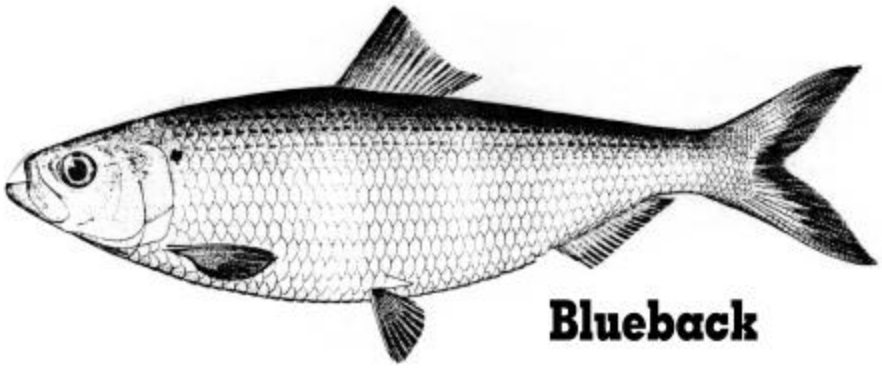
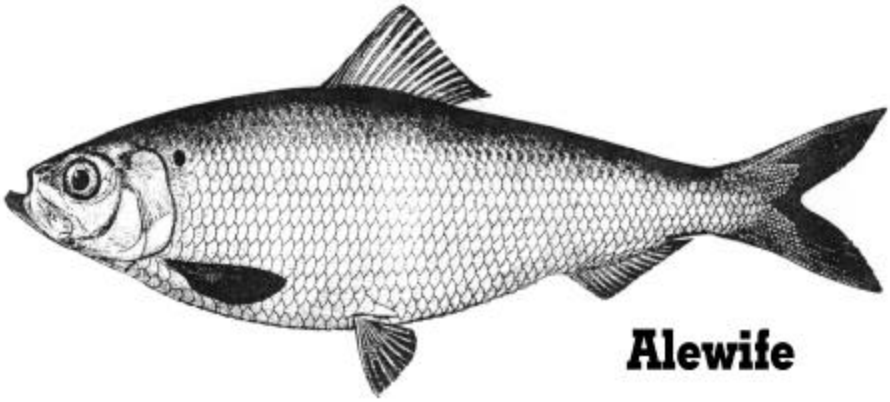
North Carolina
Fishery Management Plan

Albemarle Sound Area
River Herring



Blueback



Alewife

North Carolina
MARINE
FISHERIES
Dept. of Environment and Natural Resources

February 2000

North Carolina Fishery Management Plan:
Albemarle Sound Area River Herring

By
River Herring Plan Development Team

North Carolina Division of Marine Fisheries
Department of Environment and Natural Resources
Morehead City, NC 28557

February 2000

1. Acknowledgments

The 1999 Albemarle Sound River Herring Fishery Management Plan (FMP) was developed under the direction of the North Carolina Marine Fisheries Commission (MFC) with the advice of the MFC River Herring Advisory Committee (RHAC). The plan was prepared by the North Carolina Department of Environment and Natural Resources' Division of Marine Fisheries (DMF), Wildlife Resources Commission (WRC), Division of Water Quality (DWQ), and the US Fish and Wildlife Service (USFWS). Deserving special recognition are the members of the River Herring Advisory Committee, the MFC and WRC, staff of DMF, WRC, DWQ and USFWS, and numerous individuals who contributed their time and knowledge to this effort.

River Herring FMP Advisory Committee

Scott Keefe, Co-chair
Kelly Dilday, Co-chair

Wayne Ashley
C.J. Belch
Herbert Byrum
Ray Davenport
Kurt Fickling
Frank Furlough
Leslie Gardner
Dr. Mary Moser
Terry Pratt
Connell Purvis
Dr. Doug Rader
Lee Wynns
Elbert Bryant

River Herring Plan Development Team

Sara E. Winslow, Chair (DMF)
John Carmichael (DMF)
Solo Diaby (DMF)
Larry Eaton (DWQ)
Brian Spain (DMF)
Pete Kornegay (WRC)
Dr. Wilson Laney (USFWS)
Ronnie Smith (USFWS)
Mike Street (DMF)
Christian Waters (WRC)

Marine Fisheries Commission

Jimmy Johnson, Chairman
Dr. Barbara Garrity-Blake
Dr. B. J. Copeland
Bob Eakes
Kurt Fickling
Bryan Gilliken
Pete Moffitt
Willy Phillips
Robert Southerland

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3. Executive Summary

The management unit for the Albemarle Sound Area River Herring Fishery Management Plan (FMP) includes the two species of river herring (blueback herring, *Alosa aestivalis*, and alewife, *A. pseudoharengus*) and their fisheries throughout the Albemarle Sound area of northeastern North Carolina and the Atlantic Ocean from Cape Hatteras to the North Carolina/Virginia border northward.

Stock Status

When the exploitation rate on a fish stock exceeds sustainable or target levels, then overfishing is occurring. The June 1999 Division of Marine Fisheries stock assessment indicates the Albemarle Sound area river herring stock is overfished. This determination is based on an overall evaluation of the stock and review of several available stock-status indicators.

Spawning stock biomass is greatly reduced from historical levels exceeding 4 million pounds. There are too few repeat spawners in the stock. Recruitment to the stock has been poor for several years, as indicated by both juvenile abundance index (JAI) (below the long-term average for more than 10 years) and the estimated number of recruits (fewer than 5 million since 1989). Blueback herring spawning repetition has been below 5% since 1987. Fishing mortality has exceeded sustainable levels for 25 of the last 27 years.

Fishery Status

The river herring fishery can be divided into two segments: commercial and recreational, with both 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).

Commercial Fishery

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 used 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. Annual landings prior to the early 1970s regularly exceeded 10 million pounds.

Landings in the commercial fisheries have been depressed since the late 1980s (not considering the limits imposed since 1995). The depressed nature of the fishery has greatly reduced the economic value of the harvest, and almost eliminated what was once an extensive processing sector which provided hundreds of seasonal jobs for local residents.

In 1995, a fishing season was implemented by MFC rule which prohibited taking 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. The 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, 250,000 lb and 400,000 lb, 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 lb for the entire management area.

During 1995-1998, North Carolina accounted for 29-52% of the total river herring landings from the U.S. Atlantic coast, compared to 13.6-84.5% from 1950 to 1994. The Chowan River pound net fishery contributed 60.3%-76.5% of the states annual river herring harvest during 1995-1999.

Recreational Fishery

The recreational river herring harvest is unknown.

Socioeconomic Considerations

Commercial value of river herring in North Carolina peaked in 1985 at $846,000. The value then fell sharply to approximately $67,000 in 1993 due to lower landings, but a rise in the average price per pound helped to temper somewhat the effect on revenues to fishermen. The gross income earned from river herring fishing has declined significantly in recent years. There has been a severe decline in river herring processing activities over the years, due to reduced harvest and demand for the products. A recovered fishery of several million pounds, either as a food source or as bait, would produce more revenue to the fishermen. Economic data specific to

the recreational river herring fishing are not available.

Principal Issues

Stock Condition

River herring stocks are currently overfished and cannot replace themselves at existing levels of mortality (recruitment overfishing). Fishing mortality can be reduced through management actions implemented to improve the status of the stocks. The nature of the fisheries during a recovery period and thereafter would depend on the severity of management restrictions utilized to reduce fishing mortality and promote stock recovery, market conditions, economic conditions of the affected fishermen, and many other factors.

Habitat and Water Quality

Considerable habitats important to river herring have been degraded or lost in the Albemarle Sound area. There are still problems with non-point source runoff and some discharges in the area, but the overall water quality of the area has improved since the late 1970s 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.

Assessment Data

Full assessment of the river herring resources from the entire Albemarle Sound area are needed and will require a major expansion of research and monitoring activities. Fishery-dependent and fishery-independent sampling must be initiated throughout the area.

Socioeconomic Data

Every management decision has socioeconomic effects. The DMF should begin regular sampling of licensees for data with which to develop socioeconomic baselines from which to estimate impacts of decisions.

Education

The river herring fishery, even though it was North Carolina's largest food fish fishery for many decades, is poorly known beyond the immediate Albemarle Sound area. The general

public should be educated concerning both the history and potential future benefits which can come from a recovered fishery.

Management Goals

To manage the Albemarle Sound area river herring fishery 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.

To achieve an interim spawning stock biomass (SSB) level for the Albemarle/Roanoke system river herring that coincides with a 4 million pound SSB level for the Chowan River stock. (This level of SSB is considered the Minimum Stock Size Threshold (MSST)).

To achieve for the long-term a spawning stock biomass (SSB) level for the Albemarle/Roanoke system river herring that coincides with an 8 million pound SSB level for the Chowan River stock. (This level of SSB is considered the Biomass capable of producing MSY (Bmsy)).

Optimum Yield

The river herring stock assessment indicates that maximum sustainable yield (MSY) for Chowan River blueback herring for a recovered stock is approximately 2 million pounds. Consequently, the target optimum yield (OY) for a healthy river herring population can not exceed 2 million pounds. Because the stock is overfished, the allowable harvest, or rebuilding OY, must provide for stock rebuilding. The rebuilding OY for river herring is not to exceed 300,000 pounds of commercial harvest. Based on stock projections incorporating the stock-recruitment relationship, this level of harvest may rebuild the stock to the threshold spawning stock biomass (minimum stock size threshold, MSST) of 4 million pounds in 14 years and to the MSY biomass in 24 years. This level of harvest should not be exceeded until the JAI reaches a three-year moving average of 20 or the spawning stock biomass exceeds the MSST of 4 million pounds.

Management Objectives

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

2. Restore river herring stocks in the Albemarle Sound area to viable status.

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

4. Manage the fishery 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 stock, its habitats and fisheries, and the rationale for management efforts to solve these problems.

Management Actions

Stock Restoration

*****Specific objectives will be achieved through the preferred Fisheries Management Alternative (see below).

Habitat and Water Quality

*Conduct spawning area surveys in one drainage basin annually, beginning in Spring 2001.

*Develop and implement a Coastal Habitat Protection Plan for river herring spawning and nursery areas.

*Develop and implement drainage area habitat restoration plans and alleviate identified impediments.

***** Protect river herring spawning and nursery areas by specifically designating such areas through MFC rules.

*The Environmental Management Commission (EMC) should take appropriate steps to achieve established water quality objectives and protect designated river herring spawning and nursery areas.

*The Coastal Resources Commission (CRC) should take appropriate steps to achieve established habitat objectives and protect designated river herring spawning and nursery areas.

Fishery Management Alternatives

* The MFC approved management alternative is to allow an annual commercial quota (calendar year) for river herring in the Albemarle Sound Management Area of 300,000 pounds 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.

*It is unlawful to possess more than 25 blueback herring or alewife (river herring), in the aggregate, per person per day taken for recreational purposes.

*Effective January 1, 2001, it will be unlawful to use drift gill nets with a stretched mesh less than 3 inches from January 1 through May 15 in the ASRHMA.

*Once the MSST of SSB equals 4 million pounds (mlb) is reached, the DMF should recommend measures to achieve the target biomass capable of producing MSY (SSB= 8 mlb) that equals 8 million pounds and an ultimate harvest of OY.

*The WRC should implement a no-sale provision for river herring taken with Special Device Licenses and prohibit gill nets in Inland Water in the ASRHMA.

*The DMF and WRC should prepare and implement a plan to restore river herring spawning runs in designated areas.

Data Collection

*Expand and enhance fishery-dependent and fishery-independent sampling throughout the ASRHMA.

*****Design and implement surveys to estimate the recreational fishing catch/effort and collect biological data.

*Fund research to evaluate impacts of water quality on larval and juvenile river herring.

*Design and conduct studies on multi-species effects on river herring, specifically abundance of top predators, such as striped bass.

*Other Fishery Management Alternatives: The following alternatives were considered by the MFC.

*Status quo: 450,000 lb commercial fishery quota allocated among existing fisheries and no recreational limits; This alternative results in continued overfishing of the stock, which violates the FRA.

*100,000 lb commercial bycatch fishery allocated among existing fisheries and 10 fish per person per day recreational limit; and

*Fixed exploitation rate- annual quota would be set based on annual fishing mortality target applied to current stock abundance that varies from year to year. Recreational limit of 25 fish per person per day.

*Total moratorium on river herring landings, with severe fishing restrictions to minimize wasteful bycatch.

4. Introduction

4.1 Management Authority

4.1.1 Introduction

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

North Carolina's existing fisheries management system is extremely powerful and flexible, with rule-making authority vested in the Marine Fisheries Commission (MFC) and Wildlife Resources Commission (WRC) within their respective jurisdictions. The Division of Marine Fisheries (DMF) implements MFC rules and policies. The General Assembly retains for itself licensing and limited entry authorities. In the 1998 amendments to the Fisheries Reform Act of 1997, the General Assembly established a process for limiting entry for fisheries under the FMP process. Federal authority under the Magnuson-Stevens Act applies for fisheries in the Exclusive Economic Zone (the area from 3 to 200 miles offshore; it also applies to a limited extent in areas within state jurisdiction deemed Essential Fish Habitat (EFH)). It does not apply to river herring in state waters because the fisheries and distribution of the stock are primarily within the jurisdictional waters of the coastal states. The Atlantic coast states worked together through the Atlantic States Marine Fisheries Commission (ASMFC) to prepare and implement an interstate FMP, but the regulatory responsibility and authority remain with the states. Passage of the Atlantic Coastal Fisheries Cooperative Management Act in 1993 gave the ASMFC oversight for species with ASMFC plans, but plans are implemented by the states. Thus, the MFC/WRC (rules) and DMF/WRC (research, enforcement, etc.) utilize their authorities to manage the fisheries. The MFC and WRC have the ability to establish seasons, authorize or restrict fishing methods and gear, limit quantities taken or possessed, and restrict fishing areas. Thus, all necessary authority needed for management of the river herring fisheries are available through the existing state fishery management process. Appropriate use of this authority, with the cooperation of stakeholders, will be demonstrated by restoration of the resource and productive fisheries.

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

4.1.2 Legal authority for management

Many different state laws (General Statutes - G.S.) provide the necessary authority for fishery management in North Carolina. General authority for stewardship of the marine and estuarine resources by the North Carolina Department of Environment and Natural Resources (NCDENR) is provided in G.S. 113-131. The DMF is the arm of the Department which carries out this responsibility. The same statute also grants management authority to the WRC within its jurisdictional area. Enforcement authority for DMF enforcement officers (Marine Patrol) and WRC officers is provided by G.S. 113-136. Rule-making authority is granted to the MFC and WRC by G. S. 113-134. General Statute 113-181 authorizes DMF research and statistical programs. The MFC is charged to "manage, restore, develop, cultivate, conserve, protect, and regulate the marine and estuarine resources of the State of North Carolina" (G.S. 143B-289.51). The MFC can regulate fishing times, areas, fishing gear, seasons, size limits, and quantities of fish harvested and possessed (G.S. 113-182 and 143B-289.52). General Statute 143B-289.52 also allows the MFC to delegate authority to implement its regulations for fisheries "which may be affected by variable conditions" to the Director of DMF by issuing public notices called "proclamations." The General Assembly has retained for itself the authority to establish commercial fishing licenses, but has delegated to the MFC authority to establish permits and permit fees for various commercial fishing activities. Thus, North Carolina has a very powerful and flexible legal basis for coastal fisheries management.

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

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

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

c. Include conservation and management measures that prevent overfishing, while achieving, on a continuing basis, the optimal yield from each fishery."

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

a. Will provide the greatest overall benefit to the State, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;

b. Is prescribed on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factors; and

c. In the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in the fishery." (FRA; G. S. 113-182.1)

4.2 General Problem Statement

4.2.1 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 occurring.

The June 1999 stock assessment (Carmichael 1999, Section 13, Appendix 1) indicates that the Chowan River blueback herring stock is overfished. This determination is based on an overall evaluation of the stock and review of several available stock-status indicators.

There is an inadequate number of spawners and too few repeat spawners. Spawning stock biomass is greatly reduced from historical levels. Recruitment to the stock has been poor for several years, as indicated by both the juvenile abundance index (JAI) and the estimated number of recruits. Fishing mortality has exceeded sustainable levels for 25 of the last 27 years. Landings in the commercial fisheries have been depressed since the late 1980s (not considering the limits imposed since 1995). The depressed nature of the fishery has greatly reduced the economic value of the harvest, and almost eliminated what was once an extensive processing sector which provided hundreds of seasonal jobs for local residents.

4.2.2 Environmental Issues

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. 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; research on this topic is underway. Pulp mill effluent and other 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 for many years. There are questions concerning the status of the forage base for, and predators of, river herring.

4.2.3 Insufficient Assessment Data

Data concerning the stock are lacking in many areas. Few fishery-independent data are collected. More complete data on adults during the spawning run are needed regardless of the length of the fishing season. Accurate fishing effort data are needed for all commercial fishing gears. No catch, effort, or biological data exist for the recreational fishery.

4.2.4 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, fitness and spawning success are unknown beyond a few measures, such as water temperature. There is no system in place to gather such environmental data.

4.2.5 Lack of Socioeconomic Data

Some initial socioeconomic data for commercial fishermen were gathered for this FMP. Otherwise, no data exist with which to estimate fishery impacts on the larger economy. No data at all exist for the recreational fishery. Regular collections of such data are necessary to formulate, and evaluate the impacts of, management decisions.

The river herring fishery is one of the oldest commercial fisheries in North Carolina (see Section 6.1), with significant cultural value. Because the fishery is based entirely on migrating fish, it is highly seasonal, and no fishermen are dependent on river herring for their entire fishing income. Traditionally, river herring fishermen have fished part-time, often working in agriculture the rest of the year. The major harvest gear, the pound net, is quite expensive to set and maintain. All pound net sets are officially registered with DMF, as required by rule. The only other gears with significant landings are various types of gill nets. As the stock has declined, pound net fishermen have found it economically difficult to remain in the fishery. Most of these same fishermen have cooperated with the MFC and DMF in data collection and development of management strategies over the last few years, but the stock has continued to decline. As the FMP is implemented, consideration should be given to maintenance of access to the fishery by the traditional methods, including those fishermen who have used those methods.

4.3 Definition of Management Unit

The management unit for this FMP includes the two species of river herring (blueback herring, *Alosa aestivalis,* and alewife, *A. pseudoharengus*) and their fisheries throughout the Albemarle Sound area of coastal North Carolina and the Atlantic Ocean from Cape Hatteras northward.

The management areas are defined as follows:

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' 12"N-75° 43' 06"W, running 122° (M) across the north point of Eagles Nest Bay 35° 44' 12"N-75° 31' 09"W (Figure 1).

Chowan River Herring Management Area (CRHMA)-Northwest of a line from Black Walnut Point 36° 00' 00"N-76° 41' 00"W; running 40°(M) to Reedy Point 36° 02' 12"N-76° 39' 20", to the North Carolina/Virginia state line; including the Meherrin River (Figure 2).

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 1, they have been harvested historically from virtually all coastal streams. Over the last 20-30 years; however, the fisheries have been overwhelmingly concentrated in the Albemarle Sound area. In addition, historical landings data (Section 13, Appendix 2) indicate that the river herring fisheries have always been concentrated in that area, with minor fisheries in other coastal streams. 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 10-18 years ago, varying with area, as federal aid funds were decreased (Table 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 be limited at this time to the river herring fisheries of the Albemarle Sound area as described above.

Table 1. River herring landings and value by waterbody in North Carolina, 1962-1999.

	Albemarle Sound		Croatan Sound		Currituck Sound		Chow
Year	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pound
1962	3,262,600	32,626	20,000	200	25,000	250	10,786,00
1963	2,366,100	23,661	25,000	250	40,400	404	12,288,40
1964	1,920,500	19,205	35,000	350	22,300	223	4,948,90
1965	1,827,700	19,976	15,000	150	10,000	100	10,944,20
1966	1,274,200	13,916			1,000	20	10,911,30
1967	322,100	5,427	5,000	50	11,700	121	18,016,10
1968	1,067,200	16,824	3,300	35	10,000	150	12,950,10
1969	769,000	13,415	19,300	193	12,000	180	17,536,10
1970	217,600	3,263			1,000	20	10,701,30
1971	553,500	9,088					10,426,00
1972	297,551	6,480	2,670	53			10,594,11
1973	472,153	13,327	4,590	137			7,350,57
1974	150,490	5,748			7,554	288	5,736,90
1975	597,440	28,659					5,031,75
1976	356,123	21,304			4,150	415	5,734,77
1977	828,679	38,247					7,418,21
1978	491,372	24,688			3,950	208	5,615,11
1979	466,389	32,741	3,000	120	2,900	128	4,303,66
1980	680,476	51,882	18,815	1,505	4,850	420	5,382,95
1981	1,050,871	87,524	18,653	933	2,585	225	3,314,44
1982	1,558,873	144,751	75,646	7,564	22,787	2,597	7,459,96
1983	1,190,909	118,887	110,576	10,732	39,255	3,614	4,405,91
1984	1,791,289	193,857	15,616	2,170	9,100	1,258	4,561,50
1985	2,296,010	177,908	31,759	2,110	4,137	414	8,871,39
1986	689,297	94,764	49,942	3,998			5,767,87
1987	705,585	85,153	65,500	7,860			2,334,71
1988	1,490,413	178,848	3,700	444			2,259,88
1989	554,878	69,157					908,14
1990	365,881	56,047	2,000	300			710,84
1991	352,458	28,361	10,572	1,015			1,202,53
1992	217,918	22,161	2,616	183			1,135,34
1993	111,749	10,308			117	15	801,11
1994	180,271	33,348	729	73	1,357	136	390,85

1995**	97,137	34,277	1,723	344	640	160	280,68
1996**	104,166	34,284	4,708	2,140	114	28	404,88
1997**	109,876	46,886	9,436	5,344	159	60	201,92
1998**	115,436	46,389	16,831	13,692	157	62	377,31
1999**	85,128		21,101		*	*	332,46

Continued

Table 1. (Continued)

	Roanoke River		Tribs. To Albemarle S.		Pamlico Sound		Paml
Year	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pound
1962	122,000	1,220	6,600	66	16,200	162	61,10
1963	300,000	3,000	23,100	231	16,900	169	27,70
1964	565,000	5,650	26,800	268			33,50
1965			12,000	120	3,200	33	13,40
1966	256,300	2,566	41,400	498	18,700	391	15,50
1967	38,000	746	27,700	475	33,900	467	30,30
1968	1,306,300	19,771	34,000	593	75,600	933	4,50
1969	1,286,100	19,293	10,200	181	2,000	20	1,50
1970	469,400	14,270	65,100	1,118			20
1971	1,670,500	26,062	61,700	1,396	1,000	25	10
1972	335,488	7,393	7,317	167			
1973	92,056	3,571	5,132	216	149	7	
1974	256,110	13,588	53,838	2,682			3,99
1975	230,433	14,485	89,850	3,374			25
1976	300,100	27,775	6,211	426			
1977	252,700	21,232	20,746	895	490	29	2,98
1978	383,199	15,328	76,418	5,454	30,697	1,465	5,20
1979	209,950	12,258	45,392	2,695	2,894	216	64,44
1980	71,773	6,911	20,323	1,615	5,263	527	32,60
1981	155,860	13,118	17,432	1,416	39,774	3,627	10,04
1982	240,540	25,725	49,956	4,629	4,565	429	12,55
1983	92,200	14,415	20,093	1,812	5,471	639	3,81
1984	65,672	8,495	49,815	5,315	403	60	11,13
1985	204,750	20,826	128,678	8,222	4,190	499	7,30
1986	244,994	26,519	14,860	1,937	3,780	424	3,30
1987	7,450	894	60,154	7,218			2,28
1988	56,425	6,771	20,250	2,430	339,425	40,731	1,59

1989	10,342	1,331	16,266	2,377	*	*	93
1990	5,973	896	60,037	9,065	1,505	166	30
1991	2,127	284	7,686	813			
1992	255,772	25,578	343	51			
1993			3,206	360	26	3	
1994	569	699	29,015	18,429	1,000	245	1
1995**	2,858	715	47,723	20,112	3,923	1,022	
1996**	2,176	1,679	12,562	12,077	625	154	
1997**	2,216	1,267	4,766	5,080	518	304	
1998**	662	945	10,338	6,491	601	395	5
1999**	*	*	4,470		*	*	

Continued

Table 1. (Continued)

	Cape Fear River		Atlantic Ocean		Other areas		Sta
Year	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds
1962	100	1			800	8	14,302,40
1963	4,500	45			3,500	35	15,099,60
1964	700	7					7,560,90
1965	300	3					12,825,80
1966	400	6					12,519,30
1967	300	4			900	5	18,486,00
1968	200	8			73,500	1,410	15,524,90
1969					125,500	3,765	19,761,70
1970	1,100	23			65,700	1,510	11,521,40
1971	1,200	50			7,500	150	12,721,90
1972							11,237,14
1973							7,925,89
1974							6,209,54
1975			2,338	121			5,952,06
1976							6,401,36
1977							8,523,81
1978	704	50			500	25	6,607,15
1979			19,388	1,939			5,119,15
1980			*	*	1,460	151	6,218,52
1981			143,232	5,252	823	459	4,753,72
1982			7,679	726	2,121	318	9,437,70

1983			100	15	5,868,33
1984	9,497	843	2,077	231	6,516,10
1985	*	*	55	6	11,548,27
1986	40,270	1,210			6,814,32
1987	19,279	1,000			3,194,97
1988	19,517	1,561			4,191,21
1989			512	77	1,491,07
1990	11,073	1,107			1,157,62
1991					1,575,37
1992	110,794	10,773	395	52	1,723,17
1993			1	0	916,23
1994	305,934				911,41
1995**	19,174	18	62	16	453,98
1996**	*	*	165	38	529,50
1997**	5,568	1,966	158	56	334,81
1998**					521,20
1999**	*	*	386		443,55

* Denotes confidential data, included in total landings.

** Season enacted by rule, various management measures taken on Chowan River pound net fishery.

4.4 Existing Plans, Statutes, and Rules

4.4.1 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 Shad and River Herring

Table 2. River herring research and monitoring work by the North Carolina Division of Marine Fisheries in the rivers and sounds of eastern North Carolina.

		Type of work				
System	**Years**	**Spawning areas**	**Juvenile abundance**	**Adult age**	**Migration**	**Stock assessment**
Albemarle Sound area	1971-present	1972-80 1982-83 1987-88 1993	1972-present	1972-present	1974-76	1996,1998, 1999
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		

(ASMFC 1998) was approved in 1998. It provides for restrictions on the American shad (*A. sapidissima*) fisheries in the ocean, but makes no specific regulatory recommendations concerning river herring. However, 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.

4.4.2 Statutes

All management authority for North Carolina's river herring fishery is vested in the State of North Carolina. Since the stock depends greatly on habitats found in both Coastal and Inland Waters, the North Carolina Marine Fisheries Commission and the North Carolina Wildlife Resources Commission will implement management actions in their respective jurisdictions.

General authorities noted in Section 4.1.2 provide the MFC and WRC with regulatory powers to manage the fisheries. There are some statutes (G.S. 113-268 (a), (b), and (c)) which prohibit unauthorized use of another person's fishing gear. The two commissions promulgate specific rules to implement management objectives.

4.4.3 Rules

4.4.3.1 Marine Fisheries Commission Rules

- Rule North Carolina Administrative Code (NCAC) 3M .0513 was amended in a temporary rule action as follows (effective 1 March 1999): The Fisheries Director by proclamation, based on environmental and local stock conditions, can specify size, season, area, quantity, means and methods of harvest and require submission of statistical and biological data. An annual (calendar year) commercial quota of 450,000 lb for river herring is established in the ASRHMA. The CRHMA pound net fishery was allocated 300,000 lb; 100,000 lb to the ASRHMA gill net fishery; and 50,000 lb may be allocated at the discretion of the Fisheries Director. The definitions of the management areas are contained in Section 4.3.

- NCAC 3J .0101. Unlawful to use or set fixed or stationary nets
  (1) Where they constitute 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

- NCAC 3J .0102. Unlawful to use nets or net 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

- NCAC 3J .0103. Gill nets (a) The Director may, by proclamation, restrict gill net areas, seasons, mesh size, means and methods, and number and length.
  (b) Specific gill net marking requirements
  (c) Gill nets must be 200 yards from a pound net in use

- NCAC 3J .0107 Pound nets
  (a) Identification requirements
  (b) Must have permit to set pound net; permit process

- NCAC 3J. 0203 Chowan River
  (1) Anchoring of lead lines of nets
  (2) Restricted areas for pound nets
  (3) Pound nets must be at least 200 yards apart

4.4.3.2 Wildlife Resources Commission Rules

Under WRC rules, river herring are considered as "nongame fish". Nongame fish may be taken by "special devices" (nets, traps, etc) as provided in rule (section NCAC 15A 10C), as well as by hook and line.

- 10C .0401
  (a) General provisions

(b) Some species, including river herring, taken by special devices may be sold

- 10C .0402

  (a) Authorizes taking nongame fish for bait using dip nets, small seines, cast nets, and minnow traps

- 10C .0404 (b)

  (1) and (2) Restrictions on setting fixed gill nets

  (3) Requires attending gill nets in certain counties, including the entire Albemarle Sound area

- 10C .0407 provides specific seasons and restrictions by county and for some waters within some counties

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 freshwater rivers and streams to spawn. Surviving adults return to the ocean after spawning. The young 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. Blueback herring have been 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 at 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.

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). The percentage 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. Spring catches were 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 (Street et al. 1975; Johnson et al. 1977; Johnson et al. 1981; Winslow et al. 1983; Winslow et al. 1985; Winslow and Rawls 1992) during March through May have documented spawning in many tributary streams of Albemarle Sound's major tributaries. Known historical anadromous fish spawning sites are depicted on the maps presented in Section 13, Appendix 3 and are listed in Section 9.1, which describes critical and essential habitats for the species. 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, North East Cape Fear and Brunswick rivers. 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). Spawning populations are generally younger in the south. 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 the two species co-occur.

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. Eggs of alewife 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. Larval alewives range 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). Like juvenile blueback herring, juvenile alewives may initially exhibit upstream movement, 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. Habitat requirements for critical early life history stages of the alewife as determined by Klauda et al. (1991) are presented in Table 3.

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 are important prey for other species jointly managed by federal and state governments and the ASMFC, including bluefish, American eel, striped bass and weakfish. Freshwater species managed by the state also consume alewife (largemouth bass, pumpkinseed, redfin pickerel, shiners, walleye, white bass, white perch and yellow perch; 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

Table 3. Habitat requirements for the critical early life history stages of alewife, *Alosa pseudoharengus* (after Klauda et al. 1991).

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

*NIF means no information found.

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. Sites in Albemarle Sound tributaries which have been documented as spawning habitat are depicted on the maps in Section 13, Appendix 3.

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). They have been reported to travel much farther upstream in North Carolina than alewife. Loesch (1987) reported that there is no evidence that bluebacks do not travel just as far, if not farther, than alewife.

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 from a 12.2 in (310 mm) fish (Fay et al. 1983). 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 cease spawning when water temperatures rise above 81° F (27° C). Both species spawn in groups and scatter their eggs. 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. Juveniles may exhibit an initial 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 4**.**

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 also an important forage species for other species. It is preyed upon by the same species which prey on alewife and other clupeid species, and constitutes an important link in estuarine and marine food webs between zooplankton and top predators.

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 Albemarle Sound once harvested large numbers of river herring, but landings in recent years are substantially lower. Average landings during the 90-year period of 1880-1970 were 11.9 million pounds (5.4 million kg). Landings in 1998, in contrast, 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 the season was implemented in 1995. Hightower et al. (1996) noted that the estimate of maximum sustainable yield derived from their modeling of the period 1845-1993 was 12.6 million lb (5.7 million kg), similar to the long-term average 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.

Table 4. Habitat requirements for the critical early life history stages of blueback herring, *A. aestivalis* (after Klauda et al. 1991).

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

*NIF means no information found.

Sampling throughout the coastal area has been scaled back over the years due to a reduction 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 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), and Winslow and Rawls (1992). "The Status of Blueback Herring in the Chowan River, 1972-1998" (Carmichael 1999) stock assessment analysis is presented in Section 13, Appendix 1.

5.3.1 Fishing Mortality

Mortality rates were estimated by catch curve and catch at age analyses. Total mortality based on the catch curve analyses averaged around Z=1.5 for the 1972-1998 period. By subtracting the assumed natural mortality rate of M=0.5, fishing mortality is estimated at approximately F=1.0. Estimated fishing mortality from the catch at age model for 1972-1994 is 1.01, which is equivalent to an annual exploitation rate attributable to fishing of 52%. To account for the possibility that regulatory changes have had some impact on exploitation rates, F was estimated annually for 1995-1998. Average fishing mortality has dropped since 1995 to 0.59, largely due to the estimated value in 1997 of 0.27. Fishing mortality increased in 1998 to 0.58.

5.3.2 Recruitment

Recruitment at age 3 averaged 28.7 million fish a year between 1972 and 1985; but since 1986, it has averaged 5.1 million fish (Figure 3). 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 37.6 million fish, allowed the stock to rebuild in the early 1980s, but from 1983 to 1986 several poor year classes coupled with high fishing mortality led to a precipitous decline in overall stock abundance that continued through 1998. Recruitment has been extremely low since 1989, averaging 3.5 million fish a year. Moreover, several moderate year classes observed since the early 1980s supported short-term catches, but they were subsequently removed through

excessive exploitation.

5.3.3 Spawning Stock Biomass

Spawning stock biomass (SSB) declined significantly over the analysis period, dropping from a 1972-1985 average of 8.2 million pounds (mlb) to an average of only 2.1 mlb for 1986-1998 (Figure 4; Table 5). A slight increase in 1991 and 1992 can be attributed to the 1987 and 1988 year classes reaching maturity, but continued poor recruitment further reduced SSB to a record low in 1995 of 0.9 mlb. SSB has increased slowly each year since 1995, reaching 1.3 mlb in 1998. The recent increase is largely due to the 1993 year class, the best in the last seven years. However, given that the 1994 and 1995 cohorts are among the lowest observed, it is unlikely that this slight increase in 1998 will be maintained as these poor cohorts move through the population.

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 were 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 of anadromous species.

The seine stations were pulled with a 60 ft bag seine with a 1/4 in mesh bag. One seine haul was considered one unit-of-effort. The Carolina wing trawl had a headrope length of 26 ft, containing webbing which ranged from 4 in stretched mesh in the wings to an 1/8 in mesh tail bag. The trawl was pulled for 10 minutes, which was considered one unit-of-effort. Samples were sorted to species, and up to 30 individuals of each alosid 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

Table 5. Spawning stock biomass and age-3 recruitment by cohort based on catch-at-age analysis for Chowan River blueback herring, 1969-1998.

Year	SSB (Pounds)	Recruits by cohort (est. at age-3)
1969		37.775
1970		24.020
1971		22.860
1972	14,658,461	45.502
1973	11,236,314	47.762
1974	8,337,979	22.041
1975	7,623,870	14.572
1976	9,343,361	17.704
1977	10,089,414	8.240
1978	8,015,481	39.088
1979	5,642,241	15.638
1980	4,334,143	34.926
1981	4,520,098	62.451
1982	5,869,962	12.757
1983	6,483,093	9.935
1984	8,439,608	7.336
1985	10,217,910	2.705
1986	7,718,047	3.438
1987	4,294,360	11.43
1988	2,515,429	6.908
1989	1,489,283	2.242
1990	1,360,700	4.273
1991	1,857,395	3.231
1992	1,813,063	2.584
1993	1,290,451	4.985
1994	1,028,607	3.055
1995	914,848	3.016
1996	1,014,317	
1997	1,114,928	
1998	1,345,225	

herring, and the wing trawl was 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 core stations has continued during June-October each year (Figure 5). During September, an additional 13 seine stations are sampled throughout the Albemarle Sound area (Figure 5) 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 6 and 7). 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 1986-1999 (Figure 6). The twenty-eight year average CPUE for blueback herring is 70.4. The average CPUE for alewife during the same period is 2.5 fish/seine. In 1980 a CPUE of 12.4 fish/seine was recorded for alewife; other years were much below that level (Figure 7).

Annual sampling to determine the relative abundance of young of year striped bass has been conducted at seven sampling locations (Hassler stations, Figure 8), 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).

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

The CPUE from the Hassler stations for blueback herring is shown in Figure 9. The 1996 (107.8) and 1997 (90.5) CPUEs were the highest since 1962, but the 1994, 1995, 1998 and 1999 CPUEs were less than 0.2. Figure 10 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. However, in 1997, 1998 and 1999 the CPUE dropped to 0.66, 0 and 0.05 respectively.

5.3.5 Pound Net Catch-Effort

Fishing effort (ie. 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 11). The average number of pound nets set each week in 1977 was 539, 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, 1996, 1997, and 1998 to determine the number of nets set. During 1999, aerial flights were also made. Based on the flights, the average number of nets set ranged from 50 (1995) to 92 (1997).

Several members of the Marine Fisheries Commission's River Herring Advisory Committee (RHAC) advise that since the season has been implemented and prior to 1998, some nets (8-10) may have been set only to satisfy the Pound Net Permit requirements (DEHNR 1997, 15 NCAC 3J .0107). These nets were not actively fished and probably were not a factor in the harvest or economic value. However, this anecdotal evidence cannot be refuted or substantiated due to the historic inability to determine whether or not the nets were actively fished. Therefore, determination of Pound Net Weeks (PNW) and subsequent CPUE may not be precise. (PNW is the number of pound net sets times the number of weeks fished).

Figure 12 shows the CPUE from the Albemarle Sound area pound net fishery, during 1971-1975. The CPUE was 18,614 lb per net in 1971, declining to 8,040 lb in 1975. No data are available for 1976. The CPUE has been determined for the Chowan River pound net fishery continuously since 1977 (Figure 13). In 1977, the CPUE was 14,895 lb per net, declining to 5,189 lb in 1987, and only 2,632 lb per net in 1994, the all time low prior to seasonal restrictions (Figure 13). In 1994, DMF began a new harvest data collection system through the trip ticket program which may affect comparisons with former years. Currently, there are no data on CPUE for gill nets, although DMF trip ticket data show that gill nets have accounted for 22.2-38.1% of the annual river herring harvest.

5.3.6 Age Composition/Mean Size at Age

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, when funding levels were reduced. From the 1970s to the early 1990s, sampling was conducted at up to six fishhouses on a weekly basis. Since 1993, only the Chowan area has been sampled. 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 has always targeted for unculled pound net catches, but obtaining unculled catches has not always been possible in recent years. If unculled samples were not available, culled samples were taken at the fishhouse. Size, age and sex composition of the harvest was determined from these samples. During 1998 and 1999, samples were obtained from three cooperating Chowan River pound net fishermen. Samples of up to 30 fish from each fishermen were obtained, up to
three times per week during the season, and after the season, as well, into the second week of May.

The commercial harvest of both species has been dominated by 3-5 year-old fish since sampling began in 1972. The percentage of blueback herring repeat spawners in the harvest averaged 14.8% during 1972-1982. From 1983 through 1998, the percentage of repeat spawners declined significantly, ranging from 0.6% to 6.1% (Table 6). During the 1990s, blueback herring spawning repetition has remained low, ranging from 1.2% (1994) to 4.7% (1993) (Table 6). The percentage of alewife repeat spawners has also decreased since the 1970s (Table 7), with a mean of 9.4% from 1972 through 1981. Since 1988, no or very small samples of alewife have been obtained annually from the Chowan River pound net fishery, due to their scarcity in the harvest. Concern arises with the decrease of repeat spawners, due to the loss of spawning potential in the stock. The older fish that have spawned more than once are much more fecund.

Data from pound nets for both species and sexes (1972-1998), show a general decline of 1-2 inches in the mean length at age . However, in 1995 and 1996, an increase in the mean size of blueback herring was observed in most ages, but length dropped again in 1997 and 1998 (Figure 14). Alewife mean size at age is presented in Figure 15. No alewife samples have been obtained from the Chowan River pound net fishery since 1996. Kornegay (1978) indicated an overlap of size of river herring, ages 4 to 6, which is the expected natural variation in size. The meaning for this decrease in size is unknown, but may be an indicator of stock problems.

6. Status of Fisheries

6.1 Introduction

The river herring fishery can be divided into two sections: the commercial fishery and the recreational fishery, with both occurring in Coastal, Joint and Inland Waters. These fisheries are entirely dependent on sexually mature fish, age 3 and older. Although some of the gears used are

Table 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, 1972-1998.

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

Table 7. Percentage of alewife repeat spawners (spawned two or more times) and maximum number of spawning marks from the Chowan River pound net fishery, 1972-1998.

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			

* Small sample size, less than 75 fish per year.

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, 1997-1998 (NCDEHNR 1997).

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.

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 River and Albemarle Sound. Only during the postbellum period - with improved transportation and the availability of ice - were markets created for fresh fish and shellfish, allowing independent watermen to emerge (Taylor 1992).

The first significant commercial fishing operation was documented in 1765, at Wingfield Plantation owned by Alexander Brownrigg, on the Chowan River. This was a haul seine fishery for herring and shad. Brownrigg's success inspired other planters on the Chowan River to develop fisheries to supplement their production of agricultural commodities (Taylor 1992).

Edenton's fisheries were seasonal and operated only during the spring, when herring and shad ascended the Chowan and other coastal rivers to spawn. Still, fishing had become an important enterprise by the time of the American Revolution. Between 1771 and 1776, 851 vessels cleared the Edenton customhouse carrying 24,432 barrels of fish. Most of the fish were bound for the British West Indies, although small quantities were shipped to the Middle Atlantic colonies, the Azores, and Canary Islands, southern Europe and the New England colonies (Barber 1931). Much of the Chowan's fish catch was also sold or bartered locally (Taylor 1992).

The growth of Edenton's fisheries, as well as the nation's, continued during the antebellum period and was linked to the expansion of slavery. Between 1790 and 1860, North Carolina's slave population tripled, increasing from roughly 100,000 to 330,000 individuals. Planters needed an inexpensive food supply for their laborers, and fish provided an excellent source of protein. Over time, some planters left the sheltered waters of the Chowan to establish herring and shad fisheries on Albemarle Sound (Taylor 1992).

In 1807, Joseph Skinner, owner of Manor House established the first very large-scale fishery on Albemarle Sound. Skinner's enterprise prospered, and by 1846, fifteen large haul-seine fisheries operated on Albemarle Sound from the mouth of Little River to Edenton Bay, a distance of about 30 miles (Taylor 1992). Those fisheries functioned essentially as adjuncts of plantation agriculture; they were seasonal, required large capital for investment, and yielded large profits (Skinner 1846).

The fishing season began in mid-March with the first runs of herring and ended in May.

Free blacks or employees of the fishery actually did the fishing. Slaves were too valuable to risk injury in the fishery. Each fishery employed approximately forty to eighty men and women, who worked under the plantation owner or his "shore manager". Workers fished from open beaches, the adjacent waters having been cleared of obstructions that could snag or tear a net. Behind the beach lay packing and salting sheds, where the catch was processed, and crude shelters for the laborers. Fishing was carried on around the clock, seven days a week prior to the Civil War, and fishermen usually made four to five hauls of the net in a twenty-four hour period (Taylor 1992). After the Civil War, there was a day off from Saturday midnight to Sunday midnight (North Carolina Department of Conservation and Development 1963).

The seines used in the fisheries were enormous, generally measuring from 2,200 to 2,700 yards in length and 18 ft in depth. The nets were set from two large rowboats, each manned by a captain and ten oarsmen. The boats, each with half of the seine piled on its deck, traveled in tandem a mile or more offshore to a pole, parted company, and payed out the seine in a line roughly parallel to the shore. Then the boats returned to opposite ends of the beach, and the men attached the net's hauling lines to huge windlasses powered by as many as eight horses or mules. Smaller windlasses, located at intervals down the beach, were attached to "toggle lines" that ran out to the seine and maintained its shape in a diminishing half circle as it was drawn ashore. The catch was processed by the cutters, salters and packers (Taylor 1992).

The fisheries on Albemarle Sound made very large catches. Records maintained from 1835 to 1874 at the Willow Branch Fishery, located at the mouth of Chowan River, show annual catches of herring usually numbered from 1 million to 3 million fish. These fisheries produced several commodities. They sold their catch as fresh herring, cut herring (split but not salted), or pickled herring (salt and packed in barrels). Fresh and cut herring were sold "on the beach", mostly to neighboring farmers. Individuals usually bought from 2,000 to 4,000 fish, which they salted and packed. In 1845, those fish cost $4.00 to $10.00. Most fresh fish were sold locally. However, the bulk of the catch was pickled and shipped to wholesale grocers and brokers in Virginia and Baltimore, Md. (Taylor 1992).

Despite its seasonal nature, fishing became an important business on Albemarle Sound and the Chowan River during the antebellum period. The 15 large haul seine operations in existence in 1846 employed about 1,000 people. In the late 1850s, to set up and operate a haul seine through its first season would cost $12,000 to $15,000. Thus, the opportunity to realize

large profits in the fishing business was limited to a select few in the planter and merchant class (Taylor 1992).

The Civil War brought this prosperity to a close. In 1863 North Carolina authorities prohibited haul seining because they feared that fishermen would either sell their catches to the "Federals" or have them confiscated (Taylor 1992).

The herring haul seiners resumed fishing on Albemarle Sound and the Chowan River after the Civil War, and their operations grew even larger. In 1869, Captain Peter Warren of Chowan County introduced steam-powered winches for landing seines, and ten years later he became the first to employ a small steamboat for setting the huge nets. Others followed, and the steam-powered haul seines made extremely large catches. In 1880, the average catch for steam-powered seines on the sounds was 1,750,000 herring. Horse-powered seines on the sound usually caught 1,500,000 fish, and the small river seines netted about 1 million fish (Taylor 1992).

At the beginning of the season, some of the catch from the sound seines was iced and shipped to northern cities. New markets developed with the completion of the Albemarle and Chesapeake Canal in 1869. Nearly all of the catch from the river seines, however, was sold fresh to farmers in northeastern North Carolina and Virginia.

The huge haul seines, though very efficient, ultimately became victims of their own size. In 1869, two Ohio brothers, Captain John and William Hetterick, arrived in Edenton and began fishing with pound nets in Albemarle Sound (Earll 1887). The pound net was a simple device, a long line of stakes draped with netting extended out into the channel, diverting migrating fish into a small, heart -shaped funnel and then into the "pound", or trap, nearshore (Figure 16). One or two men in a small boat, wielding large dip nets, removed the fish from the pound. The use of the pound net revolutionized fishing in North Carolina, especially in Albemarle Sound (Taylor 1992).

Pound nets had several advantages over haul seines: they cost just a few hundred dollars, were tended by only two or three men, and could be set up anywhere, even on a wooded shore. The haul seiners immediately attempted to have pound nets outlawed. The number of pound nets increased from 117 in 1880 to 950 in 1890 (North Carolina Board of Agriculture 1896). In 1887, pound nets harvested 7 million lb, haul seines 10.5 million lb and gill nets 71,780 lb (Chestnut and Davis 1975). By 1896 there were at least 1,125 pound nets on Albemarle Sound,

and only a handful of haul-seine fisheries remained. Pound nets choked Croatan Sound by the early 1900s, and fish entering Oregon and New inlets ran a veritable gauntlet before reaching Albemarle Sound and their spawning grounds in the Chowan and Roanoke rivers. The fishermen of Albemarle Sound protested as their catches dwindled, and in 1905 legislators passed the Vann
Law, which required that an open channel through the sound be maintained for the passage of migrating fish (Taylor 1992).

The prolific growth of pound nets resulted in a rapid decrease in haul seines. Fifteen haul seine operations were located on Albemarle Sound in 1846 (Taylor 1992), twelve operated in 1880 (Boyce 1917), four were functional in 1896 (Stevenson 1899), and only the Greenfield fishery remained in 1902; it closed by 1907 (Taylor 1992).

Pound nets during the late 1800s were set along the shores with 1 to 25 pounds or hearts in each string. 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). Chowan River has been the center of the river herring pound net fishery. In 1977, 615 pound nets were set in the Chowan River. From the late 1970s to the late 1980s the number of river herring pound nets ranged from 421-615 nets annually in the Chowan River. The amount of pound nets in the Chowan declined from 348 in 1989 to 175 nets in 1994.

Gill nets, anchor and drift, have historically been utilized in the river herring fishery, and their use continues. 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. Figure 17 shows the pound net and gill net landings from the Albemarle Sound area during 1978-1999. In 1986, approximately 6 million lb were harvested in pound nets and 900,000 lb from gill nets. During 1988, pound nets landed 2.3 mlb and gill nets 1.5 mlb. A total of 425,000 lb was harvested from pound nets and 175,000 lb from gill nets in 1994 (Figure 17). Several other minor types of

commercial gear have been used in the herring fishery: fyke nets, fish wheels, and dip nets. These gears have contributed very little to the total harvest in the Albemarle area.

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. Chestnut and Davis (1975) presented a synopsis of river herring landings by gear for the state (1887-1971), annual landings and value for some years, and landings by county (Section 13, Appendix 2). Annual landings by gear are shown in Table 8 for 1972-1999 and in Table 1 by waterbody for 1962-1999. The landings trend since 1985 continued down; the 1994 landings were the lowest recorded (911,410 lb) up to that time.

Taylor (1951) reported that the river herring fishery had declined during the last 40-50 years. During 1890 to 1900, annual river herring production was between 15 and 20 million lb, about 33% of the United States harvest. Between 1900 and the late 1940s, annual harvest fluctuated considerably, from a low of approximately 6 million lb in 1937, to a high of nearly 15 million lb in 1934. Such variations were probably the result of variable abundance, rather than economic factors. From 1950 to 1994, North Carolina accounted for 13.6-84.5% of the river herring landings of the Atlantic coast states.

From 1915 through 1965, various regulations were promulgated for the Albemarle Sound river herring fishery. The regulations included area closures, mesh and yardage restrictions and closed seasons (Section 13, Appendix 4).

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, 15 NCAC 3M.0513), which 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

Table 8. River herring landings and percentage by gear from North Carolina, 1972-1999.

	Pound net		Anchor gill net		Drift gill net		Haul seines		
Year	Pounds	Percent total landings	Pounds	Percent total landings	Pounds	Percent total landings	Pounds	Percent total landings	Pounds
1972	10,868,387	96.7	1,863	0.02	46,248	0.4	320,645	2.9	
1973	7,741,724	97.7	1,389	0.02	17,740	0.2	165,045	2.1	
1974	5,866,038	94.5	31,277	0.5	49,000	0.8	263,227	4.2	
1975	5,480,095	92.1	116,828	2	227,674	3.8	127,470	2.1	
1976	6,106,419	95.4	122,553	2	111,900	1.7	60,488	0.9	
1977	8,112,192	95.2	97,570	1.1	181,700	2.1	132,351	1.6	
1978	5,487,100	83	876,009	13.3	128,719	1.9	96,875	1.5	
1979	4,256,323	83.1	574,227	11.2	173,950	3.4	95,198	1.9	19,45
1980	5,354,430	86.2	757,576	12.2	56,898	0.9	46,513	0.7	1,50
1981	3,452,189	72.6	1,053,593	22.2	63,820	1.3	35,389	0.7	141,23
1982	7,720,694	81.8	1,649,488	17.5	37,000	0.4	20,721	0.2	7,67
1983	4,491,831	76.5	1,313,731	22.4	29,000	0.5	30,970	0.6	
1984	4,591,016	70.5	1,866,635	28.6	36,632	0.5	6,452	0.1	9,49
1985	10,658,014	92.3	815,364	7.1	73,500	0.6	1400	0.01	
1986	5,895,596	96.5	822,377	12.1	56,100	0.8			40,25
1987	2,411,710	75.5	764,602	23.9			*		18,56
1988	2,307,436	55	1,864,258	44.5					19,51
1989	928,759	62.3	562,308	37.7					
1990	782,356	67.6	364,196	31.5					11,07
1991	1,042,110	66.1	533,268	33.9					
1992	1,392,104	80.8	225,794	13.1					105,28
1993	804,380	87.8	111,628	12.2			*		
1994	423,644	46.5	173,568	19	4,130	0.5	*		305,70
1995	274,191	60.4	156,137	34.4	3,126	0.7	*		19,10
1996	406,411	76.7	119,305	22.5	1,278	0.3	*		
1997	201,793	60.3	123,333	36.7	2,781	0.9	*		5,55
1998	374,700	71.8	143,267	27.5	2,284	0.4			
1999	336,934	76	102,121	23	2,165	0.5	187	0.1	

* Denotes confidential landings; these are incorporated into "other gears".

days. Once the season was extended, the fishery operated on a 250,000 lb total allowable catch (TAC). During 1998, the rule was again suspended, and the season extended for 15 days, only for the Chowan River pound net fishery which operated on a 400,000 lb TAC for the entire season.

The MFC amended the river herring rule (15NCAC 3M.0513) in a temporary action for the 1999 harvest. The temporary rule gives the Fisheries Director proclamation authority, based on variability in environmental and local stock conditions, to take various actions and imposes an annual quota for river herring in the Albemarle Sound River Herring Management Area of 450,000 lb (see Section 4.4.3.1).

During 1995-1998, North Carolina accounted for 29-52% of the total river herring landings from the Atlantic coast. Landings from the Albemarle Sound area accounted for 97.9-99.8% of the state's total river herring landings during 1995-1999. The Chowan River pound net fishery contributed 60.3%-76.5% of North Carolina's annual river herring harvest during 1995-1999. 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 in recent years has accounted for greater proportions of the overall harvest each year. During 1995-1999, anchor gill nets accounted for 21.2-38.1% of the annual river herring harvest (Table 8).

During 1995-1999, the number of pound nets set in Chowan River ranged from 73 to 102. In 1999, only 14 Chowan River pound net fishermen participated in the fishery. The Chowan River pound net fishery harvested 268,534 lb, 398,476 lb, 195,221 lb, 368,666 lb and 324,995 lb during 1995-1999, respectively.

The total number of vessels and trips in the Albemarle Sound area during January through May has increased annually since 1994 (Table 9). The number of small mesh gill net trips has increased since 1994, from 23,144 to a high of 30,412 in 1996, while the number of pound net trips has decreased from 6,979 in 1994 to 3,367 in 1998. The number of vessels harvesting river herring during 1994-1998 has ranged from 457 (1995) to 553 (1996). The total number of trips harvesting river herring has decreased since 1994, ranging from 2,503-3,354.

Since the river herring season has been implemented, the number of river herring pound net trips has decreased. In 1994, pound net trips taking river herring totaled 893, compared to 411 in 1998. However, the number of trips with small mesh gill nets has remained fairly constant or increased (Table 9).

River herring have historically, and continue to be, utilized for human consumption. The filets are generally processed and salted, while the roe is utilized, either fresh or canned. During 1995-1998, the percentage of the river herring harvest utilized for bait ranged from 10.7 to 38.8%.

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 mlb). 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 herrings probably was a major factor in the 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. 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 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 over harvesting effects on the stocks still exists. Even though foreign fishing pressure on river herring stocks in offshore waters has been reduced for twenty-two years, the population has not recovered anywhere along the Atlantic coast.

In 1997, the Maine Department of Marine Resources established an observer program in the sea herring fishery. Stevenson and Scully (1999) reported 50 trips were observed, divided

between purse seiners and mid-water trawls, fishing in coastal Gulf of Maine waters, from August 1997 through July 1998. Twenty-three purse seine trips were observed, with 50 sets made. A total of 27 mid-water trawl trips were made, with 54 tows observed. A total of 7,319 lb

Table 9. Number of vessels, number of trips, pounds, and value for all species and river herring from the Albemarle Sound Management Ar
January-May, 1994-1998. ("Endorsement" refers to a license which authorized sale of fish.)

		All finfish species				Rive	
Year	Gear	Number of endorsements	Number of trips	Pounds	Value ($)	Number of endorsements	Number of trips
1994	Drift gill net	16	76	5,057	4,582	4	61
	Large mesh gill net	163	1,194	9,849	159,695	6	8
	Other gears	240	1,509	242,493	82,838	16	97
	Pound net	65	1,343	643,970	131,397	46	543
	Run-around gill net	9	16	7,115	1,978	*	*
	Small mesh gill net	381	4,919	901,808	439,500	175	1,730
	Total:	**874**	**9,057**	**1,930,290**	**819,990**	**248**	**2,440**
1995	Drift gill net	3	33	3,133	784	3	33
	Large mesh gill net	206	1,244	89,006	113,102	9	14
	Other gears	262	1,672	287,455	110,715	14	60
	Pound net	46	726	529,677	130,731	34	297
	Run-around gill net	4	19	1,378	962		
	Small mesh gill net	502	6,587	674,229	392,868	168	1,728
	Total:	**1,023**	**10,281**	**1,584,878**	**749,162**	**228**	**2,132**
1996	Drift gill net	5	13	1,322	1,548	4	12
	Large mesh gill net	148	931	60,455	81,552	*	*
	Other gears	322	1,598	253,300	144,915	19	69
	Pound net	53	831	739,636	140,267	39	361
	Run-around gill net	*	*	*	*		
	Small mesh gill net	466	6,160	970,152	474,628	216	2,102
	Total:	**996**	**9,536**	**2,025,253**	**843,048**	**279**	**2,545**
1997	Drift gill net	11	64	3,142	3,250	7	59
	Large mesh gill net	244	2,357	200,463	276,697	13	19
	Other gears	268	1,703	240,925	173,314	14	61
	Pound net	46	837	405,828	121,497	34	286
	Run-around gill net	5	8	3,087	1,513		
	Small mesh gill net	429	5,765	738,442	449,567	157	1,153
	Total:	**1,003**	**10,734**	**1,591,887**	**1,025,838**	**225**	**1,578**
1998	Drift gill net	4	17	2,743	1,223	4	17
	Large mesh gill net	187	1,857	169,013	215,996	8	11
	Other gears	247	1,556	245,584	137,865	16	65

Pound net	34	684	530,994	174,984	25	356
Run-around gill net	8	13	860	504	*	*
Small mesh gill net	408	5,518	915,741	533,309	192	1,494
Total:	**888**	**9,645**	**1,864,935**	**1,063,881**	**246**	**1,944**

of blueback herring was observed, compared to 2.5 million pounds of sea herring landed during this study, indicating a very low catch of river herring from this fishery. The mid-water trawlers make about 800 trips a year, so that a sample of 27 trips represents about 3.5% of all trips (Stevenson and Scully 1999).

The ASMFC shad and river herring fisheries management plan (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 lb between 1980 and 1989 and appeared to be increasing (Harris and Rulifson 1989). Bycatch limits for river herrings in the offshore mackerel fishery are currently set at 220,264 lb. Data from NMFS indicates that river herring catches in the Atlantic mackerel fishery were at least 600 lb during 1996 and 11,570 lb during 1997 (Mid-Atlantic Fishery Management Council 1998).

Measures must be taken to ensure that river herring bycatch in the offshore mackerel fishery is minimized. The Mid-Atlantic Fishery Management Council recommended that the foreign fishery stay at least 20 miles offshore, that a maximum bycatch of river herring be maintained and enforced, and that intercept fisheries be discouraged (ASMFC 1985).

Commercial ocean harvest of river herring occurs as bycatch in other fisheries of various gear 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%). Beach haul seines and trawls accounted for the major portions of North Carolina's Atlantic Ocean landings during 1962-1998 (Table 8 and Table 1). Between 1975 and 1999, Atlantic Ocean river herring landings from North Carolina have ranged from 0 to 305,934 lb, with an average during the period of 27,788 lb.

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 WRC and the MFC as Coastal and Joint Waters, fishery managers assume that most herring harvested will be sold. In designated Inland Waters, the assumption is made that most herring harvested will be used for personal consumption; however, a portion of these may also be sold, as allowed by WRC rules. Gill nets and several variations of dip nets (called "special fishing devices" when used in Inland Waters) are the primary gears used to harvest river herring. Because river herring do not readily take bait or artificial lures, the hook and line fishery for them in coastal North Carolina is likely inconsequential.

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 1967-68 occurred in the Chowan and Roanoke river basins. Herring were also harvested in other river basins, but American shad and hickory shad (*Alsoa 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. 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 spring months, and an active recreational herring fishery persists in tributaries to 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 1998, sales of WRC special fishing device licenses increased in the Chowan River basin from 94 to 290 (Figure 18). 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 MFC in 1995. As an example, special device license sales in Chowan County totaled less than 20 during the 1995/96 license year, but during the 1997/98 license year, well over 100 licenses were sold. If the licensees in these counties were targeting river herring in Inland Waters, this increase in license sales could reflect continued river herring harvest in Inland Waters after DMF's harvest closure in Joint and Coastal Waters. Close regulatory coordination between WRC and DMF will be necessary to ensure effective harvest restrictions where necessary.

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. DMF initiated a pilot drift net creel survey in 1999 to characterize this fishery for development of future monitoring strategies and 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.

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.

7. Economic Status

7.1 Commercial Fishery

7.1.1 Harvesting Sector

7.1.1.1 Ex-vessel Value

The commercial value of North Carolina's river herring landings increased from about $200,000 in the early 1970s to a peak of $846,000 in 1985 (Table 10). The value then fell sharply to about $67,000 in 1993 due to lower landings, but a rise in the average price per pound helped to temper somewhat the effect on revenues to fishermen.

A regular survey is conducted in which DMF periodically obtains price estimates from dealers for fish they have purchased from fishermen. The data from the survey are averaged to provide a value on an annual basis, because the river herring fishery is highly seasonal and prices fluctuate greatly within the season, based on supply and demand. Very high prices of as much as $1.50 per pound may be received early in the season for small landings from gill nets fished in the eastern part of the management area. Much lower prices of $0.09 to $0.25 per pound are received by pound net fishermen (according to some industry sources) in the Chowan River who catch the bulk of the river herring. Due to confidentiality of landings data (less than three dealers reporting), specifics for certain gears/value can not be provided. People in the industry indicate that approximately 75% to 85% of the pound net catch was processed as salted fish and canned roe each of the last three fishing seasons.

7.1.1.2 Fishing Income

DMF collected landings data from fish dealers in 1979-1982 for three pound net fishermen along the Chowan River. These data were utilized in the report by Everett (1983)

relative to the impacts of pulp mill effluent on the river herring fishery. Based on the data collected, the value of river herring ranged from $23,750 to 35,560 per fisherman.

Table 10. Commercial value of river herring landings, North Carolina, 1972-1998.

Year	Current value	Real value ($)	Current price/lb ($)	Real price/lb ($)[1]
1972	196,145	518,902	0.02	0.05
1973	213,519	472,387	0.03	0.06
1974	246,753	509,820	0.04	0.08
1975	215,501	416,025	0.04	0.07
1976	336,750	522,093	0.05	0.08
1977	421,603	604,882	0.05	0.07
1978	286,705	386,916	0.04	0.06
1979	313,779	345,191	0.06	0.07
1980	444,327	506,067	0.07	0.08
1981	316,850	354,418	0.07	0.07
1982	704,599	704,599	0.07	0.07
1983	464,389	440,597	0.08	0.08
1984	596,428	529,217	0.09	0.08
1985	845,906	738,138	0.07	0.06
1986	647,293	518,249	0.09	0.08
1987	368,062	262,901	0.12	0.08
1988	502,166	337,704	0.12	0.08
1989	183,842	128,651	0.12	0.09

1990	174,259	118,382	0.15	0.10
1991	118,272	79,112	0.08	0.05
1992	172,453	110,476	0.10	0.06
1993	67,494	43,127	0.07	0.05
1994	127,706	79,124	0.14	0.09
1995	134,934	79,001	0.30	0.17
1996	132,389	79,800	0.25	0.15
1997	128,988	72,424	0.39	0.22
1998	201,281	111,823	0.39	0.21

[1] Base year 1982=100

Source: DMF Trip Ticket Program.

Gross income (revenues) derived from the river herring fishery was estimated using the Trip Ticket and Endorsement-to-Sell (ETS) license databases. Gross income earned from the river herring fishing has declined substantially in recent years. For example, the 1997 gross income per ETS license of $518 (range from less than $1 to $9,961) was less than the 1995 average of $585 (range from less than $1 to $16,363). Confidential personal financial records available from some Albemarle Sound area fishermen tend to substantiate this trend.

7.1.1.3 Ex-vessel Price

Table 11 shows the annual average prices received by fishermen by county for river herring landed from pound nets and gill nets in the Albemarle Sound area, as reported through DMF trip tickets during 1994-1998. There are considerable differences between the gears and among counties. Martin County gill net fishermen generally received the highest prices, while pound net fishermen from Chowan and Martin counties generally were paid the least per pound. Gill nets usually take river herring in small quantities early in the season before the fish become abundant. Because the supply is small relative to demand at that time, fishermen receive high prices, often on a per-fish basis, so a small catch can have a relatively high value. In contrast, fish are landed from pound nets in larger quantities, with fishermen usually receiving a lower price per pound.

7.1.1.4 Employment

Although the number of ETS licenses is not necessarily indicative of the number of

individuals involved in the fishery, it does provide an indication of fishing activity. The number of ETS-holders reporting any river herring sales on trip tickets has remained relatively stable, ranging from 244 in 1994-1995 to 298 in 1995-1996. If sales of more than $100 of river herring are examined, the number of license holders selling river herring falls below 90 during each successive license year. River herring fishermen are predominantly owner-operators who may fish alone or with one or possibly more crew members. Most of these fishermen utilize vessels 18 ft in length or less.

7.1.2 Distribution and Processing Sector

7.1.2.1 Seafood Dealers

All seafood products, including river herring, landed in North Carolina are required to be sold through licensed dealers, some of whom are also fishermen. Although the number of dealers buying river herring fluctuated in the 42-60 range in recent years, the bulk of landings are handled by a few dealers in Chowan County and one in Bertie County.

Employment associated with river herring distribution by the seafood dealers depends on the volume of product handled; specific data are not available.

7.1.2.2 Processing Sector

There has been a severe decline in river herring processing activities in North Carolina over the years. The number of plants processing river herring increased from three to seven

Table 11. Average price per pound for Albemarle Sound river herring landed from gill nets and pound nets for counties with both gears, 1994 - 1998

	County									
	Bertie		Chowan		Martin		Dare		Tyrrell	
Year	Gill	Pound	Gill	Pound	Gill	Pound	Gill	Pound	Gill	Pound
1994	$0.15	$0.10	$0.16	$0.10			$0.21		$0.28	$0.10
1995	$0.25	$0.25	$0.35	$0.26	$0.40	$0.25	$0.22	$0.25	$0.27	$0.24
1996	$0.22	$0.13	$0.31	$0.20	$1.55		$0.22	$0.21	$1.02	$0.46
1997	$0.35	$0.27	$0.41	$0.34	$1.40		$0.37		$1.05	$0.65
1998	$1.27	$0.34	$0.38	$0.35	$1.58		$0.72		$0.58	$0.34

during 1970-1989 (Table 12). Processing activities fell during subsequent years in relation to a sharp decline in landings and due to the demand for the product.

The value of river herring processed products increased steadily from $341,000 in 1970 to a peak of almost $1.5 million in 1984 and has since decreased (Table 12). For example, within about a decade, processed product value declined more than 1700%, from about $1 million in 1985 to $55,000 in 1994.

The processing sector provides full-time and seasonal employment in some communities. Employment by the river herring processing declined greatly during 1970-1997 (Table 12). This decline is probably linked to decreased availability of raw product in recent years.

7.1.3 Economic Impact of Commercial Fishing

The economic impact of river herring harvesting activities is demonstrated by the value of its estimated purchases from other major economic sectors. Based on a total landed value of $129,000 in 1997, the industry paid 43% in wages, salaries, and profits, and 57% in non-wage expenditures. The largest components of non-wage expenditures were loan payments, fuel and oil, gear, supplies, repair and maintenance, and other expenses.

The estimated economic impact resulting from the harvesting activities was about $277,000 in 1997. This estimate shows the decline in the economic importance of the river herring fishery from the 1970s and early 1980s to the present.

7.2 Recreational Fishing

Economic data specific to recreational river herring fishing are not available at this time. The economic value of the recreational river herring fishery on a recovered stock may be significant.

7.3 Potential Economic Value

River herring landings and market value are both at historic low points. As the stock recovers, landings will increase. During the peak of the fishery in the 1970s, value was less than $0.05 per pound. Products included fresh whole fish, frozen bait, salt herring fillets, salt headless dressed fish, and roe (fish eggs), canned and fresh. The processing facilities have generally

bait. Almost certainly the bait market will have to be exploited to utilize large catches from a

recovered fishery. Fishermen will need advice, ingenuity, and experimentation to be financially successful in the low-end bait market.

8. Sociological Status

8.1. Commercial Fishery

8.1.1 Fisherman's Profile

A 1998 DMF survey of river herring fishermen from the Albemarle Sound area

Table 12. Sales and employment for river herring processors, North Carolina, 1970-1997.

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	*

* Confidential (less than 3 firms)

Source: National Marine Fisheries Service.

conducted for this FMP, indicates that the average age was 53 years, with a range of 44 to 59. Based on the survey, the average river herring fisherman has fished for approximately 20 years, and most have fished between 4 and 40 years. The educational level attained by those fishermen is high school graduation or more.

8.1.2 Economic Dependence on Fishing and Related Activities

Data from the trip tickets indicate that river herring fishermen also take other species. Consequently, river herring is not the main source of fishing income. As shown in Table 13, river herring accounts for less than 10% of the fishing income for more than 80% of the fishermen.

Most of the river herring fishermen do not fish full-time. The survey of river herring fishermen from the Albemarle Sound area showed that, on average, non-fishing activities accounted for 64% of their household income, 19% came from other fishing activities, and the remainder (17%) was derived from river herring fishing.

8.2. Recreational Fishing

Demographic data for recreational river herring fishermen are not available.

9. Critical 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 147,000 acres of coastal waters as Primary (PNA) and Secondary Nursery Areas (SNA); and Inland Primary Nursery Areas (IPNA) (about 10,000 acres) have been established by the WRC. These designations provide increased protection for these areas. State "critical habitat", as defined by the MFC, is located in North Carolina Fisheries Rules for Coastal Waters, 1997-1998 (Section 9.1.1.1) (DEHNR 1997). Essential Fish Habitat (EFH) for species managed through federal

Table 13. Distribution of percent of total fishing income of fishermen from the North Carolina river herring fishery, 1995-1998.

	Number of ETS by license year			
Percent of total fishing income from river herring	1994-1995	1995-1996	1996-1997	1997-1998
< 5%	188	241	188	198
5- 10%	21	23	19	16
10-15%	6	4	2	10
15-20%	5	4	11	2
20-30%	11	4	10	5
30-40%	4	3	7	5
40-50%	1	4	7	2
50-60%	3	1	1	2
60-70%	0	1	1	2
70-80%	0	4	1	5

Percent of total fishing income from river herring	Number of ETS by license year 1994-1995	1995-1996	1996-1997	1997-1998
80-90%	3	5	5	5
90-100%	2	4	3	3
Total	244	298	255	255

Source: DMF Trip Ticket Program.

Regional Fishery Management Councils and the NMFS is defined in the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265, as amended).

9.1.1 State Critical Habitat

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) DEHNR 1997).

"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) © DEHNR 1997).

"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) DEHNR 1997).

9.1.2 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)]

Given that the South Atlantic and Mid-Atlantic Management Councils have prepared no FMPs for anadromous fish species, there are currently no FMP's for them to amend to include designated EFH. However, it was determined that, for the purposes of the Sustainable Fisheries

Act, anadromous fish species which spent any part of their life cycle in waters under the jurisdiction of a particular Council would be deemed "under its authority". Therefore, river herring which spawn in Albemarle Sound tributaries are considered under the jurisdiction of the New England, Mid-Atlantic and South Atlantic councils since they reside much of the year in Atlantic Ocean waters outside the three-mile state waters boundary, and traverse waters under the jurisdiction of each of these councils during the course of their annual migration between continental shelf habitat off New England and their Albemarle Sound tributary spawning grounds. Further, despite the lack of a fishery management plan to amend, the South Atlantic Fishery Management Council (SAFMC) chose to include information in its Final Habitat Plan for the South Atlantic Region (SAFMC 1998) describing EFH for river herring and other anadromous species, to provide a basis for Council implementation of its mandate for carrying out the commenting provisions of Section 305 of the Sustainable Fisheries Act. This provision gives North Carolina an additional mechanism, through its representatives on the Mid-Atlantic and South Atlantic councils, for requesting additional scrutiny of federal or state projects which, in its view, are likely to substantially affect the habitat, including essential fish habitat, of an anadromous fishery resource within the state which spends any time in waters under the jurisdiction of those councils. River herring meet that requirement.

9.2.1 Alewife Critical and Essential Habitat and Environmental Requirements

The SAFMC described habitats used by alewife which would be designated as EFH, if there was a Council plan to amend, as follows:

> Spawning habitats for alewives can vary from streams only a few meters (yards) wide to larger rivers. Although some authors have reported that alewives ascend further upstream than blueback herring, others believe that upstream distribution is a function of finding appropriate spawning habitats. Alewives use standing water, oxbow lakes and mid-stream areas as spawning sites, as well as coastal ponds with an open connection to the ocean [none in North Carolina]. Optimum hatching temperature was 18° C (64° F) . Temperatures below 10° C (50° F) resulted in the absence of a functional jaw in alewives. Alewives

apparently tolerate salinity changes well. Juveniles use coastal rivers and swamps, as well as estuaries, for nursery habitats prior to migrating to the Atlantic Ocean through inlets in the fall (SAFMC 1998: 275-276).

Based on historic and present sampling by DMF for the presence of spawning adults, eggs, larvae and juveniles, EFH for alewife in Albemarle Sound and its tributaries are depicted in Section 13, Appendix 3, and specifically include the following (**bold-indicates river herring, either or both species)**: Roanoke River, and its tributaries **Indian Creek, Conoho Creek, Conine Creek, Devils Gut, Bradley Creek,** an unnamed oxbow downstream of Halifax (see Map 1), Cashie River, Hoggard Mill Creek, Wading Place Creek, **Middle River and Conaby Creek** (see Maps 6 and 7); Chowan River and its tributaries **Meherrin River, Turkey Creek,** Potecasi Creek, **Nottoway River, Buckhorn Creek, Somerton Creek, Cole Creek, Wiccacon River, Ahoskie Creek, Chinkapin Creek, Bennetts Creek, Trotman Creek, Catherine Creek, Warwick Creek, Stumpy Creek, Dillard (Indian) Creek, Currituck (Keel) Creek, Sarem Creek,** Rockyhock Creek, Pollock Swamp, and Salmon Creek (see Maps 2, 3 and 7); Perquimans River and its tributaries Mill Creek, Goodwin Creek, Raccoon Creek (Walters Creek) and **Suttons Creek** (see Maps 4 and 8); Little River and its tributaries **Halls Creek, Deep Creek and Symonds Creek** (see Map 4); **Pasquotank River and its tributaries Sawyers Creek, Mill Dam Creek, Knobbs Creek, Areneuse Creek, Portohonk Creek and Newbegun Creek** (see Map 5); North Landing River and its tributaries Tull Creek and **Shingle Landing Creek** (see Map 5); upper portion of the North River (see Map 5); Albemarle Sound and its tributary Kendrick Creek (Mackeys Creek) (see Maps 7 and 9); Edenton Bay and tributaries, Pembroke Creek and Queen Anne Creek (see Map 7); Yeopim River and its tributaries Bethel Creek, Burnt Mill Creek, Middleton Creek and Yeopim Creek (see Map 8); Scuppernong River and its tributaries, Bee Tree Canal, Cherry Ridge including canals to and including Lake Phelps (see Map 9); and Alligator River and its tributaries Alligator Creek, Second Creek, the Frying Pan, Northwest Fork, Southwest Fork, **Whipping Creek Lake**, **Mill Tail Creek,** South Lake, and East Lake, and Swan Lake (see Map 10).

9.2.2 Blueback Herring Critical and Essential Habitat and Environmental Requirements

The SAFMC described habitats used by blueback herring which would be designated EFH, if there was a Council plan to amend, as follows:

> Blueback herring are reported to prefer spawning sites with fast currents and associated hard substrates; however, in South Atlantic coastal rivers, they frequently use flooded back swamps and spawn in and among the vegetation of aquatic bed habitats. Preferred temperatures of juveniles ranged from 20 to 22° C, but they were encountered in the field at temperatures ranging between 11.5 to 32° C (53-89° F). Bluebacks are apparently highly tolerant of salinity changes, since direct transfers of adults from fresh water to salt water and the reciprocal produced no mortality. The species requires coastal rivers, associated palustrine forested and aquatic bed wetland habitats, and downstream estuaries as well as the offshore marine environment for completion of its life cycle (SAFMC 1998: 280).

Based on historic and present sampling by DMF for the presence of spawning adults, eggs, larvae and juveniles, the EFH for blueback herring in Albemarle Sound and its tributaries are depicted in Section 13, Appendix 3 and specifically include the following (**bold-indicates river herring, either or both species)**: Roanoke River and its tributaries Indian Creek, Conoho Creek, Conine Creek, Devils Gut, **Bradley Creek,** and an unnamed oxbow downstream of Halifax (see Map 1), Cashie River, **Mill Swamp Creek,** Wading Place Creek, Cow Creek, Gardners Creek, Middle River and Conaby Creek (see Maps 6 and 7); Chowan River and its tributaries Meherrin River, Kirby Creek, **Turkey Creek,** Potecasi Creek, **Nottoway River, Buckhorn Creek, Somerton Creek, Cole Creek**, Wiccacon River, Ahoskie Creek, Chinkapin Creek, Bennetts Creek, **Trotman Creek, Catherine Creek, Warwick Creek, Stumpy Creek, Dillard (Indian) Creek, Currituck (Keel) Creek, Sarem Creek,** Rockyhock Creek, Pollock Swamp, and Salmon Creek (see Maps 2, 3 and 7); Perquimans River and its tributaries Mill

Creek, Goodwin Creek, Sutton Creek and Raccoon (Walters) Creek (see Maps 4 and 8); Little River and its tributaries Halls Creek, **Deep Creek and Symonds Creek** (see Map 4); Pasquotank River and its tributaries Sawyers Creek, Mill Dam Creek, **Areneuse Creek, Portohonk Creek,** Knobbs Creek and Newbegun Creek (see Map 5); North Landing River and its tributaries Tull Creek and Shingle Landing Creek (see Map 5); upper portion of the North River (see Map 5); Albemarle Sound and its tributary Kendrick Creek (Mackey Creek) (see Maps 7 and 9); Yeopim River and its tributaries Bethel Creek, Burnt Mill Creek, Middleton Creek and Yeopim Creek (see Map 8); Scuppernong River and its tributaries, including canals to and including Lake Phelps (Map 9); and Alligator River and its tributaries **Alligator Creek,** Second Creek, **The**
Frying Pan, Northwest Fork, **Whipping Creek Lake**, **Mill Tail Creek,** South Lake, and East Lake (see Map 10).

9.3 Habitat Protection Status

The amount of river herring habitat (adult migration corridors, spawning habitat, and juvenile nursery habitat) which is presently afforded some protective status in Albemarle Sound and tributaries has not been quantified. 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 WRC has designated IPNAs in the Albemarle Sound area which serve as spawning and/or nursery habitats for river herring. These areas were established through extensive survey sampling conducted by personnel of DMF or WRC. 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 following Inland Waters have been designated: 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).

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 under the categories defined in Section 9.1.1.1 of this FMP.

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 currently 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).

The FRA of 1997 requires preparation of Coastal Habitat Protection Plans (CCHP) for various habitats important for coastal fisheries resources, including spawning and nursery areas and wetlands. Anadromous fish habitat will be subject to these plans as they are developed by DMF and WRC in cooperation with other agencies.

9.4 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).

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 have declined 92% from 1982, with only one discharger, UPDW, still discharging a significant amount of nitrogen. Most of this nitrogen is 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 will be lowered to 5.5 mg/l.

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, which comprise 76% of the Chowan watershed, were unavailable.

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 operations and their associated nitrogen-rich (ammonia) wastes. 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 rise dramatically due to citizen interest and education (Figure 19). From 1991 to the present, there have been few blooms, with the exception of 1994. Chlorophyll *a* values (Figure 20) show a decline since the 1980s with only seven instances where chlorophyll *a* exceeded 20 µg/l (half the state standard) since 1991 (DWQ 1997a).

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 10% of the international literature suggest biological degradation could occur. Nickel, chromium and DDT were the most frequent contaminants. 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. The implications of this information for river herring are unknown.

In 1990, DEHNR issued a consumption advisory for Chowan River fish due to elevated levels of dioxin in fish. 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.

Dissolved oxygen (DO) levels drop below the 4 mg/l 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). 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 above referenced earlier studies. 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 quarterly 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.

Concentrations of DO in the Roanoke River between Roanoke Rapids and Hamilton are 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. Impacts to 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 these improvements, degraded water quality has been indicated 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. These studies were carried out prior to recent water quality improvements.

Two of these 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.

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.

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). These low-hatch tributaries are thought to comprise only a small proportion of the total spawning and nursery habitat in the Chowan River. Despite the need for a current study comparing water quality to larval growth and survival, this work, along with past research and general improvements in water quality, suggests that water quality currently has a relatively minor impact on river herring reproduction within the Chowan River.

Although a functional relationship between water quality and river herring abundance does not appear to exist in the Chowan River, the impacts of water quality on river herring

reproduction in other coastal river systems have not 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). 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. The effects of variable salinity regimes on submerged aquatic vegetation and fishery resources within Currituck Sound also requires further investigation. Currituck Sound salinity levels have increased due to freshwater diversion and usage as well as the construction of the Intracoastal Waterway which has resulted in the intrusion of saltwater. On the Roanoke and Tar rivers, the impact of reservoirs used for power generation and flood control need to be evaluated. In these systems, downstream flows are highly regulated, and their management can affect both water quality and habitat. The impacts from large-scale livestock operations need to be evaluated throughout the region and state. Research on the toxic dinoflagellate *Pfiesteria piscicida*, responsible for fish kills in the Tar-Pamlico and Neuse rivers, is underway. It should be noted that the presence of river herring has not been documented in any *Pfiesteria*-related kills. 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.

9.5 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 populations has not been fully investigated.

In North Carolina, spawning and nursery habitats of river herring have been delineated for most river systems. 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 can not 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). Because very little historical data are available, losses to specific habitat types, such as wetlands and SAV, and the subsequent impacts to river herring are hard to quantify. Nevertheless, 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 14). Many of these projects occurred in the lower Chowan River basin and impacted bottom land hardwood forests, brackish marshes, headwater forests, swamp forests, and wet flats. From 1994 to 1996, 48 acres (19 ha) of wetlands were permitted to be filled within the Albemarle Sound region, excluding the Chowan and Roanoke rivers (DWQ 1997b) (Table 15).

Rapid reductions in SAV have also occurred throughout many coastal estuaries. Although the use of SAV by river herring is not well-documented, juveniles pass through this habitat during their migration to the sea. As with wetland losses, reductions in SAV are hard to quantify due to the lack of historical data. However, in the Pamlico River, SAV abundance in 1985 was only one percent of that present in the 1970s (Stanley 1992). In Currituck Sound, similar reductions were documented from 1979 through 1984 (DWQ 1997b). In recent years, the return of SAV beds has been observed in both systems.

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

Table 14. 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).

	Total permitted wetland impacts (acres)	Total number of projects
1996	22.42	18
1997	21.60	19

Table 15. Fill activities by wetland type in the Chowan River and Pasquotank River basins (Albemarle Sound and its tributaries excluding the Chowan and Roanoke rivers) basins 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**

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 16, by county and miles effected. In the Albemarle Sound area, 281.1 miles of streams have been channelized.

Stream blockages such as dams, including beaver dams, culverts, and natural obstructions have 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). The Quaker Neck Dam on the Neuse

River has recently been removed, opening up 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 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, personal communication). 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. Water control structures

Table 16. 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**

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, Thirtyfoot 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 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). Current efforts, including the installation of fish weirs and the replacement of the original wooden flap gates, are aimed at restoring river herring and estuarine species, such as blue crabs, to Lake Mattamuskeet (Rulifson and Wall 1998).

Although dams are the most common 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. 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. In 1998, a two-year study was initiated by the North Carolina Department of Transportation (DOT) to compare streams with culverts, bridges, and no crossings (Mary Moser, University of North Carolina at Wilmington, personal communication). The first year of sampling took place at over 200 sites within the Cape Fear River, Neuse River, and Albemarle Sound basins. Initial results showed that river herring were found upstream and downstream of bridge crossings, while no herring were found in sections of stream with culverts (Mary Moser, University of North Carolina at Wilmington, personal communication).

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) noted two vegetation blockages on Pollock Swamp Creek, Chowan County 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), and Bonnie (1998), 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 snagging could result in the unnecessary elimination of habitat by removing woody debris and vegetation.

10. Principal Issues and Management Options

10.1 Stock Condition

The alewife and blueback herring stocks of the Albemarle Sound area are currently overfished as documented in Section 4.2.1 Stock Problems. The stocks cannot replace themselves through spawning at existing levels of mortality (recruitment overfishing). Natural mortality cannot be controlled through any fishery management system, but fishing mortality can be controlled through management. Therefore, any program implemented to improve the status of the stocks must affect fishing mortality. Numerous options are available, both for stock status targets and for strategies to reach those targets. Possible targets include MSY, minimum stock size threshold, and spawner/recruit relationship. Strategies include effort management, control of fishing mortality and harvest quotas.

Target stock status can range from maintenance of the existing depressed stock level to a robust stock such as existed during the late 1960s before oceanic foreign fishing took its toll. Strategies to achieve that range of targets also have a wide range: from status quo (do nothing) to a moratorium on directed fishing or possession of river herring for as long as required to achieve

the stock status target.

A “do nothing”alternative will result in maintenance of a small fishery with little economic return to the participants. Full stock recovery will take a number of years, depending on many variables. The nature of the fisheries during a recovery period and thereafter would depend on the severity of management restrictions utilized to reduce fishing mortality and promote stock recovery, market conditions, economic conditions of the affected fishermen, and many other factors.

10.2 Habitat and Water Quality

Considerable habitat important to river herring has been degraded or lost in the Albemarle Sound area. Drainage and/or filling of wetlands adjacent to the rivers and creeks of the area has eliminated spawning areas. Channelization of small streams has had the same effect. Several small dams have eliminated access to upstream spawning areas. Nursery areas along the shorelines of the rivers and Albemarle Sound have been affected by dredging and filling, as well as by erection of bulkheads, although the degree of such impacts has not been measured. Major drainage work occurred during the 1960s and 1970s, but much less has been done since that time. Existing governmental regulatory systems make it very difficult to conduct major wetlands drainage projects today.

Migration of river herring may be impeded by culverts. These structures have been used to replace small bridges, and preliminary research has indicated that river herring are no longer found in the upper reaches of streams with culverts (Mary Moser, University of North Carolina at Wilmington, unpublished data). However, it is unclear that the reduction in river herring distribution in these shallow streams can be attributed solely to installation of culverts. A study to determine the effects of low light on river herring migration behavior will be completed in December 1999. The results of this work will allow better assessment of the effects of various types of culverts on river herring migration.

Options to address these habitat concerns include establishing wooded buffers and conservation easements along area streams to protect the critical shoreline areas so they can

continue to serve as spawning and nursery areas. Funding for habitat protection could come from the North Carolina Clean Water Management Trust Fund, North Carolina Wetlands Restoration Program, and the federal Conservation Reserve Enhancement Program (CREP). The MFC has defined anadromous fish spawning and nursery areas, but it has not yet designated any specific areas under those definitions. The WRC could enact the same definitions, and the DMF and WRC staffs could present specific, research-based areas to both commissions for official adoption. Then the EMC and CRC could enact rules to ensure the long-term integrity of such areas. If research shows negative impacts from the installation of culverts, the DOT could implement a mediation program to restore and maintain river herring spawning runs. All of these efforts would require expenditure of public and private funds. Policy decisions would be required to implement many of the options. The "no action" alternative would cost little in immediate costs, but the biological, social and economic benefits of restored habitats and resources would not be realized.

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 quality and quantity are significant. Throughout the Albemarle Sound watershed, applications continue for alteration and/or filling of wetlands which serve a vital function in either maintaining the quality of surface runoff entering the rivers and estuary, or serve directly as river herring spawning and nursery areas. Loss of habitat quantity or quality which results from permitted actions has a cumulative adverse impact on the ability of the system to sustain river herring populations. Although mitigation requirements exist, understaffed and underfunded federal and state agencies frequently do not have the resources to adequately review and develop recommendations for each application, conduct follow-up inspections to ensure compliance, and undertake enforcement actions when violations are discovered. Efforts at industrial recruitment within this economically stressed basin also pose a threat to water quality. A recently proposed steel plate mill (Nucor, Inc.) on the Chowan River and paper mill on the Roanoke River (Wisconsin Tissue) both have the potential to adversely impact river herring resources unless adequate environmental safeguards are imposed to prevent water quality and habitat degradation.

During the 1970s, the Chowan River area and Albemarle Sound were plagued with extensive growths of nuisance blue-green algae, major fish kills, and outbreaks of fish diseases. The Chowan River was designated as Nutrient Sensitive by the EMC in 1979, and specific measures were developed to reduce excessive inputs of nutrients, especially nitrogen and phosphorus (DEM 1998a; 1982b). The major nitrogen sources were identified, and steps were implemented to greatly reduce inputs. The Farmers Chemical nitrogen fertilizer plant has since closed, although nitrogen leaching from the plant site remains a concern. Union-Camp pulp mill effluent has been greatly reduced and improved in quality; it is now discharged earlier in the year to reduce impacts on migrating fish during late winter and spring. Other discharges into the river have been removed or improved. Many farmers have adopted Best Management Practices (BMP) in their operations to reduce fertilizer use and control runoff from their fields. Incidence of blue-green algae blooms, fish kills, and fish disease outbreaks has been greatly reduced, but they still occur sporadically. There are still problems with non-point source (NPS) runoff and some discharges in the area, but the overall water quality of the area, especially Chowan River, is much improved.

Continued improvements in water quality will come primarily from control of NPS discharges through increased adoption of BMPs by farmers, restoration of wetlands and installation of stream buffers. Failure to aggressively reduce NPS discharges will lead to degradation of water quality as growth and development inevitably occur within the Albemarle Sound area. Continued upgrading or removal of sewage and industrial discharges is similarly required.

Both the MFC and WRC have officially adopted policies to protect and enhance habitat and water quality. The WRC adopted its “Policies and Guidelines for Conservation of Wetlands and Aquatic Habitats” in May, 1988. The MFC approved its “Policies for the Protection and Restoration of Marine and Estuarine Resources and Environmental Permit Review and Commenting” in April, 1999. The WRC staff bases its review of permits affecting habitat and water quality on the WRC policy, while the DMF is in the process of developing formal agency policy.

10.3 Assessment Data

The stock assessment used in this FMP is based on data for blueback herring in Chowan River, the largest single component of the Albemarle Sound area river herring resource. Full assessment of the resources, including alewife and blueback herring from the entire area, will require major expansion of research and monitoring activities. Fishing effort data from all gears, commercial and recreational, must be obtained on a continuing basis. Biological data (length, sex, age, spawning history) are required for each adult fish sampled from the fisheries. In addition to these fishery-dependent sampling efforts, fishery-independent sampling must be initiated throughout the spawning season to obtain data on the biological parameters of the total stock for comparison with data from the catch. Current fishery-independent sampling of juveniles must be expanded to fully cover the nursery habitat.

Issues concerning water quality effects on larval and juvenile river herring can only be answered through field and laboratory research to determine hatching success and juvenile survival in different areas under varying natural and altered conditions. Such work should pay particular attention to adequacy of food sources for larval and juvenile river herring, considering species composition, amount, and temporal and spatial availability. Water quality parameters (dissolved oxygen, pH, alkalinity, temperature, turbidity, and others) must be examined for influences on each life history stage within the Sound. Utilization of spawning habitat should be examined relative to simple presence/absence of spawners, as well as the more complex physical and chemical features which may be associated with use or non-use of a given stream area for spawning.

Existing DMF sampling work should serve as a basis for expanded biological research and monitoring. The commercial fisheries trip ticket database would help identify those

fishermen to monitor for commercial fishing effort. Sales of the new Recreational Commercial Gear License (RCGL) will provide an initial license frame for sampling recreational fishermen who use commercial fishing gear such as gill nets. The WRC Special Devices License database will similarly help identify those fishermen taking river herring in Inland Waters so their catches

and effort can be examined.

10.4 Socioeconomic Data

Every management decision made by the MFC, WRC, and DMF has socioeconomic effects. People react to those decisions as they decide whether or not to make certain expenditures, go fishing, etc. Those individual decisions add up to community impacts, which together generate statewide effects. The DMF/WRC have no program to periodically gather data to aid in estimating socioeconomic impacts before decisions are made or to determine impacts which actually occur. The DMF has a staff economist; the WRC does not. The DMF could begin regular sampling of licensees for data with which to develop socioeconomic baselines from which to estimate impacts of decisions. Failure to initiate such work would continue to leave the decision-making process open to criticism for failure to consider the human dimensions of decisions.

10.5 Education

The river herring fishery today is but a fraction of the fishery which existed 20-30 years ago. Its history, even though it was North Carolina's largest food fish fishery for many decades, is poorly known beyond the immediate Albemarle Sound area . The decline of the fishery might serve as a model of declining fisheries affected by both environmental problems and overfishing. The general public should be educated concerning both the history and potential future benefits which can come from a recovered fishery.

11. Recommended Management Program

11.1 Goals: To manage the Albemarle Sound area river herring fishery 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.

To achieve an interim spawning stock biomass (SSB) level for the Albemarle/Roanoke system river herring that coincides with a 4 million pound SSB level for the Chowan River stock. (This level of SSB is considered the Minimum Stock Size Threshold (MSST)).

To achieve for the long-term a spawning stock biomass (SSB) level for the Albemarle/Roanoke system river herring that coincides with an 8 million pound SSB level for the Chowan River stock. (This level of SSB is considered the Biomass capable of producing MSY (Bmsy)).

11.2 Optimum Yield

Optimum yield, OY, is defined by the FRA as the amount of fish that will provide the greatest overall benefit to the state; is prescribed on the basis of MSY as reduced by relevant factors; and, in the case of an overfished fishery, will provide for rebuilding to a level consistent with producing MSY. The river herring stock assessment indicates that MSY for a recovered stock is approximately 2 million pounds, consequently the target OY for a healthy river herring population must be less than 2 million pounds. Furthermore, the assessment indicates that the stock is at extremely low abundance and is overfished, and that recruitment must improve before the stock can rebuild to a level capable of producing MSY. Because the stock is overfished, the allowable harvest, or rebuilding OY, must provide for stock rebuilding. Therefore, the rebuilding OY for river herring is not to exceed 300,000 pounds of commercial harvest. The recreational harvest will be limited to 25 fish possession limit. According to stock projections incorporating the stock-recruitment relationship, this level of harvest may rebuild the stock to the threshold spawning stock biomass (minimum stock size threshold, MSST) of 4 million pounds in 14 years and to the MSY biomass in 24 years. This level of harvest should not be exceeded until the JAI reaches a three year moving average of 20 or the spawning stock biomass exceeds the MSST of 4 million pounds. Observations gathered over the period of stock recovery and

increasing abundance will provide important information relevant to the stock's current growth potential that may lead to alternative estimates of MSY and accompanying OY values in future assessments.

11.3 General Objectives:

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

2. Restore river herring stocks in the Albemarle Sound area to viable status.

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

4. Manage the fishery 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 stock, its habitats and fisheries, and the rationale for management efforts to solve these problems.

11.4 Strategies

All new work and expansion of programs will require additional personnel, equipment and operating funds.

11.4.1 Population Attributes:

1. Determine juvenile abundance indices (JAI) annually for the Albemarle Sound area.

2. Maintain up-to-date data bases on size, age, and sex composition of the harvest.

3. Update the stock assessment analysis annually.

4. Determine spawning repetition annually.

Action:

1. Validate JAI time series.

11.4.2 Stock Restoration:

1. Restore blueback herring juvenile abundance to a three-year moving average of at least 20 within six years, to at least 60 within twelve years and at least 100 within eighteen years as measured by the DMF juvenile abundance index (JAI).

2. Restore alewife juvenile abundance to a three-year moving average of at least 3

within six years, and at least 6 within twelve years as measured by the DMF juvenile abundance index (JAI).

3. Restoration targets for the Chowan River blueback herring spawning stock biomass (SSB) (Section 13, Appendix 1) :

a. restore SSB to MSST = 4 million pounds (mlb) within 14 years

b. restore SSB to 6 mlb in 19 years

c. restore SSB to the 8 mlb biomass capable of producing MSY in 24 years

4. Restore the Chowan River blueback herring spawning stock age composition so that it contains at least 6% repeat spawners within six years, at least 10% repeat spawners within twelve years, and 14% within eighteen years.

5. Restore recruitment of age three fish to at least 3.5 million fish within five years (as estimated from the stock assessment) and to a three-year moving average of at least 8 million fish within 10 years.

6. Restore river herring runs through adult transplant and/or hatchery operations in specific streams to be determined by spawning area surveys.

7. Upon restoration manage fishery at F=OY.

Action:

1. Specific stock restoration objectives will be achieved through Fisheries Management Alternatives, Section 11.4.4.

2. Once SSB reaches the MSST of 4 million pounds, MFC directs DMF to recommend measures to achieve the target biomass capable of producing MSY, that equals 8 million pounds, and an ultimate harvest of OY.

11.4.3 Habitat and Water Quality:

1. Update spawning and nursery area surveys.

2. Maintain, restore and improve habitat and water quality to increase growth, survival and reproduction of river herring.

3. Identify and remove physical obstructions and water quality impediments to river herring migration.

4. MFC and WRC designate river herring spawning and nursery areas in their respective jurisdictions, so these areas can be protected and/or restoration measures can be implemented.

5. Support implementation of recommendations of DWQ basinwide water quality management plans.

6. Support implementation of habitat and water quality recommendations of Comprehensive Conservation and Management Plan (CCMP), Albemarle-Pamlico Estuarine Study (1994); and the Estuarine Shoreline Protection Stakeholders report (1999).

7. Protect vital habitat and water quality through establishment of buffer strips, conservation easements, habitat restoration and similar actions.

8. Identify and remediate aquatic habitat losses and other impacts associated with past stream channelization projects in conjunction with Natural Resources Conservation Service (NRCS).

Action:

1. Conduct a spawning area survey in one drainage basin, annually beginning spring 2001.

2. Develop and implement a CHPP for river herring spawning and nursery areas.

3. Develop and implement drainage area habitat restoration plans, using the Edenton Bay Plan as a model. Possible funding sources include: Clean Water Management Trust Fund, North Carolina Wetlands Restoration Program, Conservation Reserve Enhancement Program (CREP), and other sources.

4. Conduct a survey to update Collier and Odum (1989) - "Obstructions to Anadromous Fish Migration."

5. Based on No. 3 above, implement actions to alleviate identified impediments.

6. DMF and WRC recommend to their respective Commissions designation of documented river herring spawning and nursery areas in their respective jurisdictions.

7. Environmental Management Commission (EMC) should take appropriate steps to achieve established water quality objectives, especially those relating to nutrient inputs from both atmospheric and surface sources, nuisance algae blooms and fish kills.

8. Coastal Resources Commission (CRC) should take appropriate steps to achieve established habitat objectives, especially those relating to protection and restoration of river herring spawning and nursery areas.

9. Implement an automated water quality monitoring system (temperature, salinity, dissolved oxygen, pH, etc) throughout the Albemarle Sound River Herring Management Area (ASRHMA).

10. The EMC should require all NPDES permit holders in the ASRHMA to demonstrate their effluent is not toxic to blueback herring eggs and larvae by the next permit renewal using standard methods.

11. Develop BOD loading models and budgets for Albemarle Sound and each of its principle tributaries.

12. Establish and achieve objectives to increase the use of BMPs in agriculture in the Albemarle Sound area.

11.4.4 Fishery Management Alternatives

1. Five alternative management strategies:

(a) Status quo- Maintain the current harvest and allocation of 450,000 pounds total and regulations. Implement a 25 fish Recreational Commercial Gear License (RCGL) daily limit. This alternative results in continued overfishing of the stock, which violates the FRA.

(b) Quota harvest- Reduce the harvest quota to 300,000 pounds, allocation of 200,000 pounds to Chowan River pound net fishery, 67,000 pounds to Albemarle Sound management area gill net fishery and 33,000 pounds to the Fisheries Director's discretion. Implement a 25 fish RCGL daily limit.

(c) By-catch level of 100,000 pounds- Establish a 100,000 pound by-catch allocation for the ASRHMA to be 50,000 pounds to the Chowan River pound net fishery, 25,000 pounds to the gill net fishery and 25,000 pounds to the Fisheries Director's discretion. No increase in pound net effort will be allowed, the gill net fishery will be restricted to a 3 1/4 inch stretched mesh minimum mesh size, and river herring in either fishery may not exceed 25% of the total catch weight. Possession limits for RCGL holders would be 10 fish per person per day.

(d) Fixed exploitation rate- The annual quota would be set by proclamation based on the annual fishing mortality target applied to the current stock abundance that varies from year to year. Allocation would be as follows: 66% to the Chowan River pound net fishery, 24% to the management area gill net fishery, and 10% to be allocated to the discretion Fisheries Director's. Possession limits of 25 fish per person per day for RCGL holders.

(e) Moratorium- No possession of river herring would be allowed in any fishery in the ASRHMA. No river herring pound nets would be allowed to be set. Gill nets would be restricted to a minimum mesh size of 5 1/4 inch stretched mesh from January 1 through May 31.

2. Manage the recreational fishery in a manner that reflects its historical importance while providing for sufficient spawner escapement and juvenile recruitment.

3. Identify streams/creeks where populations are depressed or non-existent for enhancement and/or restoration purposes.

Action:

1. The MFC approved management alternative is to allow an annual commercial quota (calendar year) for river herring in the Albemarle Sound River Herring Management Area of 300,000 pounds allocated as follows:

(1) 200,000 pounds to the pound net fishery for the Chowan River Management Area;

(2) 67,000 pounds to the Albemarle Sound River Herring Management Area gill net fishery; and

(3) 33,000 pounds to be allocated at the discretion of the Fisheries Director.

2. It is unlawful to possess more than 25 blueback herring or alewife, (river herring) in the aggregate, per person per day taken for recreational purposes.

3. Effective January 1, 2001, it would be unlawful to use drift gill nets with a stretched mesh less than 3 inches from January 1 through May 15 in the ASRHMA.

4. No gill nets less than 3 inch stretched mesh will be allowed in the ASRHMA during January 1- May 15. Gill nets of 3 inch stretched mesh will be limited to no more than 400 yards until the interim SSB level (4 mlb) for Chowan River is achieved.

5. Preclude expansion of pound net effort within the Albemarle Sound Management Area from February through May, until the interim SSB (4 mlb) level for Chowan River is achieved.

6. Enforce the requirement for removal of Chowan River Pound Net Management Area pound net stakes from abandoned sets. Abandoned sets are defined as sets not permitted for the 1999 fishery. Location of sets will be through GPS.

7. If rules implemented by the MFC pursuant to this FMP result in less pound nets being set in Chowan River than were permitted in 1999, the MFC should provide a means for the reestablishment and use of those pound net sets when the stock is restored.

8. If management targets for SSB, JAI and repeat spawners are not met as provided, implement fishing effort reductions necessary to achieve those targets, using appropriate management techniques, including limited entry or a moratorium.

9. WRC should implement a no sale provision for river herring taken with Special Device Licenses and eliminate gill nets in Inland Waters in the ASRHMA.

10. Based on spawning area surveys, prepare and implement a plan to restore spawning runs in designated areas.

11.4.5 Data collection

1. Continue and enhance existing data collection programs (juvenile survey, size, age and sex composition) to monitor the stocks.
2. Enhance fishery-dependent data collection programs to better monitor the size, age and sex composition of the harvest, including a process to collect harvest and effort data on a real time basis.
3. Design and implement fishery- independent data collection programs adequate to monitor the status of the stocks.
4. Quantify recreational landings and fishing effort from Coastal, Joint and Inland waters of the ASRHMA.
5. Request that National Marine Fisheries Service (NMFS) continue to monitor river herring harvest from the oceanic Atlantic mackerel and Atlantic herring fisheries and report those data to ASMFC and DMF.
6. Design and implement research to evaluate the impacts of water quality on larval and juvenile stages of river herring.
7. Assess impacts of other species (specifically striped bass) population dynamics

on river herring.

Action:

1. Expand fishery-dependent sampling of adult river herring to include gill net fisheries throughout the ASRHMA and pound net fisheries outside the CRHMA.

2. Enhance existing fishery-independent gill net sampling to gather biological data throughout the river herring spawning run and throughout the ASRHMA.

3. Using DMF Recreational Commercial Gear License and WRC Special Devices License databases, design and implement surveys to estimate the recreational fishing catch and effort.

4. Design and implement a program to collect biological data from the recreational fisheries for river herring.

5. Fund research to evaluate impacts of water quality on larval and juvenile river herring, including phytoplankton and zooplankton abundance trends.

6. Design and conduct studies of multi-species effects on river herring, specifically abundance trends of top predators, such as striped bass.

11.4.6 Education and Information

1. Utilize the MFC Northeast Citizens Advisory Committee as the primary citizens group for discussion of Albemarle Sound river herring management

strategies and issues.

2. Prepare an annual stock status report and post it on DMF website.

3. Widely distribute FMP to the public.

11.5 Review Cycle

As provided in the FRA, this plan will be reviewed and revised by the MFC at least every three years, in conjunction with advisors.

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