by proclamation, require escape panels in pound net sets and may impose any or all of the following requirements or restrictions on the use of escape panels:

(A) Specify size, number, and location.

(B) Specify mesh length, but not more than six inches.

(C) Specify time or season.

(D) Specify areas.

(2) It is unlawful to use flounder pound net sets without four unobstructed escape panels in each pound south and east of a line beginning at a point 35° 57.3950' N - 76° 00.8166' W on Long Shoal Point; running easterly to a point 35° 56.7316' N - 75° 59.3000' W near Marker "5" in Alligator River; running northeasterly along the Intracoastal Waterway to a point 36° 09.3033' N - 75° 53.4916' W near Marker "171" at the mouth of North River; running northwesterly to a point 36° 09.9093' N - 75° 54.6601' W on Camden Point. The escape panels ~~must~~ shall be fastened to the bottom and corner ropes on each wall on the side and back of the pound opposite the heart. The escape panels ~~must~~ shall be a minimum mesh size of five and one-half inches, hung on the diamond, and ~~must~~ shall be at least six meshes high and eight meshes long.

(l) Pound net sets ~~are~~ shall be subject to inspection at all times.

(m) Daily reporting may be a condition of the permit for a pound net ~~sets~~ set for fisheries under a quota.

(n) It is unlawful to fail to remove all pound net stakes and associated gear within 30 days after expiration of the permit or notice by the Fisheries Director that an existing pound net set permit has been revoked or denied.

(o) It is unlawful to abandon an existing pound net set without completely removing from the coastal fishing waters all stakes and associated gear within 30 days.

History Note: *Authority G.S. 113-134; 113-182; 113-182.1; 113-221; 143B-289.52*
Eff. January 1, 1991;
Amended Eff. April 1, 1999; March 1, 1996; March 1, 1994; September 1, 1991; January 1, 1991;
Temporary Amendment Eff. September 1, 2000; August 1, 2000;
Amended Eff. August 1,2002; April 1, 2001;
Temporary Amendment Eff. February 10,2003
Amended Eff. August 1, 2004.

15A NCAC 03J .0209 ALBEMARLE SOUND/CHOWAN RIVER HERRING MANAGEMENT AREAS

(a) Defined areas:

(1) The Albemarle Sound Herring Management Area is defined as Albemarle Sound and all its joint water tributaries; Currituck Sound; Roanoke and Croatan sounds and all their joint water tributaries, including Oregon Inlet, north of a line from Roanoke Marshes Point 35° 48.3693' N – 75° 43.7232' W across to the north point of Eagles Nest Bay 35° 44.1710' N – 75° 31.0520' W.

(2) The Chowan River Herring Management Area is defined as that area northwest of a line from Black Walnut Point 35° 59.9267' N – 76° 41.0313' W to Reedy Point 36° 02.2140' N – 76° 39.3240' W, to the North Carolina/Virginia state line; including the Meherrin River.

(b) Effective January 1, 2001, it is unlawful to use drift gill nets in the Albemarle Sound and Chowan River river herring management areas with a mesh length less than three inches from January 1 through May 15.

History Note: Authority G.S. 113-134; 113-182; 143B-289.52;
Temporary Adoption Eff. May 1, 2000;
Eff. April 1, 2001.

10.6 Anadromous Spawning Areas

15A NCAC 03I .0101 DEFINITIONS

(a) All definitions set out in G.S. 113, Subchapter IV apply to this Chapter.

(b) The following additional terms are hereby defined:

(1) Commercial Fishing Equipment or Gear. All fishing equipment used in coastal fishing waters except:

(A) Seines less than 30 feet in length;

(B) Collapsible crab traps, a trap used for taking crabs with the largest open dimension no larger than 18 inches and that by design is collapsed at all times when in the water, except when it is being retrieved from or lowered to the bottom;

(C) Spears, Hawaiian slings or similar devices which propel pointed implements by mechanical means, including elastic tubing or bands, pressurized gas or similar means;

(D) A dip net having a handle not more than eight feet in length and a hoop or frame to which the net is attached not exceeding 60 inches along the perimeter;

(E) Hook-and-line and bait-and-line equipment other than multiple-hook or multiple-bait trotline;

(F) A landing net used to assist in taking fish when the initial and primary method of taking is by the use of hook and line;

(G) Cast Nets;

(H) Gigs or other pointed implements which are propelled by hand, whether or not the implement remains in the hand; and

(I) Up to two minnow traps.

(2) Fixed or stationary net. A net anchored or staked to the bottom, or some structure attached to the bottom, at both ends of the net.

(3) Mesh Length. The diagonal distance from the inside of one knot to the outside of the other knot, when the net is stretched hand-tight.

(4) Possess. Any actual or constructive holding whether under claim of ownership or not.

(5) Transport. Ship, carry, or cause to be carried or moved by public or private carrier by land, sea, or air.
(6) Use. Employ, set, operate, or permit to be operated or employed.
(7) Purse Gill Nets. Any gill net used to encircle fish when the net is closed by the use of a purse line through rings located along the top or bottom line or elsewhere on such net.
(8) Gill Net. A net set vertically in the water to capture fish by entanglement by the gills in its mesh as a result of net design, construction, mesh size, webbing diameter or method in which it is used.
(9) Seine. A net set vertically in the water and pulled by hand or power to capture fish by encirclement and confining fish within itself or against another net, the shore or bank as a result of net design, construction, mesh size, webbing diameter, or method in which it is used.
(10) Internal Coastal Waters or Internal Waters. All coastal fishing waters except the Atlantic Ocean.
(11) Channel Net. A net used to take shrimp which is anchored or attached to the bottom at both ends or with one end anchored or attached to the bottom and the other end attached to a boat.
(12) Dredge. A device towed by engine power consisting of a frame, tooth bar or smooth bar, and catchbag used in the harvest of oysters, clams, crabs, scallops, or conchs.
(13) Mechanical methods for clamming. Includes dredges, hydraulic clam dredges, stick rakes and other rakes when towed by engine power, patent tongs, kicking with propellers or deflector plates with or without trawls, and any other method that utilizes mechanical means to harvest clams.
(14) Mechanical methods for oystering. Includes dredges, patent tongs, stick rakes and other rakes when towed by engine power and any other method that utilizes mechanical means to harvest oysters.
(15) Depuration. Purification or the removal of adulteration from live oysters, clams, and mussels by any natural or artificially controlled means.
(16) Peeler Crab. A blue crab that has a soft shell developing under a hard shell and having a definite white, pink, or red-line or rim on the outer edge of the back fin or flipper.
(17) Length of finfish.
  (A) Total length is determined by measuring along a straight line the distance from the tip of the snout with the mouth closed to the tip of the compressed caudal (tail) fin.
  (B) Fork length is determined by measuring along a straight line the distance from the tip of the snout with the mouth closed to the middle of the fork in the caudal (tail) fin.
  (C) Fork length for billfish is measured from the tip of the lower jaw to the middle of the fork of the caudal (tail) fin.
(18) Licensee. Any person holding a valid license from the Department to take or deal in marine fisheries resources.
(19) Aquaculture operation. An operation that produces artificially propagated stocks of marine or estuarine resources or obtains such stocks from authorized sources for the purpose of rearing in a controlled environment. A controlled environment provides and maintains throughout the rearing process one or more of the following: predator protection, food, water circulation, salinity, or temperature controls utilizing technology not found in the natural environment.
(20) Critical habitat areas. The fragile estuarine and marine areas that support juvenile and adult populations of fish species, as well as forage species utilized in the food chain. Critical habitats include nursery areas, beds of submerged aquatic vegetation, shellfish producing areas, anadromous fish spawning and anadromous fish nursery areas, in all coastal fishing waters as determined through marine and estuarine survey sampling. Critical habitats are vital for portions, or the entire life cycle, including the early growth and development of fish species.
  (A) Beds of submerged aquatic vegetation are those habitats in public trust and estuarine waters vegetated with one or more species of submerged vegetation such as eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*), and widgeongrass (*Ruppia maritima*). These vegetation beds occurs in both subtidal and intertidal zones and may occur in isolated patches or cover extensive areas. In either case, the bed is defined by the presence of above-ground leaves, or the below-ground rhizomes and propagules, together

with the sediment on which the plants grow. In defining beds of submerged aquatic vegetation, the Marine Fisheries Commission recognizes the Aquatic Weed Control Act of 1991 (G.S. 113A-220 et. seq.) and does not intend the submerged aquatic vegetation definition and its implementing rules to apply to or conflict with the non-development control activities authorized by that Act.

(B) Shellfish producing habitats are those areas in which shellfish, such as clams, oysters, scallops, mussels, and whelks, whether historically or currently, reproduce and survive because of such favorable conditions as bottom type, salinity, currents, cover, and cultch. Included are those shellfish producing areas closed to shellfish harvest due to pollution.

(C) Anadromous fish spawning areas are those areas where evidence of spawning of anadromous fish has been documented by direct observation of spawning, capture of running ripe females, or capture of eggs or early larvae.

(D) Anadromous fish nursery areas are those areas in the riverine and estuarine systems utilized by post-larval and later juvenile anadromous fish.

(E) Nursery areas are defined as those areas in which for reasons such as food, cover, bottom type, salinity, temperature and other factors, young finfish and crustaceans spend the major portion of their initial growing season.

(i) Primary nursery areas are those areas in the estuarine system where initial post-larval development takes place. These are areas where populations are uniformly very early juveniles.

(ii) Secondary nursery areas are those areas in the estuarine system where later juvenile development takes place. Populations are composed of developing sub-adults of similar size which have migrated from an upstream primary nursery area to the secondary nursery area located in the middle portion of the estuarine system.

(21) Intertidal Oyster Bed. A formation, regardless of size or shape, formed of shell and live oysters of varying density.

(22) North Carolina Trip Ticket. Multiple-part form provided by the Department to fish dealers who are required to record and report transactions on such forms.

(23) Transaction. Act of doing business such that fish are sold, offered for sale, exchanged, bartered, distributed or landed. The point of landing shall be considered a transaction when the fisherman is the fish dealer.

(24) Live rock. Living marine organisms or an assemblage thereof attached to a hard substrate including dead coral or rock (excluding mollusk shells). For example, such living marine organisms associated with hard bottoms, banks, reefs, and live rock may include:

(A) Animals:

(i) Sponges (Phylum Porifera);

(ii) Hard and Soft Corals, Sea Anemones (Phylum Cnidaria):

(I) Fire corals (Class Hydrozoa);

(II) Gorgonians, whip corals, sea pansies, anemones, Solenastrea (Class Anthozoa);

(iii) Bryozoans (Phylum Bryozoa);

(iv) Tube Worms (Phylum Annelida):

(I) Fan worms (Sabellidae);

(II) Feather duster and Christmas tree worms (Serpulidae);

(III) Sand castle worms (Sabellaridae).

(v) Mussel banks (Phylum Mollusca:Gastropoda);

(vi) Colonial barnacles (Arthropoda: Crustacea: Megabalanus sp.).

(B) Plants:

(i) Coralline algae (Division Rhodophyta);

(ii) Acetabularia sp., Udotea sp., Halimeda sp., Caulerpa sp. (Division Chlorophyta);

(iii) Sargassum sp., Dictyopteris sp., Zonaria sp. (Division Phaeophyta).

(25) Coral:

(A) Fire corals and hydrocorals (Class Hydrozoa);

(B) Stony corals and black corals (Class Anthozoa, Subclass Scleractinia);

(C) Octocorals; Gorgonian corals (Class Anthozoa, Subclass Octocorallia):

(i) Sea fans (Gorgonia sp.);
(ii) Sea whips (Leptogorgia sp. and Lophogorgia sp.);
(iii) Sea pansies (Renilla sp.).

(26) Shellfish production on leases and franchises:
(A) The culture of oysters, clams, scallops, and mussels, on shellfish leases and franchises from a sublegal harvest size to a marketable size.
(B) The transplanting (relay) of oysters, clams, scallops and mussels from designated areas closed due to pollution to shellfish leases and franchises in open waters and the natural cleansing of those shellfish.

(27) Shellfish marketing from leases and franchises. The harvest of oysters, clams, scallops, mussels, from privately held shellfish bottoms and lawful sale of those shellfish to the public at large or to a licensed shellfish dealer.

(28) Shellfish planting effort on leases and franchises. The process of obtaining authorized cultch materials, seed shellfish, and polluted shellfish stocks and the placement of those materials on privately held shellfish bottoms for increased shellfish production.

(29) Pound Net Set. A fish trap consisting of a holding pen, one or more enclosures, lead or leaders, and stakes or anchors used to support such trap. The lead(s), enclosures, and holding pen are not conical, nor are they supported by hoops or frames.

(30) Educational Institution. A college, university or community college accredited by a regional accrediting institution.

(31) Long Haul Operations. A seine towed between two boats.

(32) Swipe Net Operations. A seine towed by one boat.

(33) Bunt Net. The last encircling net of a long haul or swipe net operation constructed of small mesh webbing. The bunt net is used to form a pen or pound from which the catch is dipped or bailed.

(34) Responsible party. Person who coordinates, supervises or otherwise directs operations of a business entity, such as a corporate officer or executive level supervisor of business operations and the person responsible for use of the issued license in compliance with applicable laws and regulations.

(35) New fish dealer. Any fish dealer making application for a fish dealer license who did not possess a valid dealer license for the previous license year in that name or ocean pier license in that name on June 30, 1999. For purposes of license issuance, adding new categories to an existing fish dealers license does not constitute a new dealer.

(36) Tournament Organizer. The person who coordinates, supervises or otherwise directs a recreational fishing tournament and is the holder of the Recreational Fishing Tournament License.

(37) Holder. A person who has been lawfully issued in their name a license, permit, franchise, lease, or assignment.

(38) Recreational Purpose. A fishing activity has a recreational purpose if it is not a commercial fishing operation as defined in G.S. 113-168.

(39) Recreational Possession Limit. Includes restrictions on size, quantity, season, time period, area, means, and methods where take or possession is for a recreational purpose.

(40) Attended. Being in a vessel, in the water or on the shore immediately adjacent to the gear and immediately available to work the gear and within 100 yards of any gear in use by that person at all times. Attended does not include being in a building or structure.

(41) Commercial Quota. Total quantity of fish allocated for harvest taken by commercial fishing operations.

(42) Recreational Quota. Total quantity of fish allocated for harvest taken for a recreational purpose.

(43) Office of the Division. Physical locations of the Division conducting license transactions in the cities of Wilmington, Washington, Morehead City, Columbia, Wanchese and Elizabeth City, North Carolina. Other businesses or entities designated by the Secretary to issue Recreational Commercial Gear Licenses are not considered Offices of the Division.

(44) Land:
(A) For purposes of trip tickets, when fish reach a licensed seafood dealer, or where the fisherman is the dealer, when the fish reaches the shore or a structure connected to the shore.

(B) For commercial fishing operations, when fish reach the shore or a structure connected to the shore.

(C) For recreational fishing operations, when fish are retained in possession by the fisherman.

(45) Master. Captain of a vessel or one who commands and has control, authority, or power over a vessel.

(46) Regular Closed Oyster Season. May 15 through October 15, unless amended by the Fisheries Director through proclamation authority.

(47) Assignment. Temporary transferral to another person of privileges under a license for which assignment is permitted. The person assigning the license delegates the privileges permitted under the license to be exercised by the assignee, but retains the power to revoke the assignment at any time, is still the responsible party for the license.

(48) Transfer. Permanent transferral to another person of privileges under a license for which transfer is permitted. The person transferring the license retains no rights or interest under the license transferred.

(49) Designee. Any person who is under the direct control of the permittee or who is employed by or under contract to the permittee for the purposes authorized by the permit.

(50) Blue Crab Shedding. The process whereby a blue crab emerges soft from its former hard exoskeleton. A shedding operation is any operation that holds peeler crabs in a controlled environment. A controlled environment provides and maintains throughout the shedding process one or more of the following: predator protection, food, water circulation, salinity or temperature controls utilizing proven technology not found in the natural environment. A shedding operation does not include transporting pink or red-line peeler crabs to a permitted shedding operation.

(51) Fyke Net. An entrapment net supported by a series of internal or external hoops or frames, with one or more lead or leaders that guide fish to the net mouth. The net has one or more internal funnel-shaped openings with tapered ends directed inward from the mouth, through which fish enter the enclosure. The portion of the net designed to hold or trap fish is completely enclosed in mesh or webbing, except for the openings for fish passage into or out of the net (funnel area).

(52) Hoop Net. An entrapment net supported by a series of internal or external hoops or frames. The net has one or more internal funnel-shaped openings with tapered ends directed inward from the mouth, through which fish enter the enclosure. The portion of the net designed to hold or trap the fish is completely enclosed in mesh or webbing, except for the openings for fish passage into or out of the net (funnel area).

History Note: *Authority G.S. 113-134; 143B-289.52;*
Eff. January 1, 1991;
Amended Eff. March 1, 1995; March 1, 1994; October 1, 1993; July 1, 1993;
Recodified from 15A NCAC 03I .0001 Eff. December 17, 1996;
Amended Eff. April 1, 1999; August 1, 1998; April 1, 1997;
Temporary Amendment Eff. May 1, 2000; August 1, 1999; July 1, 1999;
Amended Eff. August 1, 2000;
Temporary Amendment Eff. August 1, 2000;
Amended Eff. September 1, 2005; April 1, 2003; April 1, 2001.

SUBCHAPTER 3N - ~~NURSERY~~ FISH HABITAT AREAS

15A NCAC 03N .0101 SCOPE AND PURPOSE

To establish and protect those fragile estuarine and marine areas which support juvenile and adult populations of economically important ~~seafood~~ fish species, as well as forage fish utilized in the food chain, these Rules ~~will~~ set forth permanent ~~nursery~~ fish habitat areas in all coastal fishing waters as defined through extensive estuarine and marine survey sampling conducted by ~~Marine Fisheries personnel of the Operations Section~~. the Division.

History Note: *Authority G.S. 113-134; 113-182; 143B-289.52;*

Eff. January 1, 1991.

15A NCAC 03N .0102 NURSERY AREAS DEFINED [MOVED TO 03I .0101]

~~(a) Nursery areas are defined as those areas in which for reasons such as food, cover, bottom type, salinity, temperature and other factors, young finfish and crustaceans spend the major portion of their initial growing season.~~

~~(b) Primary nursery areas are those areas in the estuarine system where initial post larval development takes place. These areas are usually located in the uppermost sections of a system where populations are uniformly very early juveniles.~~

~~(c) Secondary nursery areas are those areas in the estuarine system where later juvenile development takes place. Populations are usually composed of developing sub-adults of similar size which have migrated from an upstream primary nursery area to the secondary nursery area located in the middle portion of the estuarine system.~~

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

15A NCAC 03N .0103 NURSERY AREA BOUNDARIES

(a) Primary and secondary nursery areas are defined in 15A NCAC 03I .0101 and designated in 15A NCAC 03R .0103, .0104, and .0105.

(b) Unless otherwise specified by the rule, primary nursery areas described in 15A NCAC 03R .0103 encompass all waters from the described line in the direction indicated in rule up to the headwaters of the waterbody or Inland-Coastal boundary lines, whichever area is first encountered.

(c) Unless otherwise specified by the rule, permanent and special secondary nursery areas designated in 15A NCAC 03R .0104 and .0105 encompass all waters from the described line in the direction indicated in rule up to the primary nursery area lines, Inland-Coastal boundary lines or the headwaters of the waterbody, whichever area is first encountered.

History Note: Authority G.S. 113-134; 113-182; 143B-289.52;
Eff. January 1, 1991;
Amended Eff. September 1, 1991;
Recodified from 15A NCAC 03N .0003 Eff. May 1, 1997;
Amended Eff. August 1, 2004; May 1, 1997.

15A NCAC 03N .0104 PROHIBITED GEAR, PRIMARY NURSERY AREAS

It is unlawful to use any trawl net, long haul seine, swipe net, dredge, or mechanical method for clams or oysters for the purpose of taking any marine fishes in any of the primary nursery areas described in 15A NCAC 03R .0103.

History Note: Authority G.S. 113-134; 113-182; 143B-289.52;
Eff. January 1, 1991;
Amended Eff. September 1, 1991;
Recodified from 15A NCAC 3N .0004 Eff. May 1, 1997;
Amended Eff. May 1, 1997.

15A NCAC 03N .0105 PROHIBITED GEAR, SECONDARY NURSERY AREAS

(a) It is unlawful to use trawl nets for any purpose in any of the permanent secondary nursery areas designated in 15A NCAC 03R .0104.

(b) It is unlawful to use trawl nets for any purpose in any of the special secondary nursery areas designated in 15A NCAC 03R .0105, except that the Fisheries Director, may, by proclamation, open any or all of the special secondary nursery areas, or any portion thereof, listed in 15A NCAC 03R .0105 to shrimp or crab trawling from August 16 through May 14 subject to the provisions of 15A NCAC 03L .0100 and .0200.

History Note: Authority G.S. 113-134; 113-182; 113-221; 143B-289.52;
Eff. January 1, 1991;
Amended Eff. September 1, 1991;
Recodified from 15A NCAC 03N .0005 Eff. May 1, 1997;
Amended Eff. August 1, 2004; May 1, 1997.

15A NCAC 03N .0106 ANADROMOUS FISH SPAWNING AREA BOUNDARIES

(a) Anadromous fish spawning areas are defined in 15A NCAC03I .0101 and designated in 15A NCAC 03R .0115.

(b) Anadromous fish spawning areas described in 15A NCAC 03R .0115 encompass all waters, including tributaries from the described line in the direction indicated in Rule up to the headwaters of the waterbody or Inland-Coastal boundary lines, whichever area is first encountered and except when:

(1) otherwise specified by 15A NCAC 03R .0115; or

(2) the waterbody is impassable to fish migration due to manmade obstructions including but not limited to dams and causeways.

History Note: Authority G.S. 113-134; 113-182; 113-221; 143B-289.52

15A NCAC 03R .0115 ANADROMOUS FISH SPAWNING AREAS

The anadromous fish spawning areas as defined in 15A NCAC 03I .0101 and referenced in 15A NCAC 03 N .0106 are delineated in the following coastal waters:

(1) Currituck Sound Area:
- (a) Northwest River- all waters of the Northwest River and its tributaries east of a line beginning on the north shore at a point 36º 30.8374’ N – 76º 04.8770’ W; running southerly to the south shore to a point 36º 30.7061’ N – 76º 04.8916’ W.
- (b) Tull Bay/Tull Creek- all waters of Tull Bay and its tributaries northeast of a line beginning on the north shore at a point 36º 30.0991’ N – 76º 04.8587 W; running southeasterly to the south shore to a point 36º 29.9599’ N – 76º 04.7126’ W; and south of a line beginning on the west shore at a point 36º30.9867’ N – 76º 02.5868’ W; running easterly to the east shore to a point 36º31.0045’ N – 76º 02.3780’ W; and west of a line beginning on the north shore at a point 36º 30.8291’ N – 76º 02.1329’ W; running southwesterly to the south shore to a point 36º 30.1512’ N – 76º 02.4982’ W.

(2) Albemarle Sound Area:
- (a) Big Flatty Creek- all waters of Big Flatty Creek and its tributaries east of a line beginning on the north shore at a point 36º 09.3267’N – 76º 08.2562’W; running southerly to the south shore to a point 36º 08.9730’N – 76º 08.3175’W and north of a line beginning on the west shore at a point 36º 07.9621’N – 76º 07.1818’W; running easterly to the east shore to a point 36º 08.2706’N – 76º 06.2525’W.
- (b) Batchelor Bay- west of a line beginning on the north shore at a point 35º 58.2070’ N – 76º 42.7267’ W; running southeasterly to the south shore to a point 35º 56.5622’ N – 76º 41.5506’ W.
- (c) Bull Bay- southwest of a line beginning on the northwest shore at a point 35º 58.9002’ N – 76º 23.9965’ W; running southeasterly to the southeast shore at a point 35º 56.7198’ N – 76º 18.8964’ W.

(3) North River- all waters of the North River and its tributaries east of a line beginning on the north shore at a point 36º 18.7703’ N – 75º 58.7384’ W; running southerly to the south shore to a point 36º 18.4130’ N – 75º 58.7228’ W; and north of a line beginning on the west shore at a 36º 16.9952’ N – 75º 57.0758’ W; running easterly to the east shore to a point 36º 16.9801’ N – 75º 56.6820’ W.

(4) Pasquotank River- all waters of the Pasquotank River and its tributaries south of a line beginning on the west shore at a point 36º 18.0768’ N – 76º 13.0979’ W; running easterly to the east shore along the south side of the Highway 158 Bridge to a point 36º 18.0594’ N – 76º 12.9620’ W; and northwest of a line beginning on the northeast shore at a point 36º 14.3294’ N– 76º 04.7866’ W; running southwesterly to the southwest shore to a point 36º 12.8147’ N- 76º 07.0465’ W.

(a) Charles Creek- north of a line beginning on the west shore at a point 36º 17.8090’ N – 76º 13.0732’ W; running easterly to the east shore to a point 36º 17.8024’ N – 76º 13.0407’ W.

(b) New Begun Creek- east of a line beginning on the north shore at a point 36º 13.3298’ N – 76º 08.2878’ W; running southerly to the south shore to a point 36º 13.0286’ N – 76º 08.1820’ W.

(5) Little River- all waters of the Little River and its tributaries southeast of a line beginning on the west shore at a point 36º 12.5237’ N – 76º 16.9418’ W; running southeasterly to the east shore to a point 36º 12.2950’ N – 76º 17.1405’ W; and north of a line beginning on the west shore at a point 36º 09.6537’ N – 76º 15.0689’ W; running northeast to the east shore to a point 36º 10.2112’ N – 76º 14.0287’ W.

(6) Perquimans River- all waters of the Perquimans River and its tributaries northeast of a line beginning on the west shore at a point 36º 11.6569’ N – 76º 28.0055’ W; running southeasterly to the east shore to a point 36º 11.6123’ N – 76º 27.9382’ W; and northwest of a line beginning on the southwest shore at a point 36º 11.1512’ N – 76º 27.4424’ W; running northeasterly to the northeast shore to a point 36º 11.5124’ N – 76º 26.7298’ W.

(7) Perquimans River Area:

(a) Walter’s Creek- northeast of a line beginning on the north shore at a point 36º 11.1305’ N – 76º 27.9185’ W; running southeasterly to the south shore to a point 36º 11.0224’ N – 76º 27.6626’ W.

(b) Mill Creek- south of a line beginning on the west shore at a point 36º 11.9766’ N – 76º 27.2511’ W; running easterly to the east shore to a point 36º 11.9757’ N – 76º27.5752’ W.

(8) Yeopim River- all waters of the Yeopim River and its tributaries east of a line beginning on the north shore at a point 36º 05.4526’N – 76º27.7651’W; running southerly to the south shore to a point on Norcum Point 36º 05.1029’N – 76º27.7120’ W; and west of a line beginning on the north shore at a point 36º 04.7426’ N – 76º 24.2537’ W; running southwesterly to the south shore to a point 36º 04.1137’ N – 76º 24.5366’ W.

(9) Yeopim River Area, Yeopim Creek- south of a line beginning on the west shore at a point 36º 04.7206’ N – 76º 24.8396’ W; running easterly to the east shore to a point 36º 04.7426’ N – 76º 24.2536’ W.

(10) Edenton Bay- all waters of Edenton Bay and its tributaries west of a line beginning on the north shore at a point 36º 03.3757’ N – 76º 36.3629’ W; running southerly to the south shore to a point 36º 03.3551’ N – 76º 36.3574’ W; and north of a line beginning on the west shore at a point 36º 02.1767’ N – 76º 38.4058’ W; running easterly to the east shore to a point 36º 02.0299’ N – 76º 36.0445’ W; and east of a line beginning on the west shore at a point 36º 03.2819’ N – 76º 37.0138’ W; running northeasterly to the east shore to a point 36º 03.4185’ N – 76º 36.6783’ W.

(11) Chowan River- all waters of the Chowan River and tributaries northwest of a line beginning on the west shore at a point 36º 02.3162’ N – 76º 42.4896’ W; running northeasterly to the east shore to a point 36º 03.1013’ N – 76º40.8732’ W; and south of a line beginning on the west shore at a point 36º 32.6293’ N – 76º 55.3564’ W; and running to the east shore to a point 36º 32.6284’ N – 76º 55.1757’ W.

(12) Chowan River Area, Meherrin River- all waters of the Meherrin River and tributaries west of a line beginning on the north shore at a point 36º 25.9937’ N – 76º 56.8884’ W; running southerly to the south shore to a point 36º 25.7926’ N – 76º 56.8966’ W; and south of a line beginning on the west shore at a point 36º 32.7867’ N – 77º 09.8885’ W; running easterly to the east shore to a point 36º 32.7807’ N – 77º 09.8565’ W.

(13) Cashie River- all waters of the Cashie River and tributaries east of a line beginning on the north shore at a point 35º 54.7865’ N – 76º 49.0521’ W; running southerly to the south shore at a point 35º 54.6691’ N – 76º 49.0553’ W; west of a line beginning on the north shore at a point 35º 56.4598’ N – 76º 43.8093’ W; running southerly to the north shore to a point on the north shore of an island in the mouth of the river 35º 56.2250’ N – 76º 43.9265’ W; west of a line beginning on the south shore at a point of an island in the mouth of the river 35º 56.1254’ N – 76º 43.9846’ W; running southerly to the south shore to a point 35º 56.0650’ N – 76º 43.9599’ W.

(14) Middle River- all waters of the Middle River southwest of a line beginning on the west shore at a point 35º 55.4000’ N – 76º 43.8259’ W; running southeasterly to the east shore to a point 35º 55.3977’ N – 76º43.6797’ W.

(15) Eastmost River- all waters of the Eastmost River and its tributaries south of a line beginning on the west shore at a point 35º 56.5024’ N – 76º 42.4877’ W; running westerly to the east shore to a point 35º 56.4070’ N – 76º 42.7647’ W.

(16) Roanoke River - all waters of the Roanoke River and tributaries south of a line beginning on the west shore at a point 35º 56.5068’ N – 76º 41.8858’ W; running easterly to the east shore to a point 35º 56.5324’ N – 76º 41.5896’ W; and southeast of a line beginning on the west shore at a point 36º 12.5264’ N – 77º 23.0223’ W; running northeasterly to the east shore along the south side of the Highway 258 Bridge to a point 36º 12.5674’ N – 77º 22.9724’ W.

(17) Roanoke River Area:

(a) Warren Neck Creek- all waters of Warren Neck Creek and its tributaries west of a line beginning on the northwest shore at a point 35º 52.1820’ N – 76º 47.4855’ W; running southerly to the southeast shore to a point 35º 52.1448’ N – 76º 47.4237’ W.

(b) Thoroughfare- all waters of the Thoroughfare south of a line beginning on the west shore at a point 35º 54.0510’ N – 76º 48.1206’ W; running easterly to the east shore to a point 35º 54.0684’ N – 76º 48.0613’ W; and north of a line beginning on the west shore at a point 35º 53.2842’N – 76º 48.8650’ W; running easterly to the east shore to a point 35º 55.2800’ N – 76º 48.8077’ W.

(c) Devils Gut- all waters of Devils Gut and its tributaries northwest of a line beginning on the west shore at a point 35º 49.5300’ N – 76º 54.2209’ W; running easterly to the east shore to a point 35º 49.5486’ N – 76º 54.1703’ W.

(d) Conine Creek- all waters of Conine Creek and its tributaries west of a line beginning on the north shore at a point 35º 52.9752’ N – 76º 58.0474’ W; running southwesterly to the south shore to a point 35º 52.9776’ N – 76º 57.9958’ W.

(18) Scuppernong River- all waters of the Scuppernong River and tributaries southeast of a line beginning on the northeast shore at a point 35º 56.7196’ N – 76º 18.8964’ W; running southwesterly to the southwest shore to a point 35º 56.3351’ N – 76º 19.6609’ W; and north of a line beginning on the west shore at a point 35º 54.0158’ N – 76º 15.4605’ W; running easterly to the east shore to a point 35º 54.0406’ N – 76º 15.3007’ W.

(19) Alligator River- all waters of the Alligator River and tributaries east of a line beginning on the north shore at Cherry Ridge Landing at a point 35º 42.2172’ N – 76º 08.4686’ W; running southerly to the south shore to a point 35º 42.1327’ N – 76º 08.5002’ W; and south of a line beginning on the west shore at a point 35º 57.4252’ N – 76º 00.8704’ W; running easterly to the east shore to a point 35º 57.5494’ N – 75º 56.8268’ W.

(20) Alligator River Area, the Frying Pan- all waters of the Frying Pan and its tributaries west of a line beginning on the north shore at a point 35º 46.0777’ N – 76º 03.3439’ W; running southerly to the south shore to a point 35º 45.6011’ N – 76º 03.3692’ W.

(21) Neuse River – all waters of the Neuse River and its tributaries northwest of a line beginning on the west shore at a point 35° 08.8723’N - 77° 04.6700’ W; running northeasterly to the east shore to a point 35° 09.1032’ N - 77° 04.3355’ W and southeast of a line at Pitch Kettle Creek beginning on the north shore at a point 35° 16.9793’N - 77° 15.5529’W; running south to the south shore to a point 35°16.9237’N - 77° 15.5461’ W.

(22) Neuse River Area:

(a) Smith Creek – north of a line beginning on the west shore at a point 35° 02.2439’N - 76° 42.3035’ W; running easterly to the east shore to a point 35° 02.2392’ N - 76° 42.1910’ W.

(b) Kershaw Creek – north of a line beginning on the west shore at a point 35° 02.4197’N - 76° 43.7886’ W; running easterly to the east shore to a point 35° 02.4218’N - 76° 43.7367’ W.

(23) White Oak River – all waters north of a line beginning at a point on the west shore 34° 46.0728 N - 77° 08.9657’ W; running easterly to a point on the east shore 34° 46.1431' N - 77° 08.8907' W; running north to the Coastal – Inland waters boundary line beginning at a

point on the west shore 34° 48.1466' N - 77° 11.4711' W; running northeasterly to a point on the east shore 34° 48.1620' N - 77° 11.4244' W.

(24) Cape Fear River – all waters north of a line beginning at a point on the west shore 34° 07.7034’ N – 77° 57.3431’ W; running easterly to a point on the east shore 34° 08.0518’ N – 77° 55.7626’ W; running north to the Joint - Inland waters boundary on the following rivers:

(a) Cape Fear River – at a line beginning at a point on the west shore 34° 24.2628' N - 78° 17.6390' W; running northeasterly along the Lock and Dam # 1 to a point on the east shore 34° 24.2958' N - 78° 17.5634' W.

(b) Black River – at a line beginning at a point on the north shore 34° 22.0783' N - 78° 04.4123' W; running southeasterly to a point on the south shore 34° 21.9950' N - 78° 04.2864' W.

(c) Northeast Cape Fear River – at a line beginning at a point on the west side 34° 26.5658' N - 77° 50.0871' W; running northeasterly along the southern side of the NC 210 Bridge to a point on the east side 34° 26.6065' N - 77° 49.9955' W.

History Note: Authority G.S. 113-134; 113-182; 113-221; 143B-289.52