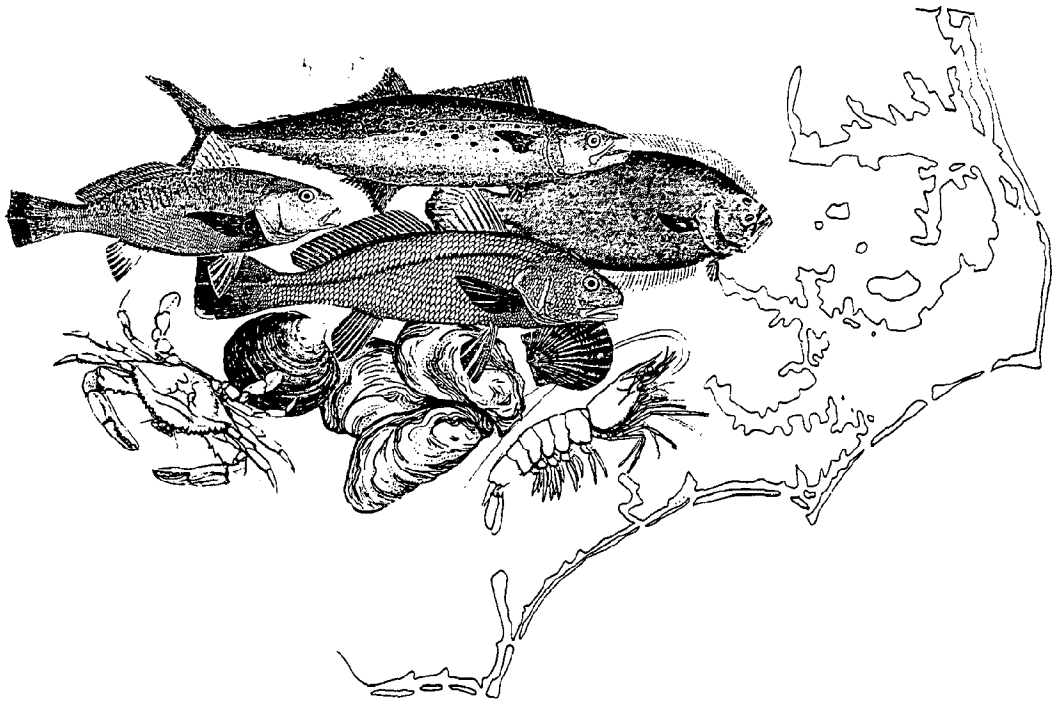
NORTH CAROLINA STRIPED BASS



North Carolina Department of Environment,
Health, and Natural Resources

Division of Marine Fisheries
Morehead City, NC 28557

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NORTH CAROLINA STRIPED BASS

July 1985 - August 1991

By

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Health, and Natural Resources

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ABSTRACT

Information generated by Project AFS-26 updates and complements the historical long-term monitoring database for the Albemarle Sound/Roanoke River stock of striped bass (*Morone saxatilis*). These data provide the basis for evaluation of stock condition and are essential in guiding management efforts. Annual juvenile striped bass sampling was conducted at seven trawl stations in western Albemarle Sound July-October, 1985 through 1990. The 1985-1987 and 1990 juvenile abundance values fell far below the 26-year mean of 6.8. Juvenile abundance increased to near historic levels in 1988 and 1989, with values greater than 4.0. An additional twelve stations were sampled July-October, 1985-1990, in the central and eastern Albemarle Sound to determine juvenile abundance. Continued low abundance was observed at these sites, but an increase occurred in 1989 to 3.7. Seven hundred and sixty-two adult striped bass were tagged in the Albemarle, Croatan and Roanoke sounds from December 1985 through March 1991, to determine resource utilization and migration. A return rate of 8.0% has been determined, with all returns being from the Albemarle Sound area. During spring 1988-1991, 2,093 adult striped bass participating in the spawning migration in the Roanoke River area were tagged to determine migration and utilization. A return rate of 2.4% has been determined. All the returns were reported from the Roanoke River or Albemarle Sound area, with recreational anglers accounting for 78% of the returns. During the project, 457,242 Phase II striped bass were released in coastal North Carolina. Of the total, 28,496 were tagged prior to stocking, and 921 (3.2%) have been returned. All of the returns have occurred from inside waters of North Carolina indicating no evidence of contribution to the Atlantic migratory population. The stocked fish contributed to the commercial and recreational harvest and to some extent augmented the spawning population. The Albemarle Sound commercial fishery was sampled annually, 1986-1991, to determine size, age, and sex composition. The catch was dominated by age II-IV fish. The size, age, and sex composition of the Roanoke River spawning population was determined annually, 1986-1991. Females age IV and older accounted for 12.9-86.4%, which was a decrease from the 1981-1984 seasons. A cooperative effort to assess the age composition of the Atlantic migratory stock overwintering off North Carolina and Virginia has been conducted annually since winter 1988. A total of 6,343 striped bass was tagged from False Cape, VA to Cape Hatteras, NC, ranging in size from 288-1,255 mm TL. The 1988 and 1989 samples were dominated by the 1982 and 1983 year classes, while the 1990 and 1991 samples were dominated by the 1983 and 1984 year classes. Limited Atlantic Ocean striped bass fisheries were opened in 1990 and 1991. The 1983 and 1984 year classes dominated the commercial harvest in both seasons.

INTRODUCTION

Declines in the commercial and recreational striped bass (*Morone saxatilis*) fisheries and low reproduction levels along the Atlantic coast from the late 1970's to the present, prompted federal management initiatives to conserve and restore the Atlantic migratory striped bass stocks (ASMFC 1981). North Carolina striped bass stocks, of which the Albemarle Sound-Roanoke River population is the principal component, were experiencing a similar decline due to poor water quality conditions, habitat alteration, and continued fishing on a reduced population (Street and Johnson 1977 and 1982, Street 1986). Information from the current AFS-26 project, together with past data on these fisheries, are vital for the preparation and implementation of fishery management plans at the State, regional, and national levels, under the coordination of the Atlantic States Marine Fisheries Commission (ASMFC). Information generated by project AFS-26 updates and complements the historical long-term monitoring database for the Albemarle Sound/Roanoke River stock of striped bass. This project data provides the basis for evaluation of stock condition in North Carolina. These data are essential in guiding the present and future management of the Albemarle Sound area fisheries and in striped bass conservation/ restoration efforts.

Literature Review

Street and Hall (1973) completed an Annotated Bibliography of Anadromous Fishes of North Carolina through 1972. They provided historical literature and information for the current project. An extensive literature review was conducted throughout the project period to provide current information. The literature cited provides a listing of the available literature.

STUDY I: STRIPED BASS JUVENILE ABUNDANCE

NEED: Long-term indices of juvenile abundance by species is required for fishery management considerations, including stock-recruitment relationships, evaluation of environmental factors affecting recruitment, and health of the aquatic system. Juvenile monitoring data provide the earliest indication of year class strength and an important fishery-independent measure of spawning success. This monitoring provides relative abundance of the Albemarle/Roanoke striped bass stock prior to recruitment of each year class into the recreational and commercial fisheries.

The continuation of a long-term data base of juvenile indices, should make it possible to determine if factors other than fishing such as temperature or river flow affect recruitment of a given species to a fishery. Monitoring of the associated environmental factors may give early insight to possible changes in future stock size. Data showing simultaneous changes in the abundance of several

species that cannot be correlated with a change in fishing effort may indicate a change in the environment and indicate the health of the aquatic system.

OBJECTIVE: To determine an annual relative abundance index of juvenile striped bass in the Albemarle Sound area

APPROACH

Western Albemarle Sound Survey

In the western Albemarle Sound area, bi-weekly sampling was conducted at seven established trawl stations July through October, 1985-1990 (Figure 1). Each station was towed for a period of 15 minutes. These stations were sampled to determine the relative abundance index or catch-per-unit-effort (CPUE) of young-of-year striped bass for the Albemarle-Roanoke population.

Eastern Albemarle Sound Survey (Central and Eastern Albemarle Sound)

Twelve trawl stations established in 1984 and described by Winslow et al. (1985) were sampled bi-weekly during July through October, 1985-1990 in the central and eastern Albemarle Sound to determine the relative abundance index (CPUE) of juvenile striped bass (Figure 1). Trawl tow time for each station was 10 minutes.

All stations were sampled with a 5.5 m (18 ft) head rope, semi-balloon trawl, constructed of webbing which ranged from 19.1 mm (0.75 in) stretched mesh in the body to 12.7 mm (0.5 in) in the cod end. All striped bass captured were measured to the nearest millimeter, fork length (mm, FL). Other species captured were also measured and noted, as were environmental conditions (water temperature and salinity).

FINDINGS

Western Albemarle Sound Survey

The 1985-1990 relative abundance or CPUE values for the western Albemarle Sound sampling area are shown in Figure 2. The 1985-1987 and 1990 relative abundance values fell far below the 26-year (1955-1980) mean of 6.8 as reported by Hassler et al. (1981). In 1988 and 1989, relative abundance increased to near historic levels, and were the highest values obtained since 1976. The increased abundance observed during 1988 and 1989 represent the first time since 1975 and 1976 that two consecutive relative abundance values were greater than 4.0. These increased abundance values have been attributed to the beneficial effects of water flow modifications from the Roanoke River reservoir system, favorable habitat or environmental conditions, and reflect harvest restrictions implemented by the North Carolina fishery resource management agencies during the late 1980s (ASMFC 1990).

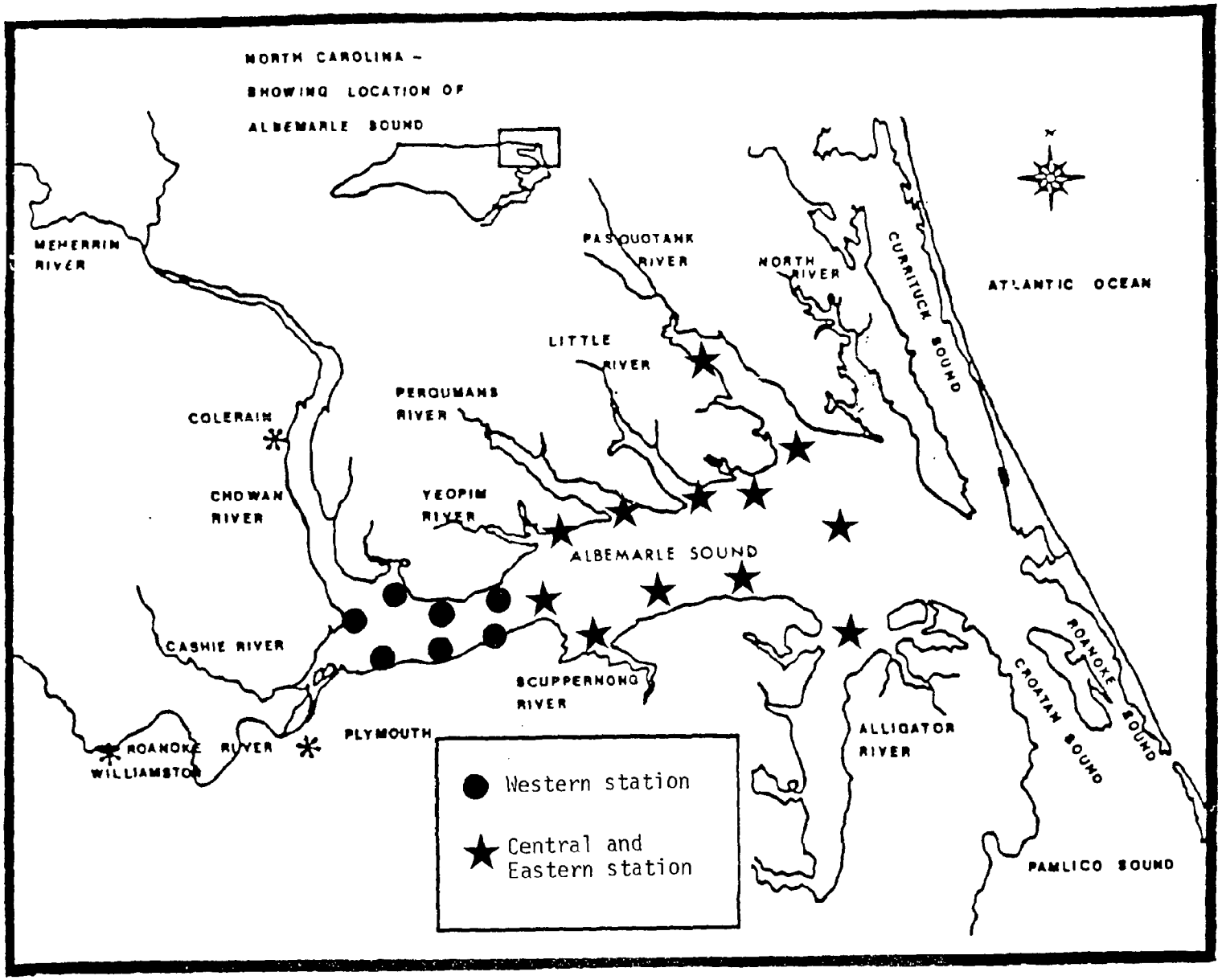

Figure 1. Station locations for young-of-year striped bass sampling, Albemarle Sound area, NC, 1985-1990.

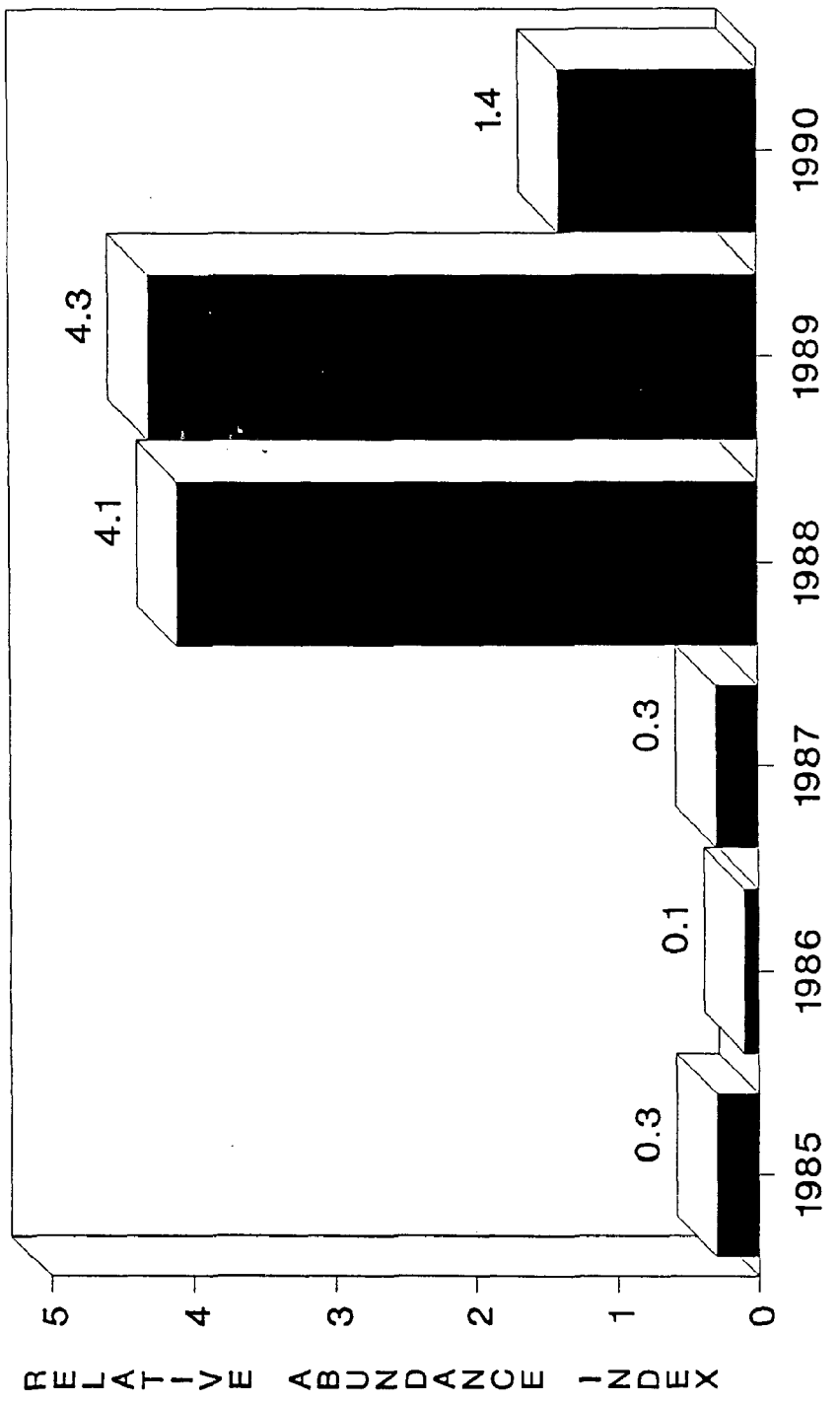

Figure 2. Relative abundance of juvenile striped bass, western Albemarle Sound, NC, 1985-1990.

Eastern Albemarle Sound Survey

The relative abundance values for the 1985 through 1990 sampling seasons are shown in Figure 3. The 1984 juvenile value (0.2) was higher than those observed in 1985 (0) and 1986 (0), approximately equal to 1987 (0.2), and 1990 (0.3) and considerably lower than 1988 (0.5) and 1989 (3.7).

CONCLUSIONS

The relative abundance index of juvenile striped bass was determined annually from 1985 through 1990, in the Albemarle Sound area. The monitoring of juvenile abundance indices provides the earliest indication of year class strength and indicates a relationship with subsequent landings. Phalen (1988) reported that as a result of the similarity in methods of DMF and Hassler's (1955-1987) surveys the estimates should be comparable for the western sound.

The very low relative abundance levels for this project and those reported by Hassler et al. (1981) and Hassler and Taylor (1986b and 1988) for the 1985-1987 seasons, in the western Albemarle Sound area, indicate poor reproductive success has been experienced since 1977. Juvenile production in 1988 and 1989 approached historic levels and represent the first time since the 1975 and 1976 seasons that two consecutive CPUEs were greater than 4.0. The high abundance of the 1988 and 1989 year classes in the commercial harvest is reflective of the increased production.

This study has provided a relative abundance index for the western Albemarle Sound area (1985-1990), which is a reliable indicator of future recruitment to the fishery. Gibson and Crecco (1991) reported a positive correlation between the western juvenile indices and their relative contribution to the Albemarle commercial fishery landings at ages 3 and 4. Continuation of the western sound data base through monitoring will allow juvenile abundance indices to be compared with historical indices to allow trends and year classes to be accessed. Monitoring will also allow further comparison to landings data where the age composition is known.

The significance of the values determined in the eastern sound has not been determined. The sampling in the eastern sound area currently provides a monitoring database. Additional juvenile information from the eastern sound may prove that what appeared to be a moderate year class, as observed in the western Albemarle Sound in 1989, may have been a much stronger year class.

Both databases should be assessed and utilized to further document year class strength. The western sound area provides a reliable juvenile abundance index. Continuing the monitoring in the eastern sound area may lead to future reliability of a combined or an eastern juvenile abundance index. Comparisons

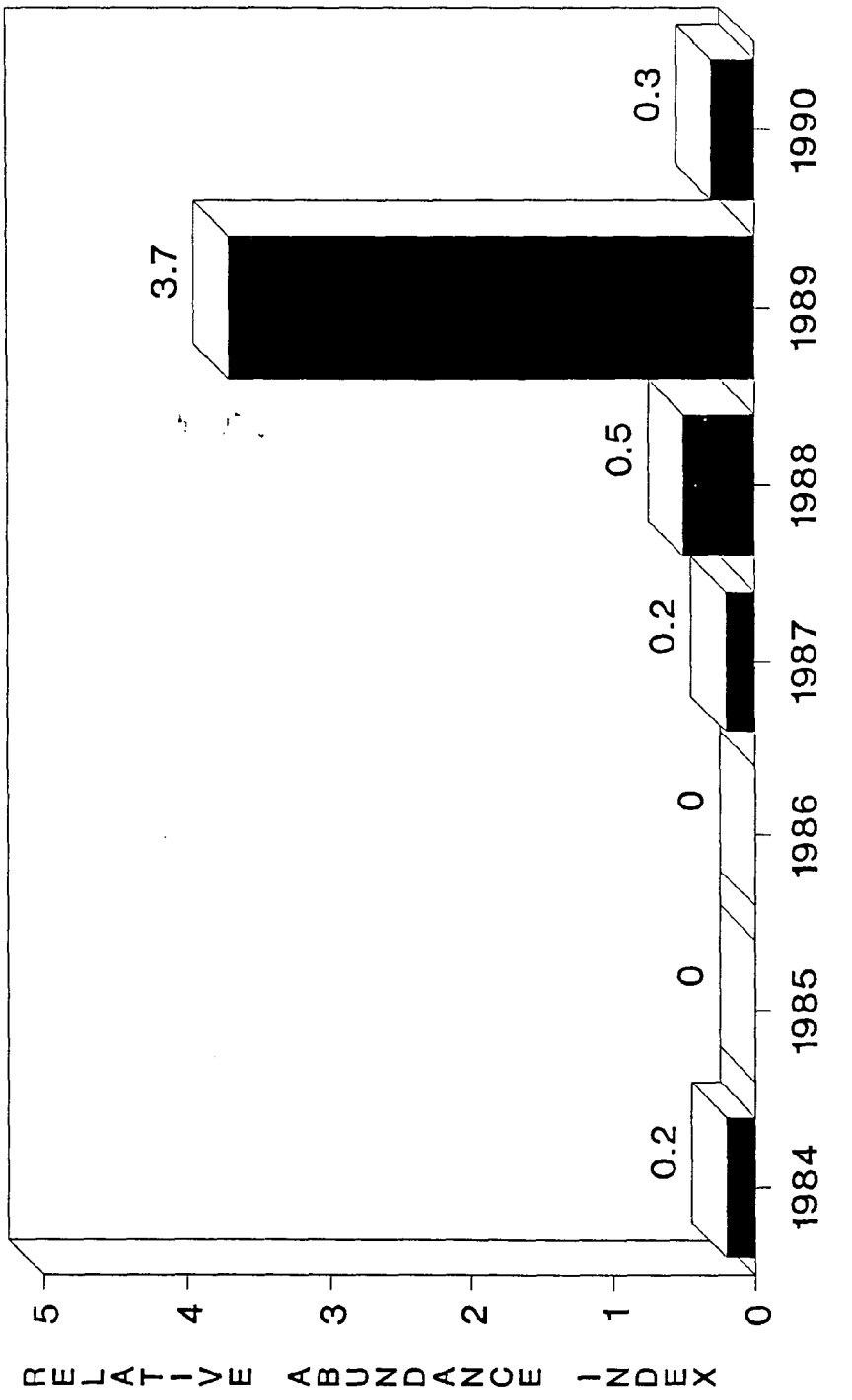

Figure 3. Relative abundance of juvenile striped bass, eastern Albemarle Sound, NC, 1984-1990.

of each data base through time will allow trends to be followed. General comparisons between the two areas will provide a relative indicator of juvenile distribution and abundance. These juvenile abundance values will continue to be used by state and federal agencies as an index to assess population status and to direct management efforts.

STUDY II: ADULT STRIPED BASS UTILIZATION AND MIGRATION

NEED: With the decline of striped bass stocks since the mid-1970s, it appears that historical migration, distribution, and utilization data are not sufficient for current management needs. Therefore, current information on migration and utilization is needed for the various fisheries.

An integral part of fisheries management is the allocation of the harvest to different user groups. The North Carolina fisheries management system's flexibility provides the ability to adjust seasons, and quotas, based on analysis of field data. Returns of tags from fish marked in Albemarle and Croatan sounds should indicate utilization of the resource and provide a portion of the information on which allocation decisions are made. Knowledge of migration patterns will be utilized in state and interstate management activities.

OBJECTIVE: To determine migration and utilization of adult striped bass which overwinter in the Alligator River, Croatan and Albemarle sounds

APPROACH

In the Albemarle and Croatan sounds, trawling was conducted annually during the winter months, 1985-1988, to capture, tag, and release overwintering striped bass (Figure 4). Two vessels were employed: (1) the 44 ft R/V CAROLINA COAST, which utilized two 9.1 m (30 ft) fish trawls, and (2) the 26 ft R/V BATCHELOR BAY, which utilized a 7.9 m (26 ft) fish trawl. Tow times ranged from 10 to 45 minutes. Secondary capture methods were hook-and-line and anchored gill nets. During 1989, trawling was eliminated due to limited success and the principal capture methods were hook-and-line and anchor gill nets. The predominantly used tag was the Floy FT-1 dart tag during 1985-1989, while some smaller fish were tagged with cinch-up spaghetti tags. Both the dart and spaghetti tags were inserted near the soft dorsal fin. The principle capture methods employed during Fall 1990 and Winter 1991 were commercial pound nets and anchor gill nets. Healthy fish were marked with individually applied tags and released immediately upon tagging. The Floy FM-84 internal anchor streamer tag, inserted in the abdominal cavity on the left side of the body just behind the pectoral fin, was the predominantly used tag in 1990 and 1991. Some smaller fish were tagged with cinch-up spaghetti tags.

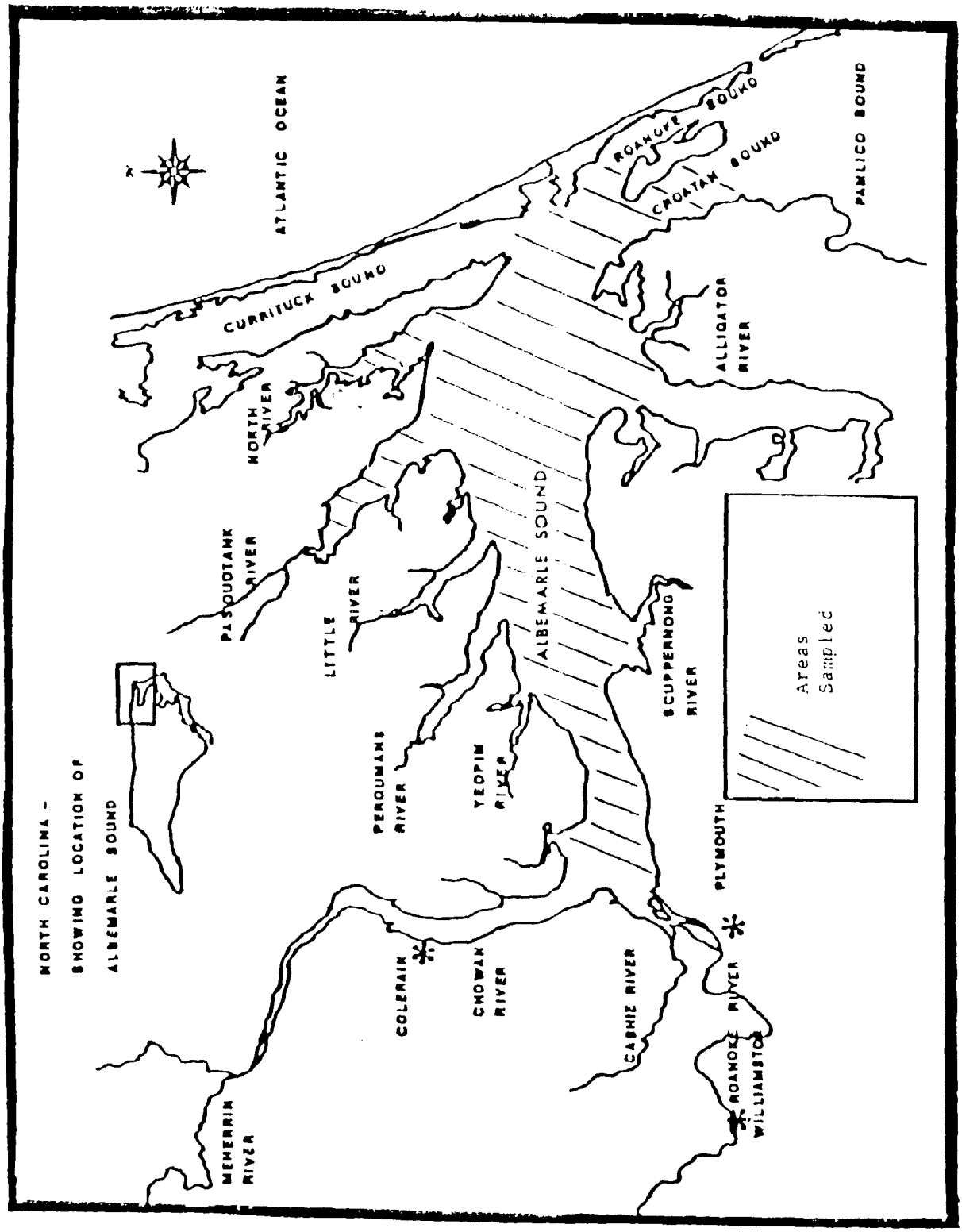

Figure 4. Sampling area for adult striped bass tagging, Albemarle and Croatan sounds, NC, Fall and Winter, 1985-1991.

Size, age, and sex data was to be obtained from at least 10% of the striped bass captured. Other species captured were also noted, as were environmental conditions (salinity, conductivity, and water temperature).

Tagging kits consisting of dart tags, applicators, and log books were supplied to volunteer sport fishermen during the winters of 1986 and 1987. All information was coded and entered into the DMF biological database. Recapture information was used to determine direction, distance, seasonality of movement, and harvest rates by various fisheries.

The tagging programs were widely publicized. Rewards were offered for the return of the tags and pertinent information concerning the recapture. Letters were sent to all persons returning tags, providing information on when and where the fish was released.

FINDINGS

Attempts to capture and tag adult striped bass using fish trawls during the fall and winter, 1985-1989, resulted in few fish tagged. Trawling was conducted in December 1985, January 1986, January and February 1987, and February 1988 throughout the Croatan and Albemarle sound areas (Figure 4). Eight striped bass were captured, tagged, and released; no recaptures have been reported. Due to the limited success achieved with trawls, other methods of capture were employed with limited success, principally hook-and-line (1986-1988) and anchor gill nets (1988).

Tagging kits were supplied to three volunteer taggers during the winters of 1986 and 1987. Volunteer anglers tagged four striped bass in the Alligator River area during February, 1986. One of these fish was recaptured by gill net in Croatan Sound during March, 1987 (395 days at large and 28 miles from release site).

Three striped bass were captured during the Fall 1988 by hook-and-line and tagged in the Chowan River. One fish was tagged and released near Colerain on 10 September 1988. Two fish were tagged near the mouth of Chowan River on 15 November 1988. One of the November tagged fish was at large 442 days prior to recapture by hook-and-line at the same site in January 1990.

Five striped bass were captured by gill net and tagged in the western Albemarle Sound on 22 November 1988. Two of these fish were recaptured by commercial gill nets in western Albemarle Sound. The first recapture occurred on 30 December 1988 (38 days at large) near the mouth of Chowan River, a distance of 7 miles from the release site. The second fish was recaptured approximately 5 miles east of the release site on 10 March 1989 after 108 days at large.

No directed gill net or hook-and-line tagging effort was expended during 1989 due to the prior limited success during 1985-1988.

During 1990, tagging efforts shifted to the eastern Albemarle Sound and portions of the Croatan and Roanoke sounds to tag fish caught in pound nets. A total of 420 striped bass was tagged and released during 19-26 November 1990. Thirty-two tags have been returned, of which 14 (43.7%) were by hook-and-line fishermen, 14 (43.7%) were from commercial gill netters, and 4 (12.6%) tags from pound net fishermen. All tag returns were from the Albemarle and Croatan sounds, Roanoke River, or Chowan River areas. Nine returns (30%) came from the Roanoke River spawning grounds hook-and-line recreational fishery.

From December 1990 through March 1991, two hundred and eighty-two striped bass were captured, tagged, and released through the Fishery Independent Gill Net Survey for Albemarle Sound Striped Bass (North Carolina Striped Bass Study Management Board Work Order No. 90-1 and 91-1). Twenty-two recaptures have been reported thus far. Recreational hook-and-line fishermen returned the majority of the tags (N=17, 77.3%), with 11 of these returns coming from the Roanoke River spawning area. Commercial gill netters in Albemarle Sound accounted for the remaining five tag returns (22.7%).

Fifty-eight recaptures have been reported from the 722 fish tagged during 1985-1991 in the Albemarle area for an 8.0% return rate. Percent return rate by gear indicating utilization for the 58 recaptures included, 55.2% recreational hook-and-line, 37.9% commercial gill net, and 6.9% from commercial pound nets. Twenty (34.5%) of the fifty-eight recaptures were returned by hook-and-line fishermen from the Roanoke River spawning area.

CONCLUSIONS

Due to the reduced status of the Albemarle/Roanoke stocks throughout the mid-1980s, capture and subsequent tagging of striped bass to determine migration and utilization by the various fisheries met with very limited success during the 1985-1989 period. Only 20 fish were tagged from 1986 through 1988. Tagging from pound nets (Fall 1990) and from gill nets (Fall 1990-Winter 1991) proved to be successful due to the increased abundance of the 1988 and 1989 year classes, with 702 fish tagged.

The objective to determine migration and utilization of adult striped bass which overwinter in the Croatan and Albemarle sounds has been difficult to achieve, due to the limited number of fish that were tagged. A return rate of 8.0% was determined for the entire project period. The tag return data shows that the tagged fish have contributed to the commercial and recreational harvest and participated in the spawning population. The higher percentage (34.5%) of

returns from the spawning grounds by hook-and-line may be a result of the fish being concentrated in a relatively small area with a large amount of directed effort.

All recoveries were from within the Albemarle Sound area showing no contribution to the Atlantic migratory stock. Historical adult tag recovery databases (Merriman 1941; Vladykov and Wallace 1952; Davis and Sykes 1960; Chapoton and Sykes 1961; Nichols and Cheek 1966; Street et al. 1975; Johnson et al. 1977; Hassler et al. 1981; Hassler and Taylor 1986a) suggest that the Albemarle/Roanoke striped bass stock is composed principally of a discrete resident population which contributes insignificantly to the Atlantic migratory stocks.

STUDY III: STRIPED BASS SPAWNING STOCK UTILIZATION AND MIGRATION

NEED: Albemarle/Roanoke striped bass are considered to be a stock with different migration habits relative to the Atlantic migratory population of striped bass which has historically been dominated by Chesapeake Bay fish. Tagging Roanoke River spawners will provide much needed data to further evaluate the possible contribution of North Carolina striped bass to the Atlantic migratory stocks.

Tagging of adult striped bass (spawning stock) from the Roanoke River delta area will provide timely information on the utilization (commercial and recreational) and migration patterns of Albemarle/ Roanoke striped bass.

As stated in Study II, allocation of harvest to various user groups is extremely important. Tag returns will provide information for allocation decisions.

OBJECTIVE: To determine migration and utilization of adult Albemarle/ Roanoke striped bass spawning stock

APPROACH

Striped bass participating in the spawning run were captured, tagged, and released in the Roanoke River, Batchelor Bay, and Edenton Bay areas (Figure 5). Capture methods were pound net, electrofishing, hook-and-line, and anchored gill nets. Healthy striped bass were marked with internal anchor streamer, cinch-up, or dart tags as described in Study II. Some fish were held for a short time to assess their condition; otherwise, they were released immediately after tagging. Up to 500 fish were to be marked and released annually. Assistance in capture and tagging was provided by the US Fish and Wildlife Service (USFWS) and the NC Wildlife Resources Commission (WRC).

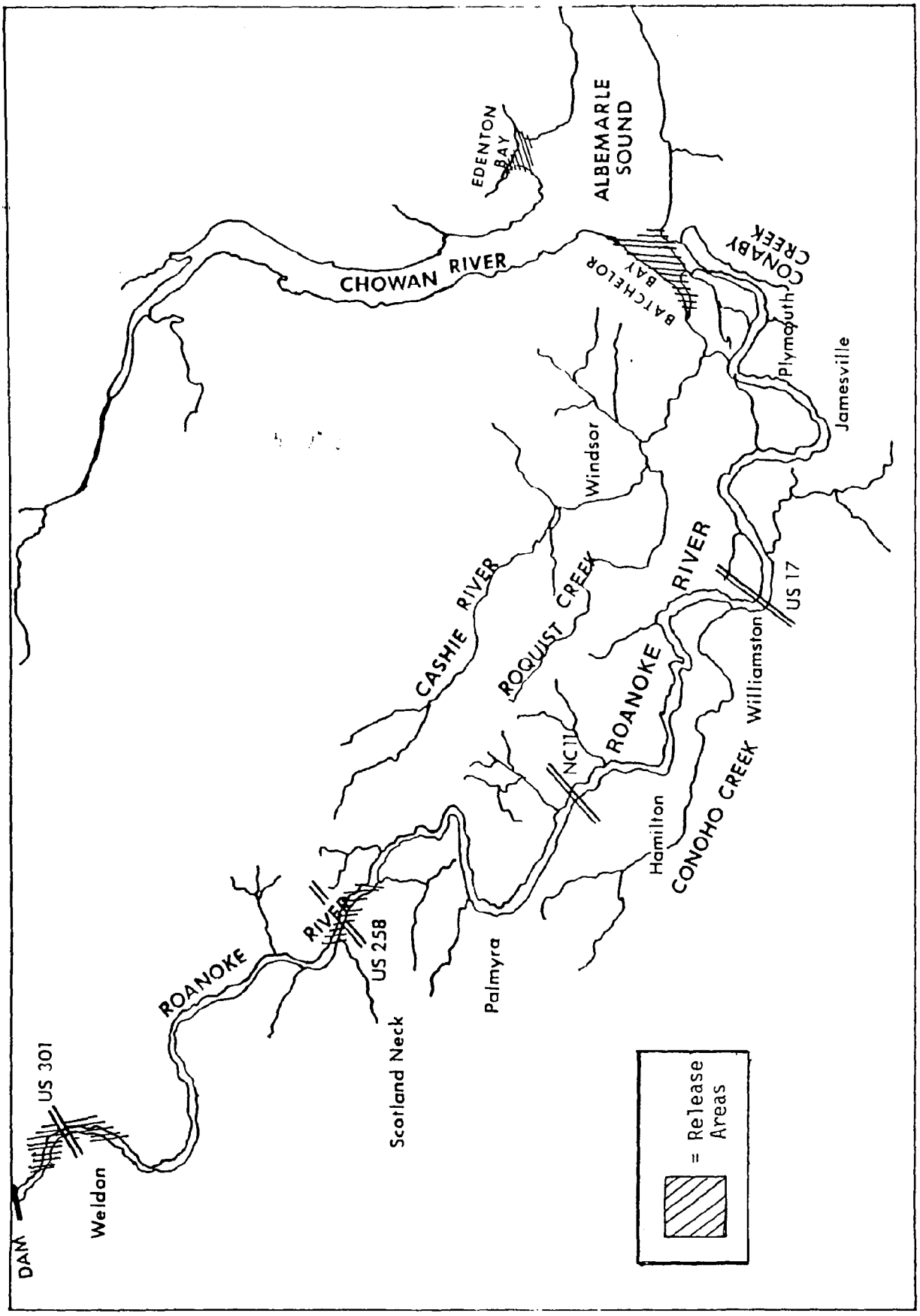

Figure 5. Release areas for the Roanoke/Albemarle striped bass spawning stock tagging, Roanoke River and western Albemarle Sound, NC, including Batchelor Bay and Edenton Bay, 1988-1991.

Tagging information was entered into the DMF biological database and assessed to determine direction, distance, seasonality of movement, and harvest rates by various fisheries. The reward system and publicizing of the program was the same as previously described in Study II.

FINDINGS

Thirty-seven striped bass were collected from the Roanoke River spawning area during 1988 and utilized by the USFWS Edenton National Fish Hatchery as brood stock. These fish were tagged and released in Albemarle Sound after spawning. Nine recaptures have been reported, five (56%) by hook-and-line, one (11%) by pound net, and three (33%) by anchor gill net, all from the Albemarle Sound or Roanoke River.

During 1989, twenty-three striped bass, taken from the Roanoke River spawning area were released in Albemarle Sound. No returns have been reported. In addition, four female fish were tagged and released on the Roanoke River spawning grounds. One of those fish was recaptured 17 days later in the same area by a recreational angler.

Seventy-four striped bass were tagged and released from the Roanoke River spawning area during 1990. One fish was recaptured by a recreational angler in the western Albemarle Sound. In addition, two hundred eighty-nine fish were tagged from various gears in the lower Roanoke River-Batchelor Bay area during the spring 1990 spawning run. No returns from this tagging were reported until the harvest season reopened in January 1991. The majority of those recaptures occurred in April 1991. Sixteen total returns were reported, however, one return was from a Virginia fish house and neither the recapture site nor gear was known. The other 15 recaptures were reported from Albemarle Sound and its tributaries and included nine (60.0%) from recreational anglers, four (26.6%) from commercial gill nets, one (6.7%) from a pound net, and one (6.7%) from the DMF fishery independent gill net survey. Eight (53.3%) of the recaptures were reported by recreational anglers from the Roanoke River spawning area during April.

Tagging effort for spring 1991 was concentrated in the upper Roanoke River near Roanoke Rapids and Weldon. Through a WRC project entitled "Roanoke River Striped Bass Spawning Stock Assessment" funded by the NC Striped Bass Study Management Board (Work Order 91-10) (Nelson and Kornegay 1991), 1,657 striped bass were captured with electrofishing gear, tagged, and released. Twenty-seven returns have been reported. Recreational hook-and-line accounted for 24 (88.9%) of the returns, with the majority (N=19) being reported from the upper Roanoke River tagging area. Two hook-and-line recaptures were reported from the lower Roanoke River and three from the Albemarle Sound area. One (3.7%) of the 27 recaptures was caught in the DMF fishery independent gill net survey in western

Albemarle Sound and two fish (7.4%) were found dead in Roanoke River. In addition, six fish captured by hook-and-line were tagged and released in the upper Roanoke River and 31 fish were tagged from pound nets in the Batchelor Bay area of western Albemarle Sound during 1991. No returns have been reported from these 37 fish.

A summary of the tagging efforts conducted during 1988-1991, including numbers of fish tagged, tagging location, capture gear, and recapture information by gear, is contained in Table 1.

CONCLUSIONS

Tagging of Albemarle/Roanoke striped bass spawning stock during each spring, 1988-1991, proved to be very beneficial in determining resource utilization and migration of this stock. Fifty-three recaptures (2.4%) have been reported from the 2,093 fish tagged during spring spawning runs. All the returns were reported from the Roanoke River or Albemarle Sound area.

Sixty-one percent (N=31) of the recaptures came from recreational anglers fishing on the Roanoke River spawning grounds. The return rate by gear type for the Albemarle Sound area indicates the following utilization: 78% recreational anglers, 18% commercial gill nets, and 4% commercial pound nets. These data indicate that the tagged fish have contributed to both the commercial and recreational harvest of the Albemarle area.

Hassler et al. (1981) and Hassler and Taylor (1986a) reported 12,619 striped bass were tagged and released from the Roanoke River spawning migration from 1956-1984 and 3,328 tags (26.4%) have been recovered. None of these tag returns have been recovered outside of North Carolina, indicating that the Albemarle/Roanoke fish do not exhibit the age and sex specific migratory habits exhibited by other Atlantic migratory stocks. It has been generally concluded (Street et al. 1975), based on tagging studies (Merriman 1941; Valdykov and Wallace 1952; Austin and Custer 1977; Boreman and Lewis 1987) and other information (Koo 1970), that striped bass in Albemarle Sound and its tributaries form a discrete, self-sustaining population contributing little, if any, to the Atlantic coastal migratory population. The returns reported during this project reinforce the historical observations (Trent and Hassler 1968) that the Albemarle/ Roanoke striped bass are relatively restricted to Albemarle Sound and adjacent coastal waters.

Hassler and Taylor (1984 and 1986a) reported that the majority of their returns from 1982-1984 taggings came from commercial gear in Albemarle Sound, whereas the majority of the recaptures during the present study (1988-1991) came from recreational anglers during the Roanoke River spawning run.

Table 1. Summary of striped bass spawning stock tagging and recaptures by location and gear type, 1988-1991.

Year	Capture gear	Release location	Total tagged	Total recaptures	Returns by gear: Gill net	Pound net	Hook & line	DMF gill net survey
1988	EL	Albemarle Sound (Edenton Bay)	37	9	3	1	5	
1989	EL	Albemarle Sound (Edenton Bay)	23	0				
1989	EL	Roanoke River (Spawning area)	4	1			1	
1990	EL	Roanoke River (Spawning area)	46	1			1	
1990	PN	Albemarle Sound (Batchelor Bay)	243	14**	4	1	8	1
1990	HL	Albemarle Sound (Batchelor Bay)	41	1			1	
1990	GN	Albemarle Sound (Batchelor Bay)	5	0				
1991	EL	Roanoke River (Spawning area)	1,657	25***			24	1
1991	HL	Roanoke River (Spawning area)	6	0				
1991	PN	Albemarle Sound (Batchelor Bay)	31	0				
Total number			2,093	51	7	2	40	2
Percent of total					14%	4%	78%	4%

*EL = Electroshocking
PN = Pound net
HL = Hook and line
GN = Gill net

** One additional recapture was reported from Virginia; recapture site and gear was not known.

*** Two additional returns were reported from dead fish found in the Roanoke River.

It appears from the limited tag returns, that utilization has shifted from a fishery that was commercially dominated to a recreationally dominated harvest. This shift in utilization may be due to the extensive regulatory measures implemented on the Albemarle area commercial fisheries, or the concentrated recreational effort on the spawning grounds. Documentation of this shift among the resource user groups needs to be verified through additional utilization information.

Recaptures reported from the 1989 and 1990 tagging studies decreased significantly when compared to the 1988 tagging. This decrease in tag returns is principally due to the extensive harvest closures implemented in 1989 and 1990. Also, many fishermen may be reluctant to provide recapture information to fishery management agencies when harvest seasons are closed or restricted. Fishermen sometimes feel that cooperation with regulatory agencies may further impact their ability to utilize the resource. However, a change from this attitude is evident from the most recent tag returns (1991), as fishermen perceive that the harvest restrictions are helping to restore the striped bass population.

STUDY IV: EVALUATION OF COASTAL STRIPED BASS STOCKING

NEED: Stockings have been utilized to enhance striped bass populations where depressed stocks existed. Guier et al. (1980) recommended experimental stocking in coastal North Carolina, and work began in 1980 on rearing and stocking Phase II striped bass (Winslow and Johnson 1984).

Phase II fish were stocked exclusively for three reasons: (1) natural reproductive success is monitored annually in the Albemarle Sound area, through juvenile sampling (Study I) and Phase I (1-5 in) stocking in mid-summer could significantly bias juvenile abundance indices; (2) late summer and early fall environmental conditions such as low dissolved oxygen levels, and blue green algae blooms) in the Albemarle Sound area lead to occasional kills of juvenile striped bass, therefore stocking Phase II fish in late fall allows the fish to avoid Albemarle Sound during that critical period; and (3) Phase II fish are large enough to bear an external tag. The recapture of tagged fish will enable distribution, migration, utilization and contribution to the fishery to be determined from each area stocked. Continuation of stocking is needed to augment the basic spawning stock during the current period of limited natural reproduction. Marking a portion the fish stocked is necessary to evaluate the stocking.

OBJECTIVE: To determine effects of striped bass stocking on the fisheries and natural populations

APPROACH

Brood fish from various spawning areas, using the techniques of Bonn et al. (1976), were artificially spawned and the larvae reared at the US Fish and Wildlife Service (USFWS) National Fish Hatcheries, located at Edenton and McKinney Lake, North Carolina. Phase II fish were harvested from ponds in late fall and early winter at approximately 102-254 mm (4-10 in).

Prior to stocking, a portion of the fish were tagged with cinch-up spaghetti tags (approximately 5 in long) or internal anchor tags (approximately 2.5 in long). Tagged fish were held two to seven days prior to stocking to establish short-term tagging mortality rates. The fish were transported by the USFWS to appropriate stocking locations and released.

The stocking and tagging programs were widely publicized. Rewards were offered for the return of tags and pertinent information concerning recapture. Letters were sent to all persons returning tags providing information on when and where the fish were released.

FINDINGS

During the project, 457,242 Phase II striped bass were released in coastal North Carolina. Of the total, 28,496 were tagged prior to stocking, and 921 (3.2%) have been returned (Table 2). All of the tag returns have occurred from the internal waters of North Carolina, indicating no evidence of contribution to the Atlantic Ocean migratory stock.

Phase II striped bass were released in the Albemarle Sound area annually during 1986-1990, in the Neuse River in 1986, 1988, and 1990, in the Pamlico River area in 1987, and in the Cape Fear River in 1989 (Figure 6). All of these stockings occurred in the natural striped bass nursery areas in each system (Street et al. 1975; Marshall 1976; Johnson et al. 1977; Sholar 1977, Hawkins 1979 and 1980, and Winslow et al. 1983 and 1985).

Albemarle Sound Area - 1986-1990

A total of 17,007 tagged Phase II striped bass was released in the Albemarle Sound area from January 1986 through December 1990 (Figure 7). Since the stockings occurred, 4.5% of the tags have been returned. Table 2 presents the annual stocking figures, number of returns, and the methods of recapture.

The pre-recruit striped bass movements were the same for each stocking regardless of the release site and similar to those reported by Winslow and Johnson (1984). This was especially true along the southeastern shore of Albemarle Sound and the Alligator River during the winters. During the spring,

Table 2. Summary of Phase II striped bass stockings, returns, and recapture gears from coastal North Carolina, 1986-1991

System stocked	Total number stocked	Number tagged	Returns No.	Returns %	Percent returns after recruitment	Recapture gear: Gill nets No.	Gill nets %	Pound nets No.	Pound nets %	Hook & line No.	Hook & line %
Albemarle Sound area-Jan 1986	45,200	1,110	35	3.2	48.6	30	85.7	0	-	5	14.3
Neuse River area-Jan 1986	39,769	2,199	58	2.6	17.3	45	77.6	0	-	13	22.4
Albemarle Sound area-Dec 1986	118,345	4,999	443	8.9	23.1	432	97.5	1	0.3	10	2.2
Albemarle Sound area-Dec 1987	15,435	2,499	179	7.2	38.6	168	93.7	0	-	11	6.1
Pamlico River area-Dec 1987	17,993	2,500	34	1.4	5.9	28	82.3	0	-	6	17.7
Neuse River area-Dec 1988	71,092	2,500	11	0.4	63.6	6	54.5	0	-	5	45.5
Albemarle Sound area-Dec 1988	5,000	5,000	82	1.6	15.9	81	98.8	0	-	1	1.2
Albemarle Sound area-Dec 1989	3,289	1,399	8	0.5	0	8	100.0	0	-	0	-
Cape Fear River area-Dec 1989	77,242	1,298	19	1.5	0	18	94.7	0	-	1	5.3
Albemarle Sound area-Dec 1990	2,000	2,000	0	-	0	0	-	0	-	0	-
Neuse River area-Dec 1990	61,877	2,992	52	1.7	0	46	88.5	0	-	5	9.6
Total	457,242	28,496	921	3.2							

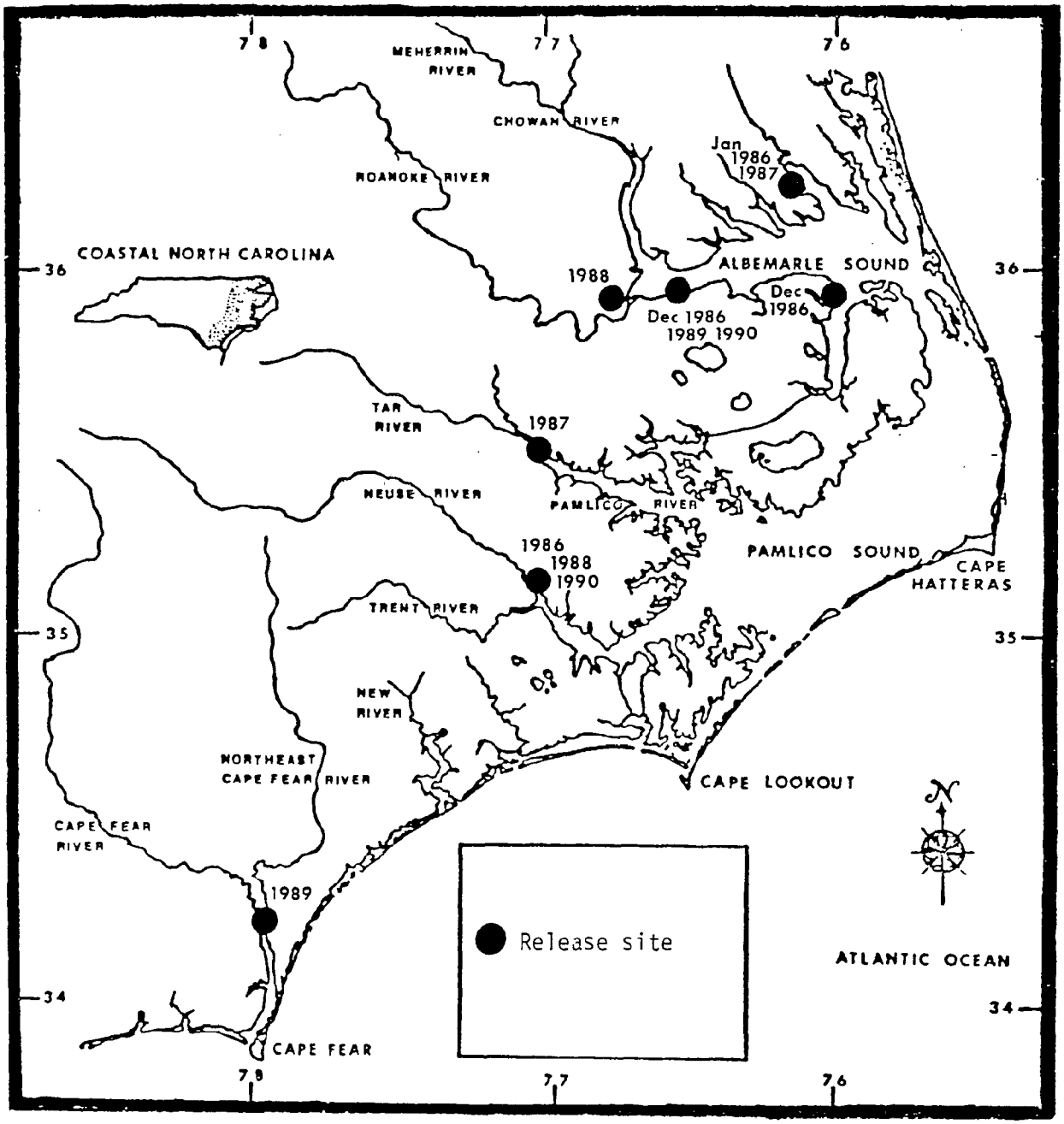

Figure 6. Release sites of Phase II striped bass stockings, 1986-1990.

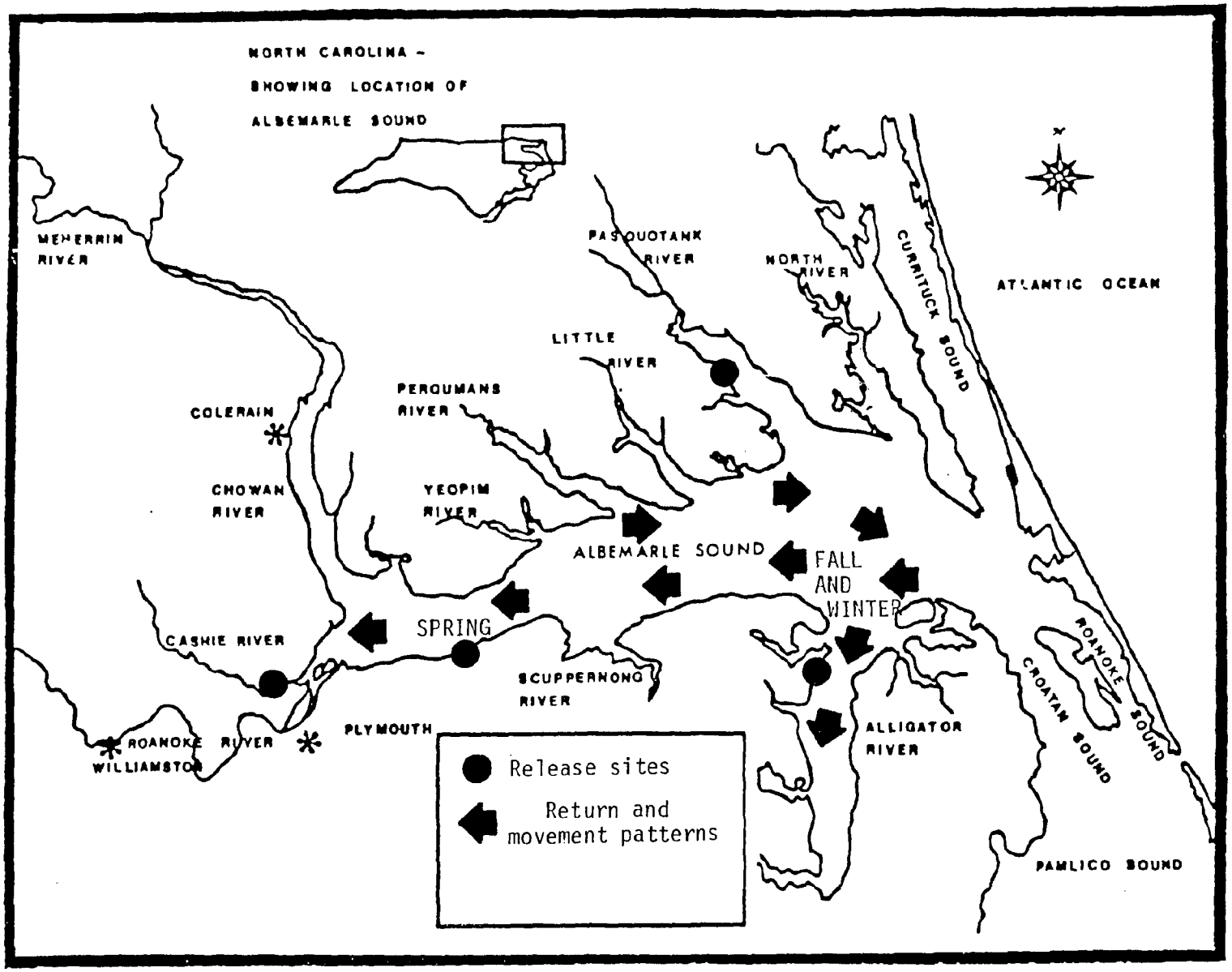

Figure 7. General return and movement patterns of Phase II striped bass stocked, Albemarle Sound area, NC, 1986-1991.

a general movement to the western sound was observed. As the winter months approached, the returns again were from the eastern sound area (Figure 7).

The majority of the returns have consistently been from gill nets (85.7-100%) with hook and line accounting for any remainder (Table 2). Many of the early returns prior to recruitment into the fisheries were a result of entanglement of the tag in gill net webbing. However, since the fish have reached legal size the percentage of return from all gear has ranged from 15.9% to 48.6%. These data confirm that stocked fish have contributed to the commercial and recreational fisheries in the area.

During this project, four returns were from the spawning grounds on the Roanoke River, each occurring during May (Table 3). Two additional returns were from the Roanoke River in May 1990, but not from the spawning area. However, these fish may have been participating in the spawning migration. Winslow and Johnson (1984) reported eleven Phase II tag returns from the spawning grounds in Roanoke River. The returns from the spawning grounds indicate that the stocked fish have contributed to the spawning population. Due to the known age of these fish an assumption of contribution can be made.

Neuse River Area

The Neuse River was stocked with 7,691 tagged Phase II fish during the project (Figure 8) and 121 (1.6%) have been returned. The stocking numbers, returns and recapture gears are shown in Table 2.

The movements of these Phase II striped bass from the various stockings were similar to that reported for the Neuse River area by Winslow and Johnson (1984). The majority of the returns occurred between the release site and the mouth of Goose Creek (Figure 8).

Gill nets have accounted for the majority of the returns from the Neuse River area (Table 2). The percentage of hook and line returns ranged from 9.6-45.5%. Returns have occurred from both sectors of the fishery since the 1986 and 1988 stockings reached legal size.

Pamlico River Area

A total of 2,500 tagged Phase II striped bass was released in the Pamlico River area during December 1987 (Figure 9). Thirty-four tags (1.4%) have been returned (Table 2).

Eighty-two percent of the returns occurred from the area between Washington and Goose Creek (Figure 9). This percentage is higher than that reported by Winslow and Johnson (1984) for the 1983 stocking (48%) and Winslow et al. (1985)

Table 3. Phase II striped bass tag returns (N=4) from the Roanoke River spawning grounds as the result of various Albemarle Sound area stockings, 1986-1990.

Release date	Recapture date	Days at large	Miles recaptured from release site
Jan 1986	May 1987	503	172
Dec 1986	May 1988	526	142
Dec 1986	May 1989	885	135
Dec 1987	May 1989	522	172

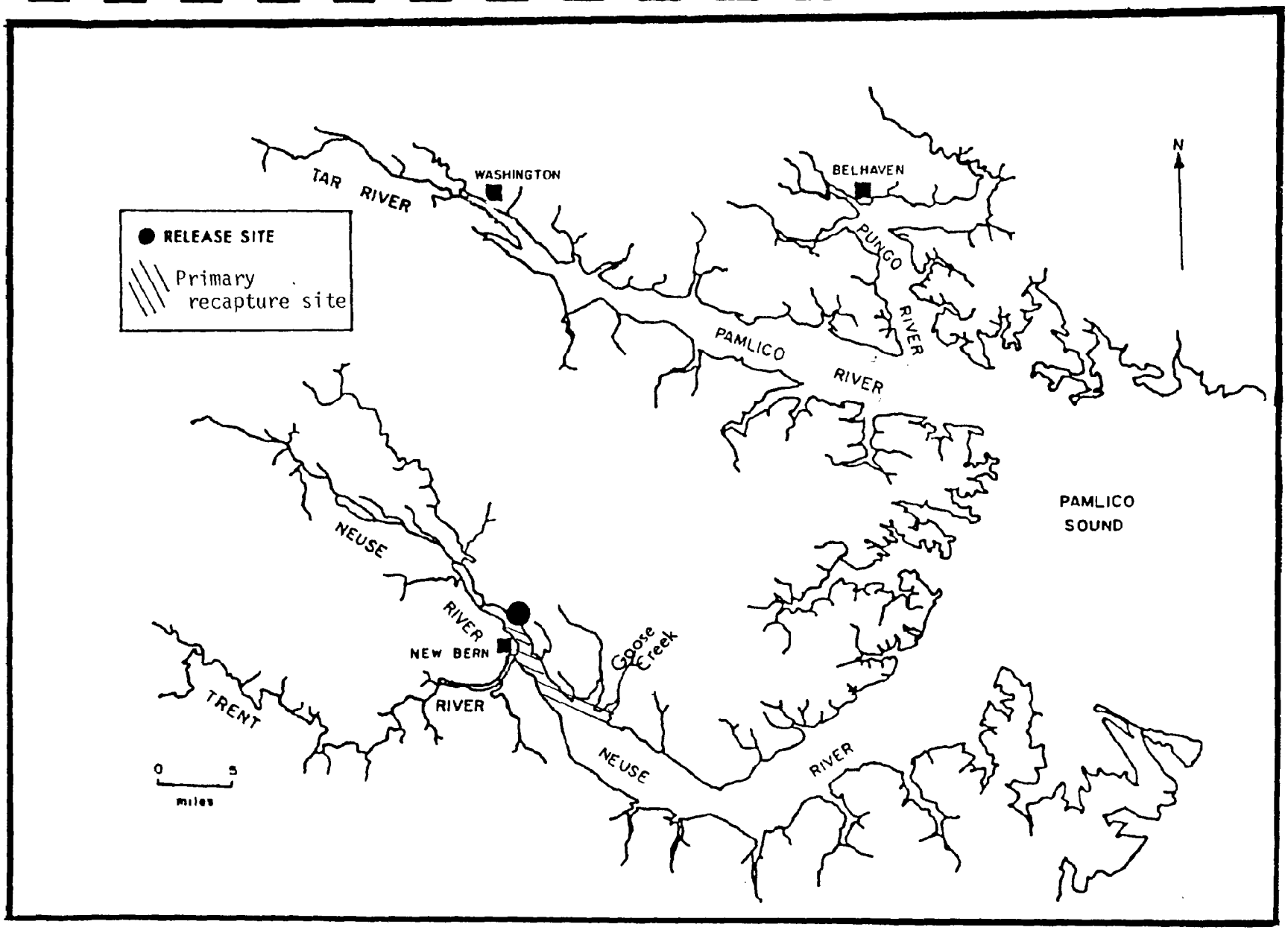

Figure 8. Primary recapture location of Phase II striped bass released in Neuse River, NC, 1986, 1988, and 1990.

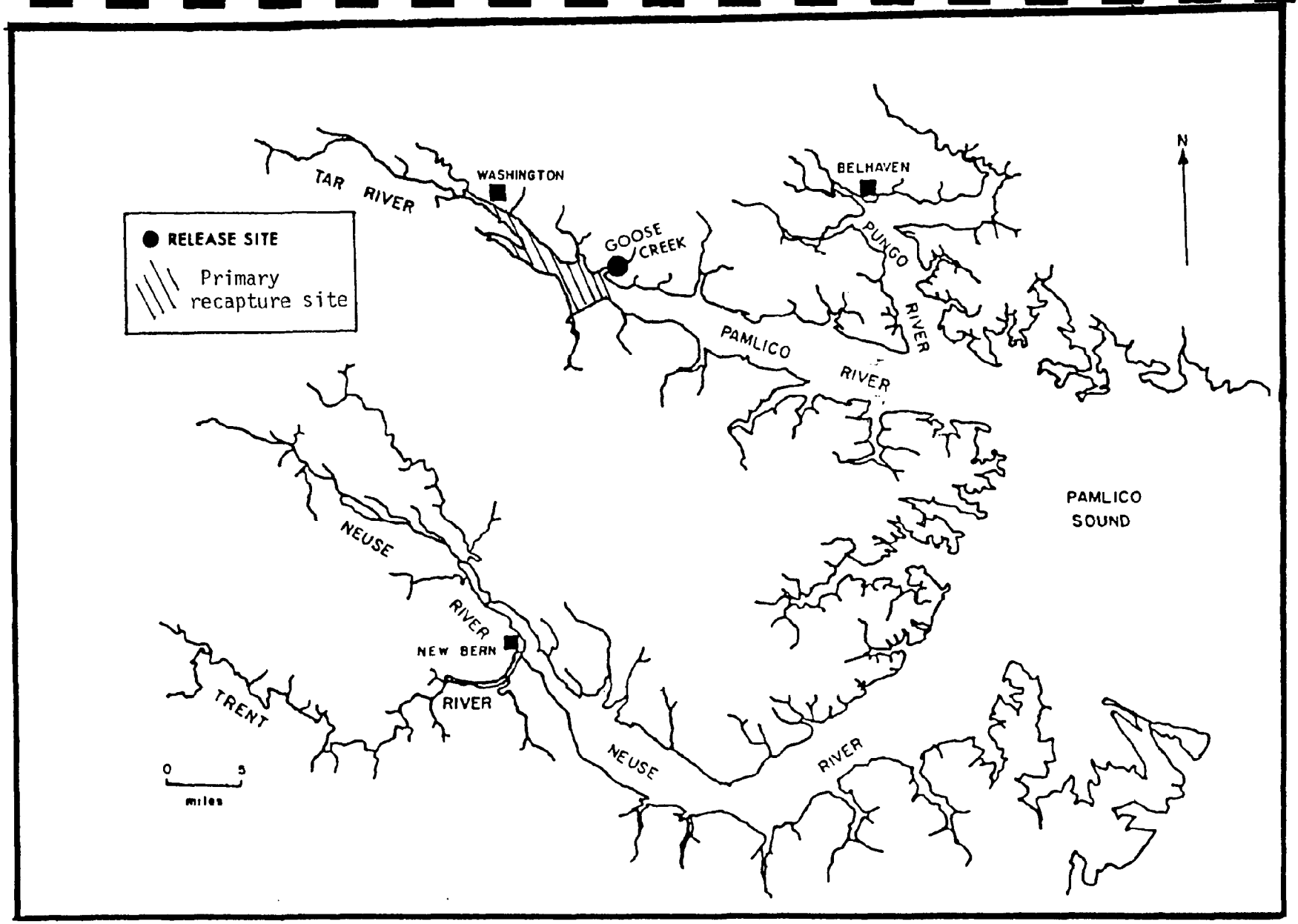

Figure 9. Primary recapture location Phase II striped bass released in Pamlico River, NC, 1987.

for the 1984 stocking (76%). No returns occurred from outside the Tar-Pamlico River drainage from the 1987 stocking. Winslow and Johnson (1984) and Winslow et al. (1985) reported significant returns from below Goose Creek in Pamlico River, the Pungo, and Neuse rivers, and Albemarle Sound.

The majority of the tag returns were from gill nets prior to recruitment into the fishery. Hook and line returns have accounted for 17.7%. Only 5.9% of the returns have occurred from the commercial and recreational fisheries since the fish attained legal size (Table 2).

Cape Fear River Area

In December 1989, 1,298 tagged Phase II fish were released in the Cape Fear River (Figure 10), and 1.5% (N=19) have been returned (Table 2). All of these returns occurred prior to the fish attaining legal size. Of these returns, 94.7% were taken by gill nets and 5.3% by hook-and-line.

The recapture locations were similar to previous stockings as described by Winslow and Johnson (1984) for 1980 and Winslow et al. (1985) for the 1984 stockings (Figure 10).

CONCLUSIONS

The results of these Phase II stocking programs have shown that stocking can be used as a management tool. The data indicate that the stocked fish do contribute to the commercial and recreational harvest in each system. Tag returns from the Roanoke River spawning grounds show that these fish are, to some extent, augmenting the spawning population. All of the tag returns during this project were from the internal waters of North Carolina. These returns indicate no evidence of contribution to the Atlantic Migratory Stock from North Carolina.

Tagging a portion of Phase II fish will continue to provide data for determining exploitation rates and survival to first spawning. These stocking programs will help sustain a striped bass population during low levels of abundance. However, stocking at these levels will not be effective in restoring populations to self-sustaining levels in the face of fishing pressure prior to sexual maturity and poor environmental conditions.

STUDY V: ASSESSMENT OF ADULT STRIPED BASS

NEED: In order to adequately evaluate the status of the striped bass population of Albemarle Sound, Roanoke River, and the Atlantic Ocean migratory stock which overwinters off the North Carolina coast, the age and size composition of these stocks must be sampled. Because male and female striped bass exhibit different growth patterns, these data must be combined with data on sex of the fish examined. The North Carolina Division of Marine Fisheries participates in the

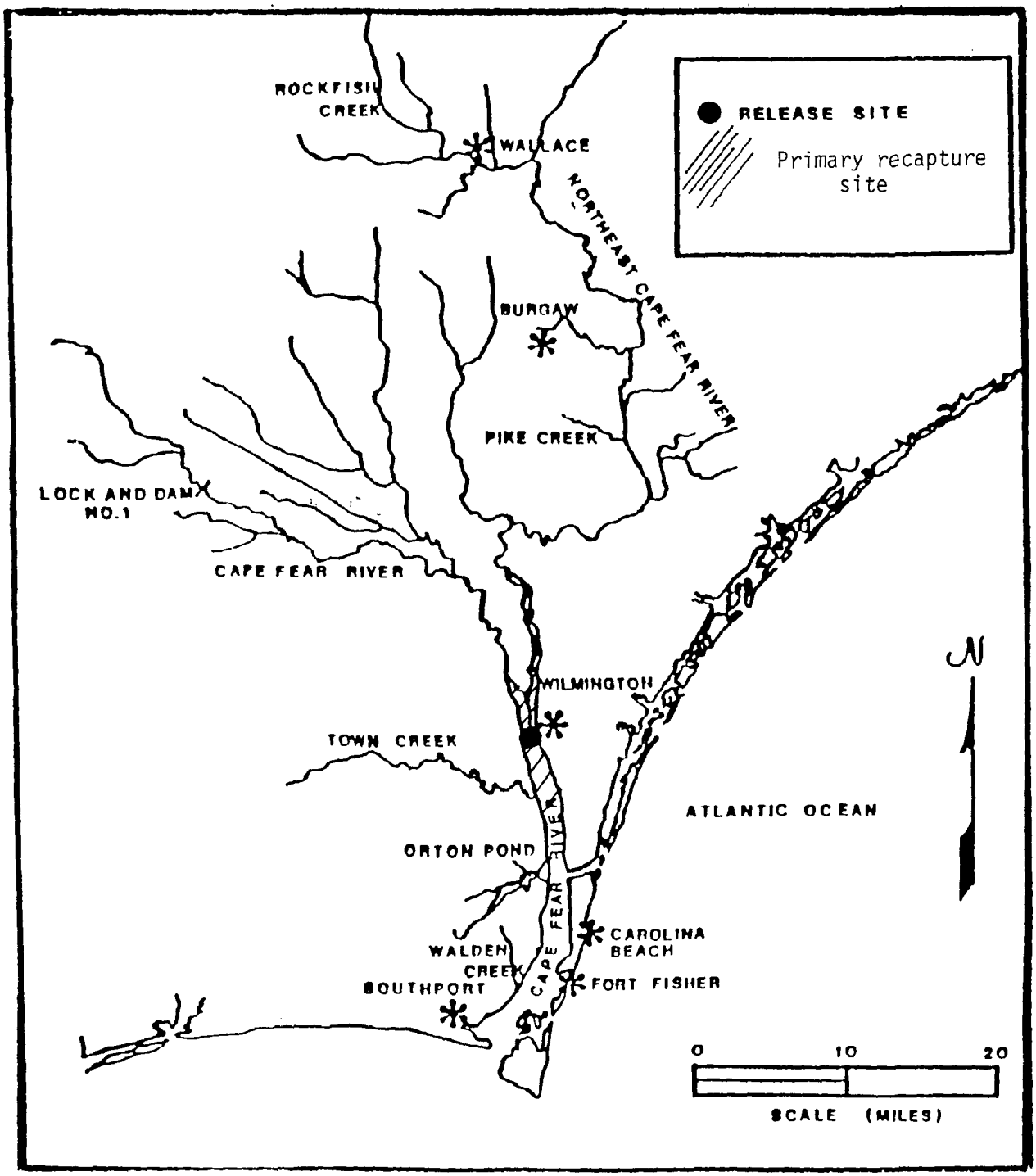

Figure 10. Primary recapture location Phase II striped bass released in Cape Fear River, NC, 1989.

interstate striped bass program of the Atlantic States Marine Fisheries Commission (ASMFC) and North Carolina striped bass come under the jurisdiction of the Atlantic Striped Bass Conservation Act (PL89-613). The North Carolina Marine Fisheries Commission (MFC) has enacted increasingly stringent regulations to conserve striped bass. Current data on the status of the Albemarle/ oanoke stock are essential for MFC deliberations. The ocean fishery for striped bass off North Carolina is currently very limited, due to restrictions required by the interstate program. Data on these fish are needed for coastwide assessment of the status of the migratory stock.

OBJECTIVE: To determine size, age, and sex composition of the major striped bass populations in North Carolina

JOB 1: Size, Age, and Sex Composition of Albemarle Sound Striped Bass
OBJECTIVE: To determine the size, age and sex composition for adult Albemarle Sound striped bass harvest

APPROACH

Adult Sampling

A target of up to 500 striped bass was to be sampled annually to obtain size, age, and sex data from the Albemarle Sound fishery. Approximately 30 fish were to be sampled monthly at two or three locations (Figure 11) during the commercial season, generally November-March.

Samples were taken in approximate proportion to the sizes of fish present in the fish house. Individual fish were measured (mm, FL), weighed (nearest .01 kg), and scales were taken for age determination. Sex was determined by the Sykes (1958) method.

During 1986 through 1990 a portion of the scale samples was subsampled annually for age according to Ketchen (1950). Scales were read and annuli measured as described by Harriss et al. (1985). Age and year class were assigned according to conventions developed by the ASMFC Striped Bass Scientific and Statistical Committee. In North Carolina, the time of annulus formation is considered to be January. Age and year class are then assigned in consideration of the date of capture relative to the January birthday. Thus, individuals from a given year class could be assigned two different ages depending on the date of capture.

Contribution of Year Class to Harvest

Striped bass from the Albemarle Sound commercial harvest, for which age, sex, and weight data were available, were placed in the appropriate year class for each month sampled from January 1986 through April 1991. The number of

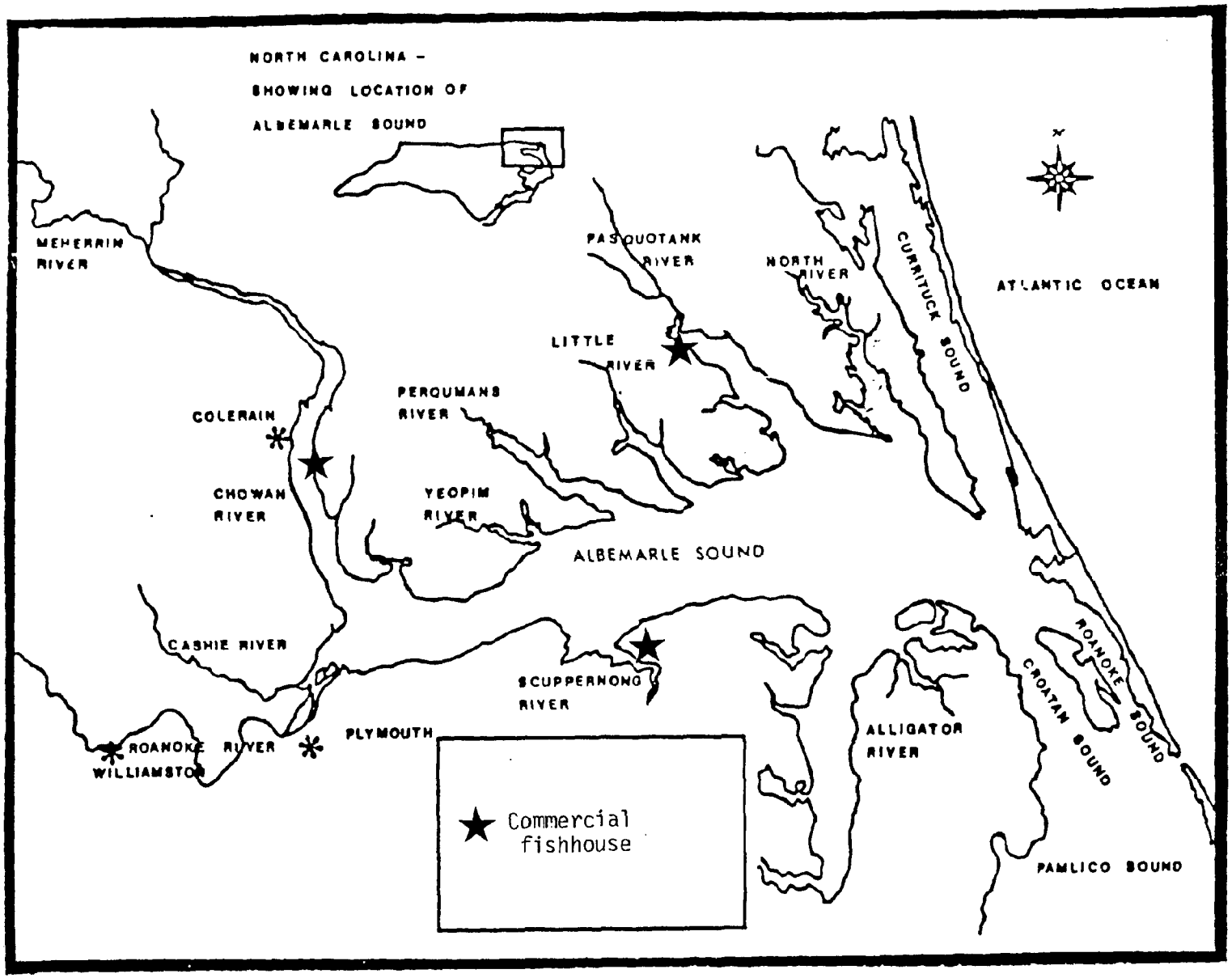

Figure 11. Locations of Albemarle Sound area commercial fishhouses sampled, 1986-1991.

individuals of each year class was followed monthly through the sampling period. The number (N) of striped bass landed for a month of a particular sex and age class was calculated by multiplying the landings (kg) by the percent weight of the landings made up of that sex and age class divided by the mean weight of that sex for that year class during the month. To obtain the estimated number of individuals, the following calculations were performed:

$$\text{Number of individuals landed} = \frac{\text{Landings (kg)} \times \text{\% wt of sex of year class}}{\overline{\text{wt}} \text{ of sex of year class}}$$

$$\text{To obtain \% wt of sex, year class} = \frac{\text{wt of sex of year class}}{\text{wt of all year classes, both sexes}}$$

FINDINGS

A total of 2,123 striped bass was sampled from three commercial fish dealers in the Albemarle Sound area from January 1986-April 1991 (Figure 11). Of the total, 1,012 were male and 1,111 female, for a sex ratio of 0.91:1. Sex ratios ranged from 0.61:1 to 1.73:1, male to female during the six seasons. The range of these sex ratios were between those reported by Harriss et al. (1985) and Winslow and Harriss (1986) for 1980-1985.

1986 Season

During January-March 1986, 150 striped bass were sampled from the Albemarle Sound commercial harvest. The small sample was the result of a shortened commercial striped bass season (90 days), which ended 31 March, and lack of cooperation by dealers, who were retaliating against management and conservation regulations (Street 1986). All fish were found suitable for age determination.

The length and weight ranges, by sex, and sex ratio data for the sampling period are presented in Table 4. Striped bass from the 1984 year class (age II) dominated the catch, comprising approximately 77% of the total sample (Table 5). The length-frequency distribution was dominated by fish in the 351 mm to 400 mm size range.

1986-1987 Season

A total of 454 striped bass was sampled from the Albemarle Sound commercial harvest from November 1986 through April 1987. Scales from five of these fish were unsuitable for age determination. Subsamples were taken from males and females in the 300 to 350 mm size group and females in the 500 to 550 mm size group.

Table 4 shows the length and weight ranges, by sex and the sex ratio for the November 1986-April 1987 samples. Striped bass from the 1983-1985 year classes (ages IV-II) dominated the catch, comprising approximately 92% of the

Table 4. Striped bass size ranges (length and weight) and sex ratios by harvest season from the Albemarle Sound commercial fishery, 1986-1991.

Harvest season	Male		Female		Sex ratio
	Fork length range (mm)	Weight range (kg)	Fork length range (mm)	Weight range (kg)	Male to female
Jan-Mar 1986	335-535	0.49-2.23	333-1,170	0.56-19.06	1.3:1
Nov 1986-Apr 1987	324-1,219	0.45-21.38	330-792	0.50-6.80	0.8:1
Nov 1987-Apr 1988	324-722	0.47- 4.99	329-1,041	0.47-13.18	0.7:1
Nov 1988-Apr 1989	316-564	0.47-3.12	308-668	0.44-4.99	0.6:1
Nov 1989-Apr 1990	332-742	0.46-6.80	326-1,120	0.45-19.96	1.2:1
Jan-Apr 1991	333-745	0.44-6.35	338-755	0.53-8.28	1.7:1

Table 5. Percent contribution by year class for striped bass (sexes combined) sampled from the Albemarle Sound, NC, area commercial harvest 1972-1991 (1972-1985 from Street 1986).

Year class	FISHING YEAR																			
	1972[1]	1973[1]	1974[1]	1975[1]	1976[2]	1977[2]	1978[2]	1979[2]	1980[2]	1981[2]	1982[2]	1983[2]	1984[2]	1985[2]	1986[2]	1987[2]	1988[3]	1989[3]	1990[3]	1991[3]
1961	0.2	0.2																		
1962	0.1	0.2																		
1963	0.2	0.2	0.3																	
1964	0.7	0.4	1.6	0.3																
1965	1.8	0.6	1.0	-		0.3														
1966	2.8	2.4	1.0	0.6	0.1	0.7														
1967	11.5	4.1	-	1.7	0.1	1.0														
1968	22.5	7.7	0.3	2.9	1.5	2.0														
1969	28.2	19.9	7.8	5.2	1.9	3.0														
1970	30.2*	40.5	25.0	25.2	9.4	3.5									0.7	0.2				
1971		23.8*	48.4	25.5	23.7	4.0														
1972			14.6*	21.2	16.0	4.5	1.3	0.7												
1973				17.4*	43.2	10.0	8.3	5.0	0.6		0.3	0.3	0.3							
1974					4.1*	50.0	25.1	13.4	2.7	0.3	-	0.3	-							
1975						21.0*	36.2	15.1	3.8	2.3	0.3	1.1	-						0.3	
1976							29.1*	37.1	5.9	5.0	1.8	2.3	-		0.7					
1977								28.7*	7.4	3.7	4.9	3.1	1.5	0.1	-					
1978									31.4*	9.4	9.5	5.6	1.8	0.4	-					
1979									48.2	45.1*	34.9	16.4	11.8	0.6	0.7	0.7	0.3		0.3	
1980										35.2	48.3*	38.1	15.0	1.0	0.7	-	0.8		0.3	
1981												32.8*	3.8	1.8	-	0.4	0.5		-	
1982													65.2*	23.7	7.3	6.7	2.0	0.2	0.6	0.5
1983														63.3*	12.6	19.6	4.8	0.4	0.6	-
1984														9.1	77.3*	21.8	13.2	4.3	1.1	0.9
1985																50.6*	28.0	24.7	3.1	0.9
1986																	50.4*	28.2	11.7	2.7
1987																		42.2*	7.5	12.8
1988																			74.5*	61.2
1989																				21.0*

* Denotes age II fish

1. Only spring time sampling occurred.
2. 1976-1987 year-round sampling.
3. 1988-1991 seasonal sampling due to harvest season.

sample (Table 5). The largest male sampled during this season was 1,219 mm and is possibly the largest and oldest (17 years) male recorded from the Albemarle Sound. The total sample was comprised mainly of fish in the 351 to 400 mm size range. Female fish in the 501 to 600 mm size range of ages IV and V composed a significant portion (20%) of the commercial samples.

1987-1988 Season

During November 1987-April 1988, 400 samples were obtained from the commercial harvest, of which 394 were suitable for ageing. Males and females in the 351-400 mm size interval and females from 451-500 mm were subsampled for age.

The length and weight ranges and sex ratio are presented in Table 4. The percent contribution of the year classes are shown in Table 5. Striped bass from the 1984-1986 year classes (ages IV-II) dominated the catch, comprising approximately 91% of the sample. The sample was mainly composed of fish in the 351 to 400 mm size range, sexes combined. Female fish in the 451 to 600 mm size range, ages II through V, comprised a significant portion (29%) of the commercial samples.

1988-1989 Season

The Albemarle Sound area commercial harvest survey from November 1988 through April 1989, yielded 470 striped bass. Ten scale samples were unsuitable for age determination. Both sexes were subsampled for age in the 351-400 mm and 451-500 mm size intervals and females in the 501-550 mm size group.

The length and weight ranges and sex ratio for the period are shown in Table 4. Striped bass from the 1985-1987 year classes (ages IV-II) dominated the catch, comprising approximately 95% of the sample (Table 5). Males and females of the 351-400 mm size group and females in the 501-550 mm size group dominated the sample.

1989-1990 Season

A total of 358 striped bass was sampled from the commercial harvest, November 1989-April 1990. Only one sample was unsuitable for age determination. Subsamples for ageing were taken from both male and female in the 351 to 400 mm size intervals.

Table 4 presents the length and weight ranges and sex ratio data. The 1986-1988 year classes (ages IV-II) dominated the catch, comprising approximately 94% of the sample (Table 5). However, age II fish (1988 year class) made up 75% of the total sample. The sample was composed mainly of fish in the 351 to 400 mm size range for both sexes.

1991 Season

From January through April 1991, 291 samples were obtained from the commercial harvest. Scales from two of these fish were unsuitable for age determination. Size intervals 401-500 mm, male and female, were subsampled for age as previously described.

The length and weight ranges for both sexes during the period are shown in Table 4, as well as sex ratio. The percent of each year class to the striped bass harvest is presented in Table 5. Striped bass from the 1988 year class (age III) dominated the catch, comprising approximately 61% of the total sample. Males of the 401-451 mm size group and females in the 451-500 mm size group dominated.

The percent contribution of each year class of striped bass for 1986 through 1991 are shown in Table 5. The age components of the 1986 and 1990 harvest are similar with age II fish, comprising greater than 74% of the entire harvest. The 1987 through 1989 catch compositions are similar in that the age II fish represented 42.2-50.6% of the total harvest sample. The contribution of age III and IV fish combined (41-53%) were approximately equal to the age II composition during 1987-1989. The 1991 age composition of age II fish was significantly lower (21.0%) than the previous years. Age III fish represented 61.2% of the total harvest in 1991.

Contribution of Year Class to Harvest

The Albemarle Sound striped bass age and weight data from January 1986 through April 1991 were used to estimate the number of individuals in the commercial harvest from each year class by month.

Based on the estimated number of individuals from the striped bass harvest, January 1986 through April 1991, two and three year olds have consistently dominated the harvest, ranging from 69.9-92%. The percentage of age V and older fish (0.8-10%, Table 6) was higher than that reported by Winslow and Harriss (1986) for October 1984-December 1985 (1.7%), except for January-March 1986. The percentages found from the estimation of individuals by year class (Table 6) are similar to those found by year class from ageing data, except for 1989 (70.4%) and 1991 (82.2%-Table 5).

CONCLUSIONS

The size, age, and sex composition was determined annually, 1986-1991, for the striped bass commercial fishery in Albemarle Sound. The fishery, principally an anchor gill net fishery, continued to harvest a depressed population composed mainly of fish two to four years of age. This agrees with the harvest

Table 6. Estimated percent contribution by year class of the striped bass harvest from the Albemarle Sound, NC, commercial fishery, 1986-1991.

Year class	Fishing season					
	1986	1987	1988	1989	1990	1991
1970	0.2	0.4	-			
1972	-	-	0.3			
1975	-	-	-		0.1	
1976	0.2	-	-		-	
1979	0.2	1.0	-		0.1	
1980	0.2	-	0.8		0.2	
1981	-	0.6	0.9		-	
1982	10.0	8.0	2.2	0.1	0.3	0.2
1983	14.9	20.1	4.3	0.2	0.4	-
1984	74.3	24.8	16.3	2.2	0.7	0.7
1985		45.1	28.6	12.3	3.6	0.6
1986			46.6	12.1	10.7	1.5
1987				73.1	7.3	5.0
1988					76.6	50.1
1989						41.9

information reported by Harriss et al. (1985) and Winslow and Harriss (1986) for the 1980-1985 fishing seasons.

Data from this project and information presented in Harriss et al. (1985) and Winslow and Harriss (1986) provide a long term sex and age specific database for the commercial harvest spanning the period, July 1980 through April 1991. Several conclusions can be made comparing the harvest seasons.

Approximately equal numbers of male and female fish were present through age III. The number and proportion of males in the harvest generally decreased as age increased, declining significantly beginning at age IV. Few males of age V or greater were present in the harvest. The percentage of females in the harvest increased significantly after age IV. Females of ages IV-VII were consistently present in the Albemarle Sound harvest. The majority of females age IV and greater were harvested in large mesh gill nets, which are fished in the spring principally for American shad (*Alosa sapadissima*) in the spring.

Typically, the commercial fishery targets and harvests the most abundant year classes available. During these years of low population levels, relatively abundant year classes, such as 1984 and 1988, tend to dominate the harvest at age II and effectively overshadow the contribution of older year classes. The increased abundance of these two year classes were reflected in the 1986 and 1990 landings.

Comparison of harvest from the 1970s show that three or four year classes each contributed 10% or more to the catch prior to 1980 (Table 5) (Street 1986). It should be noted that prior to July 1976, only spring time sampling occurred for age determination. Since 1980, two or three year classes have contributed 10% or more to the annual harvest. This change reflects the decreased annual juvenile abundance indices which has occurred since 1977 in the Albemarle Sound (Street 1986).

The fishery is increasingly dependent on one or two year classes as a result of poor juvenile production. Prior to 1984, no single year class contributed more than 50% to the harvest. During this project, single year classes of age II fish accounted for over 50% of the total harvest in 1986-1988, and 1990.

An increased minimum size limit and complimentary gill net mesh restrictions would be beneficial for striped bass conservation. The North Carolina Marine Fisheries Commission (MFC) increased the minimum size limit for striped bass to 18 inches total length, in internal coastal waters, effective 1 November 1991. This was in compliance with Amendment No. 4 to the ASMFC Striped

Bass Management Plan (ASMFC 1989) for "producing areas," which includes Albemarle Sound. The MFC has provided the Fisheries Director with proclamation authority to limit or prohibit the use of gill nets in coastal waters and/or impose areas, seasons, mesh sizes, lengths, and number of net restrictions.

Fishery size limits are designed to exclude a segment of the stock from harvest (ASMFC 1989) and potentially allow more fish to reach sexual maturity. The 18 inch TL minimum size limit will practically eliminate the harvest of age II fish and delay initial fishing mortality for approximately one year. The increased size limit will reduce fishing mortality on a large segment of the Albemarle/Roanoke population, since age II fish have been a major portion of the harvest since the 1980s.

A 24 inch TL size limit would be necessary to provide increased protection to a portion of the female spawning population. Lewis (1962), Harriss et al. (1985), and Olsen and Rulifson (1991) reported the principal age of maturity for female Albemarle/Roanoke striped bass to be age IV.

The 24 inch TL size limit would eliminate the harvest of fish age IV and younger and allow more females to reach maturity and spawn. Whereas, the 18 inch size limit may direct additional harvest pressure towards age III and IV fish.

Gill net restrictions, will provide the means to reduce the bycatch of striped bass less than the minimum size limit. The Albemarle Sound gill net fishery must be managed to minimize the bycatch wastage of striped bass, as the losses may negate the potential gains from the increased size limit.

A negative aspect of the increased size limit will be that sampling the commercial harvest will not reflect the relative abundance of the various age classes as in the past. The increased size limit will not provide fishery managers the opportunity to utilize a portion of the inherent natural mortality or bycatch mortality incurred by undersize fish to assess the population.

Early life history and adult information suggest that abnormally high natural mortality, caused by various environmental changes, has contributed to the Albemarle/Roanoke striped bass decline. The DMF realizes that the Albemarle/Roanoke striped bass resource may not be able to recover to historical levels due to environmental changes and habitat degradation.

Monitoring of the commercial harvest by size, age and sex is an important component of striped bass management and its continuation meets the requirements of the ASMFC Striped Bass Plan (1989). Harvest information has allowed resource managers to evaluate the year class composition, status of the stocks, and the

effects of regulations on the harvestable population. Harvest surveys will become increasingly important as resource managers attempt to estimate fishing mortality for the various year classes through population modeling efforts.

Harvest quota management is currently utilized as the principal management component to control fishing mortality for the Albemarle/Roanoke striped bass population. As the state management agencies refine data analysis and the decision making process, quota management will become increasingly important for managing harvest allocations and maintaining acceptable levels of fishing mortality. Minimum size limits and effort restrictions, in the absence of quota management, are not presently sufficient to control harvest.

The ongoing Fishery Independent Gill Net Survey for the Albemarle Sound Striped Bass (NC Striped Bass Study Management Board, Work Order 90-1 and 91-1) incorporated a random sample design to monitor the stock independent of the commercial fishery. This fishery-independent work has become increasingly important, as the commercial harvest composition will no longer provide an overall evaluation of the size, age, and sex composition for the population. The fishery-independent survey will also allow pre-recruits to be followed from the time the juvenile survey ends until the fish enter the commercial and recreational fisheries.

JOB 2: Size, Age, and Sex Composition of Striped Bass from the Roanoke River Spawning Population

OBJECTIVE: To determine the size, age, and sex composition of the spawning population of striped bass in the Roanoke River.

APPROACH

Throughout the Roanoke River area, including Batchelor Bay up to the major spawning grounds at Weldon and Roanoke Rapids, project personnel obtained size, age, and sex data from commercially and recreationally harvested striped bass. Local access points, fish camps, and commercial fish houses along the Roanoke River were visited and sampled. A target figure of up to 150 striped bass was to be sampled annually. Individual fish were measured (mm, FL) and weighed (nearest .01 kg). Scales and occasional otoliths were taken for age determination. Sex was determined for each fish by the Sykes method (1958) or by visual inspection.

Scales were read and annuli measured as described by Harriss et al. (1985). Age and year class were assigned as previously described in the Albemarle Sound commercial harvest approach (Study V, Job 1). Otoliths were aged and compared to the age derived from the corresponding fish scale, utilizing the otolith

ageing process outlined by Humphries and Kornegay (1985). Otoliths were obtained only through the cooperation of recreational fishermen.

FINDINGS

During April through June 1986-1991, 1,082 striped bass were examined to determine size, age,and sex composition of the Roanoke River spawning population. Scales from 1,039 fish were suitable for ageing. The majority of the fish were obtained from the spawning area by sampling recreational hook-and-line fishermen between Weldon and Roanoke Rapids (Figure 12). Of these fish, 618 were male and 464 were female, for a sex ratio of 1.3:1. The data gathered during the spring Roanoke River spawning run is summarized by season.

1986 Season

A total of 112 striped bass was examined to determine size, age, and sex composition of the Roanoke River spawning population, April through May 1986. One hundred and two fish sampled were suitable for age determination. The 1983 and 1984 year classes (ages III-II) accounted for the majority (84.6%) of the males sampled. The female sample was dominated (84%) by the 1982 and 1983 year classes (ages IV and III).

Male striped bass numbers peaked at the 451-500 mm size interval, while numbers of female fish peaked at the 551-600 mm. The length and weight ranges, by sex, and sex ratio data for the sampling period are presented in Table 7.

Age composition data was obtained from pound nets (lower river), hook-and-line (throughout the river), and electroshocking (spawning area). Data obtained from hook-and-line and electroshocking are probably the most representative of the spawning population of mature fish. These data show that 91.9% of the spawning male and female fish are age V or younger. However, 82.9% of the females sampled on the spawning run were age IV or older (Table 8). Data from several maturity studies (Lewis 1962, Harriss et al. 1985) indicate that age IV is the age of principal female spawning in the Roanoke River population.

1987 Season

During April through June 1987, 247 striped bass were sampled from the spawning population. Two hundred and forty fish were suitable for age determination. The 1984-1985 year classes (ages III-II) accounted for the majority (92.3%) of the male fish sampled. The 1983 year class (age IV) dominated (40.3%) the female sample.

Numbers of male striped bass peaked at the 401-450 mm size interval and females at 501-600 mm. Table 7 shows the length and weight ranges, by sex and the sex ratio for the spawning run.

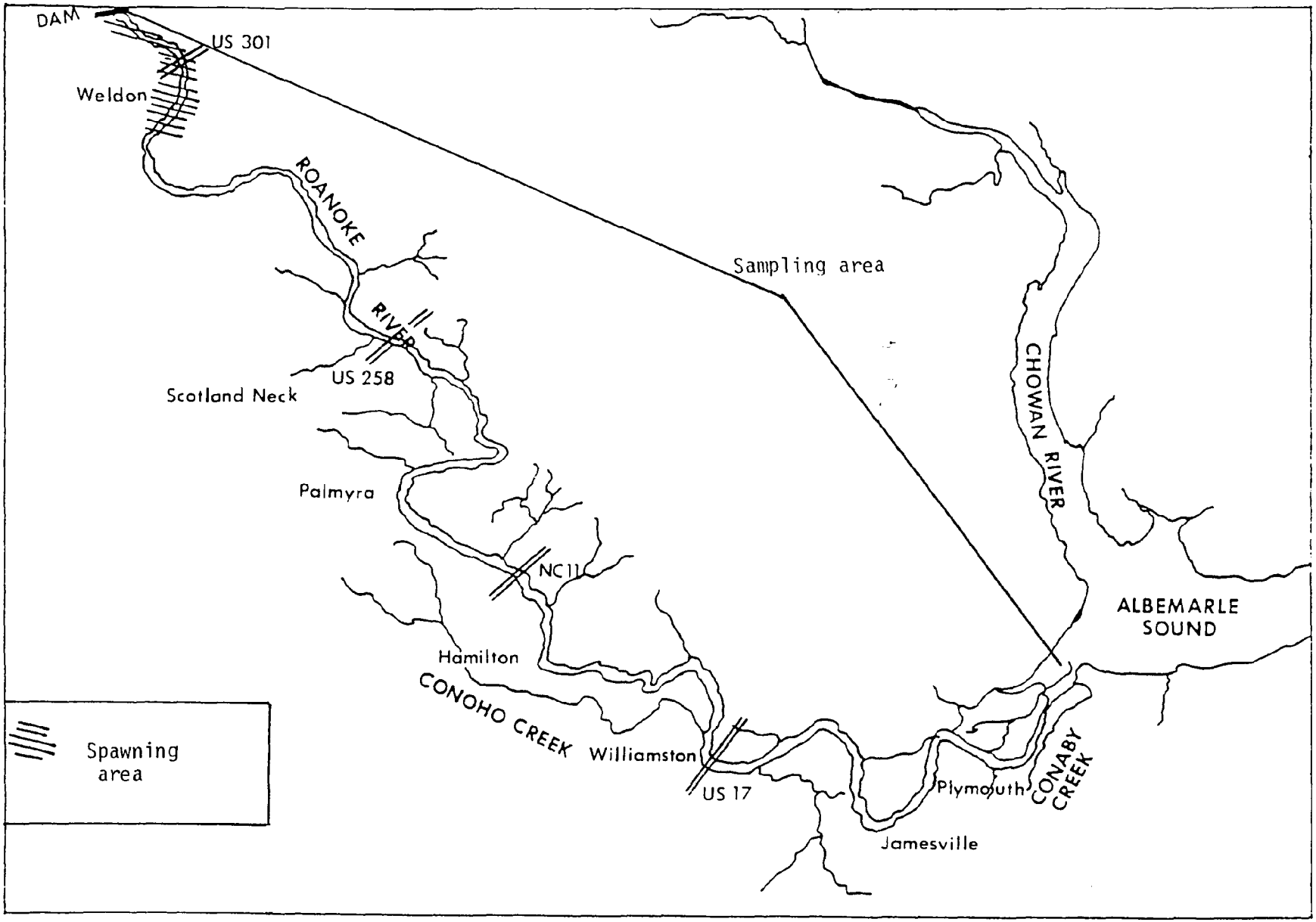

Figure 12. Principal spawning area and sampling lcoations for striped bass in Roanoke River, NC, 1986-1991.

The majority of the age composition data was obtained from the spawning grounds through a creel survey of recreational hook-and-line fishermen between Weldon and Roanoke Rapids. The hook-and-line data, which is most representative of the population, shows that 93.8% of the fish sampled were age IV or less. Of the females sampled on the spawning grounds 77.8% equaled or exceeded age IV.

1988 Season

The Roanoke River striped bass spawning population was sampled March through June 1988. A total of 160 striped bass was sampled and 143 were suitable for age determination. The 1985-1986 year classes (ages III-II) accounted for 72.4% of the males sampled and the 1984 year class (age IV) dominated the female sample (28.6%).

The size intervals for male striped bass peaked at 451-500 mm and females at 551-700 mm. The length and weight ranges, by sex, and sex ratio for the period are presented in Table 7.

Hook-and-line and electroshocking data give the least biased representation of spawning stock composition, with 58.3% of the females being age IV or greater (Table 8).

1989 Season

A total of 147 fish was sampled during March-June 1989 from the spawning run and 139 were found suitable for ageing. The 1986-1987 year classes (ages III and II) accounted for the majority (90.2%) of the male fish sampled. The female sample was dominated by the 1985 year class (age IV), contributing 51.5%.

Male striped bass peaked at the 351-400 mm size interval, while female fish showed a peak in the 501-550 mm size. Table 7 shows the length and weight ranges, by sex, for the spawning run and the sex ratio.

The electroshocking and hook-and-line data as previously mentioned, are the most representative of the spawning population of mature fish. The sample data show that 53.7% of the spawning population, was composed of age II and III fish. However, 86.4% of the females sampled from these sample gears were age IV or greater (Table 8).

1990 Season

During May 1990, a total of 247 striped bass was sampled, of which 246 were suitable for ageing. All samples were obtained by hook-and-line and electroshocking. The 1987 and 1988 year classes (ages III and II) accounted for the majority (95.8%) of the male fish sampled (Table 8). Age IV and older fish comprised 71.8% of the female sample.

Table 7. Striped bass size ranges (length and weight) and sex ratios from the Roanoke River spawning run, by year, 1986-1991.

Spawning season	Male		Female		Sex ratio
	Fork length range (mm)	Weight range (kg)	Fork length range (mm)	Weight range (kg)	Male to female
Apr-May 1986	394-600	0.71-2.67	420-791	1,22-6.08	1.2:1
Apr-Jun 1987	345-630	0.49-3.18	356-800	0.58-8.16	2.3:1
Mar-Jun 1988	345-811	0.65-7.00	342-847	0.57-9.95	1.4:1
Mar-Jun 1989	342-711	0.45-4.05	394-841	0.90-5.60	1.0:1
May 1990	350-616	0.50-3.44	385-832	0.73-7.40	2.1:1
Apr 1991	380-510	0.76-1.72	352-659	0.66-4.11	0.4:1

Table 8. Percent contribution of each year class of female striped bass sampled from the Roanoke River Spring spawning migration, 1981-1990. From Harriss et al (1985)*, Winslow and Harriss (1986)**, and DMF data combined with Nelson and Kornegay (1991).

	Spring sample season																					
Year class	1981*		1982*		1983*		1984*		1985**[1]		1986[2]		1987[3]		1988[2]		1989[2]		1990[2]		1991[2]	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
1971	3	2.0																				
1972	7	4.8			1	0.7																
1973	9	6.1	1	0.9	1	0.7																
1974	11	7.5	5	4.3	1	0.7	1	0.7														
1975	32	21.8	7	6.0	5	3.2	2	1.4														
1976	45	30.6	37	31.6	17	10.9	6	4.0														
1977	37	25.2	33	28.2	29	18.6	9	6.0														
1978	0	-	16	13.7	52	33.3	14	9.4	3	4.7					1	2.8						
1979	3	2.0	4	3.4	45	28.8	64	43.0	0	-	3	8.6	1	2.8	0	-						
1980			15	12.8	4	2.6	45	30.2	12	18.8	3	8.6	2	5.6	1	2.8	2	3.0				
1981					1	0.7	2	1.4	4	6.3	1	2.9	0	-	0	-	1	1.5	1	1.3		
1982							6	4.0	27	42.2	22	62.8	6	16.6	3	8.3	4	6.1	2	2.6	3	0.7
1983									18	28.1	6	17.1	19	52.8	6	16.7	9	13.6	3	3.8	5	1.1
1984											0	-	8	22.2	10	27.8	6	9.1	7	9.0	9	2.0
1985													0	-	9	25.0	35	53.1	11	14.1	9	2.0
1986															6	16.6	8	12.1	32	41.0	7	1.6
1987																	1	1.5	17	21.8	25	5.5
1988																			5	6.4	291	64.5
1989																					102	22.6
Total	147	(100%)	117	(100%)	156	(100%)	149	(100%)	64	(100%)	35	(100%)	36	(100%)	36	(100%)	66	(100%)	78	(100%)	451	(100%)
≥ age IV	143	(97.9%)	99	(84.7%)	151	(96.9%)	141	(94.7%)	19	(29.8%)	29	(82.9%)	28	(77.8%)	21	(58.4%)	57	(86.4%)	56	(71.8%)	58	(12.9%)

1. Data from pound net sampling only.
2. Data from hook-and-line and electroshocking sampling only.
3. Data from hook-and-line sampling only.

The male size interval peaked at 351-400 mm, while female fish showed a peak in the 551-600 mm range. The length and weight ranges by sex for the period and sex ratio are presented in Table 7.

1991 Season

The Roanoke River spawning population was sampled in April 1991 to determine size, age, and sex composition. A total of 169 fish was sampled from the hook-and-line fishery and all were aged. The 1988 year class (age III) accounted for the majority (87.6%) of the fish sampled, sexes combined. Age IV and older fish comprised 12.9% of the female sample (Table 8).

Male striped bass peaked at the 401-450 mm size interval, while female fish showed a peak in the 451-500 mm size interval. Table 7 presents the length and weight ranges, by sex and the sex ratio for 1991.

The North Carolina Wildlife Resources Commission (WRC), conducted a project entitled "Roanoke River Striped Bass Spawning Stock Assessment" (Work Order 91-10, Nelson and Kornegay 1991) during April-June 1991. This project was funded by the North Carolina Striped Bass Study Management Board to provide information as mandated in Section 5 of Public Law 100-589. One of the objectives was to estimate the size, age and sex composition of the Roanoke River spawning population.

The WRC sampled 2,001 striped bass from the spawning grounds from 15 April through 10 June 1991, of which 6 fish could not be sexed. Age III and II fish from the relatively abundant 1988 and 1989 year classes comprised 96.1% of the total. Of the females, 29.3% and 56.6% were age II and III, respectively, and 14.1% were 4 years old or older. The 1989 and 1988 year classes (ages II and III) accounted for 98.2% of the male sample.

The DMF data showed the 1989 and 1988 year classes, sexes combined, comprised 93.5% of the total sample. Females at age II contributed 3.4%, age III 87.6%, with 9.4% being age IV or greater. Male fish were from the 1989 year class (11.5%) or 1988 year class (88.5%).

Each agency sampled at different locations along the river. All electroshocking by the WRC occurred on the traditional spawning grounds between Gaston and Weldon, NC. The DMF sampled 58% (N=98) of the 169 striped bass from recreational fishermen from Hamilton down river to Plymouth, with the remaining 71 fish sampled at Weldon. The WRC sampling was fishery-independent, which would have an affect on the differences in age and sex composition.

CONCLUSIONS

The size, age, and sex composition of the Roanoke River spawning population was determined annually 1986-1991 and is an important component of the fisheries which must be monitored annually. The pound net fishery in the Roanoke River delta and Batchelor Bay area has been sampled since 1980. This fishery was initially sampled to gain unbiased (relative to gear) samples from the spring spawning run. However, samples from pound nets are affected by the seasonal sex and age specific migratory habits of striped bass. The relative abundance of mature male and female fish in this area fluctuates considerably, with male fish being most abundant in the early spring, followed by an increase of females later during the spring migration. Immature females also appear to congregate in the lower river areas during late spring. A long-term and intensive pound net sampling program (March-June) would be needed to eliminate the bias of the current sampling program. As a result of the potential gear bias and variable sample sizes, no reasonable comparisons can be made from the year to year pound net samples relative to the spawning population age composition.

Hook-and-line harvest and electroshocking data combined provides the most reliable indicator of the stock composition, particularly for mature females. The 16 and 18 inch (TL) seasonal minimum size limits for Roanoke River striped bass may affect efforts to determine the contribution of age II and III fish relative to the older age groups. Age II fish on the spawning grounds are principally males; therefore, the minimum size limit should not affect relative age distribution for mature females. The recreational fishery on Roanoke River spawning grounds is under the jurisdiction of the WRC. The WRC enacted a slot limit during the spring 1991 spawning season, which prohibited the harvest of fish between 22 and 27 inches TL, greatly affecting the age composition comparisons for female fish in future years.

Electroshocking samples should be relatively unbiased, and thus a good indicator of the age distribution present on the spawning grounds. The sample size from electroshocking was very small prior to 1991, and only covered a short time period, in respect to the overall spawning season.

The relative abundance of age IV and older females sampled during the 1986-1991 period decreased from the levels observed during the 1981-1984 seasons. Harriss et al. (1985) reported that females of age IV and older comprised from 84.7% to 97.9% of the females sampled (1981-1984). This study showed females age IV and older accounted for 12.9% to 86.4% for 1986-1991 (Table 8). The higher percentage of older females during the 1981-1984 period was attributed to the gears sampled, principally gill nets and pound nets, and/or the relatively strong year classes observed during 1975 and 1976.

The percentage of age IV and older females was relatively more abundant during the 1981-1984 period (Table 8). These females of the 1975-1980 year classes did not produce historical levels of year class strength, throughout the early to mid-1980s, except a slight increase during 1982. A combination of factors, including flow regulation on the Roanoke River (Manooch and Rulifson 1989), deteriorating water quality (Street and Johnson 1982, Manooch and Rulifson 1989), and heavy fishing pressure on immature fish (Crecco et al. 1988 draft, Richkus et al. 1990, and ASMFC 1990), have had an adverse impact on the population as evidenced by extremely poor juvenile production. Even though juvenile production was in decline and the percent of females which equaled or exceeded age IV decreased slightly during the mid-1980s, two juvenile year classes near historical levels were produced during 1988 and 1989. The increased juvenile production, as previously stated in Study I has been attributed to improved management of Roanoke River water flows (Rulifson and Manooch 1990), favorable habitat and environmental conditions (Street and Johnson 1982), and harvest limitations.

The 1986-1991 project data, when comparing age and sex composition from the various gears sampled relative to sample location, show that mature and immature female striped bass enter the Roanoke River each spring. However, immature fish do not frequently ascend the river all the way to the spawning grounds. In addition,the proportion of males in the spawning population generally decreased as the age of the fish increased, agreeing with that reported by Harriss et al. (1985).

JOB 3: Size, Age, and Sex Composition of Striped Bass from the Atlantic Ocean off North Carolina

OBJECTIVE: To determine size, age, and sex composition of the migratory striped bass overwintering off North Carolina

APPROACH

Striped Bass Bycatch from Various Fisheries

Striped bass were to be obtained from the bycatch of cooperating fishermen engaged in the winter trawl, haul seine, and gill net fisheries operating along the Outer Banks of North Carolina during January-March each year. Arrangements were made to obtain fish taken incidentally which would otherwise have been discarded. This sampling was to be conducted only if significant catches were reported.

North Carolina Cooperative Tagging Survey

An offshore North Carolina-Virginia trawl survey was conducted through the joint efforts of the National Marine Fisheries Service (NMFS), US Fish and

Wildlife Service (USFWS), Maryland Department of Natural Resources (MD DNR), and North Carolina Division of Marine Fisheries (DMF) utilizing National Oceanic and Atmospheric Administration (NOAA) vessels. Scales for ageing and lengths (mm, TL) were obtained from a representative portion of the oceanic migratory striped bass captured during the winter Cooperative Tagging Survey.

Commercial Harvest

Biological samples were taken from approximately 10% of the commercially harvested striped bass, as required by ASMFC. Striped bass were measured to the nearest mm (TL), weighed to the nearest .01 kg, and sexed. Scale samples, age and year class were processed and assigned as previously described in the Albemarle Sound commercial harvest section (Study V, Job 1).

FINDINGS

North Carolina's Atlantic Ocean striped bass fisheries were closed on 1 August 1984 in response to coastwide declines in the Atlantic migratory stocks. The striped bass decline prompted interstate management actions by the ASMFC and the US Congress. The DMF is currently managing the Atlantic Ocean striped bass fishery under the guidelines established in the Fisheries Management Report No. 15 (ASMFC 1989).

The DMF reopened and closely monitored a limited Atlantic Ocean striped bass fishery in 1990 and 1991. These limited seasons were proposed by DMF and approved by ASMFC based on an increase in the Atlantic migratory population, principally the Chesapeake Bay stock. Prior to the 1990 season, the overwintering Atlantic coastal stock was monitored through the North Carolina Cooperative Tagging Survey.

Striped Bass Bycatch from Various Fisherys 1986-1991

North Carolina striped bass season in the Atlantic Ocean was closed from 1 August 1984 through January 1990. The winter trawl, haul seine, and gill net fisheries rarely captured striped bass during this period; therefore no samples were taken from these fisheries. Several unconfirmed incidental trawl catches were reported, but resulted in no samples.

North Carolina Cooperative Tagging Surveys 1988-1991

A cooperative effort to tag and assess the age composition of the Atlantic migratory stock overwintering off North Carolina and Virginia has been conducted annually since the winter of 1988. The majority of the striped bass captured were measured and tagged with USFWS internal anchor tags. Scale ageing, data entry, and analysis of the Cooperative Tagging Surveys 1988-1991 was the responsibility of MD DNR.

January 1988

A total of 1,377 striped bass was measured during the 1988 cruise, ranging in size from 423 to 1,335 mm (16.5 to 52.5 in). These fish were tagged and released from False Cape, VA to Cape Hatteras, NC (Figure 13). Three previously tagged fish, from other tagging programs, were recaptured during the survey. Scale samples from 1,188 striped bass were suitable for age determination. The 1982 and 1983 year classes (73.7% combined) dominated the sample. The year class composition data are presented in Table 9.

January 1989

During the 1989 tagging cruise, 1,168 striped bass were measured. The fish ranged in size from 510-1,162 mm (20 to 45.8 in). The majority of the 1,156 striped bass tagged and released were captured in the area off False Cape, VA (Figure 13). Six tagged fish were recaptured during the 1989 survey. Four of the recaptures were fish tagged by other organizations. Two recaptures were tagged on the 1988 Cooperative Tagging Survey. The length data from the initial tagging and subsequent recapture show that these fish grew from 644 to 696 mm (25 to 27 in) and from 695 to 752 mm (27 to 29 in) in one year. The growth of these two fish was consistent with expected growth (MD DNR 1989). Two hundred and one striped bass were aged from the survey. Table 9 shows that the 1982 and 1983 year classes comprised 64.7% of the sample, being consistent with the year class composition found in 1988.

January 1990

Three thousand and six fish were captured, of which 2,010 were tagged and released between the North Carolin/Virginia state line and Cape Hatteras, NC (Figure 13). These fish ranged in size from 288 mm through 1,228 mm (11-48 in). Fifteen tagged fish were recaptured during the 1990 survey (MD DNR 1990).

Scale samples from 296 fish were successfully aged and the year class compositions are presented in Table 9. The 1984 year class (28.4%) dominated the sample(MD DNR 1990).

January 1991

During the 1991 survey, 1,800 striped bass were measured, tagged, and released from False Cape, VA to Cape Hatteras, NC (Figure 13). Fish ranged in size from 507 to 1,020 mm (20 to 40 in). Sixteen previously tagged fish were recaptured during the tagging survey, 9 of which were tagged during this cruise. Scale samples from 628 striped bass were suitable for age determination and the year class composition are presented in Table 9. The 1983 and 1984 year classes dominated the sample, comprising 67.3% of the total (MD DNR 1991).

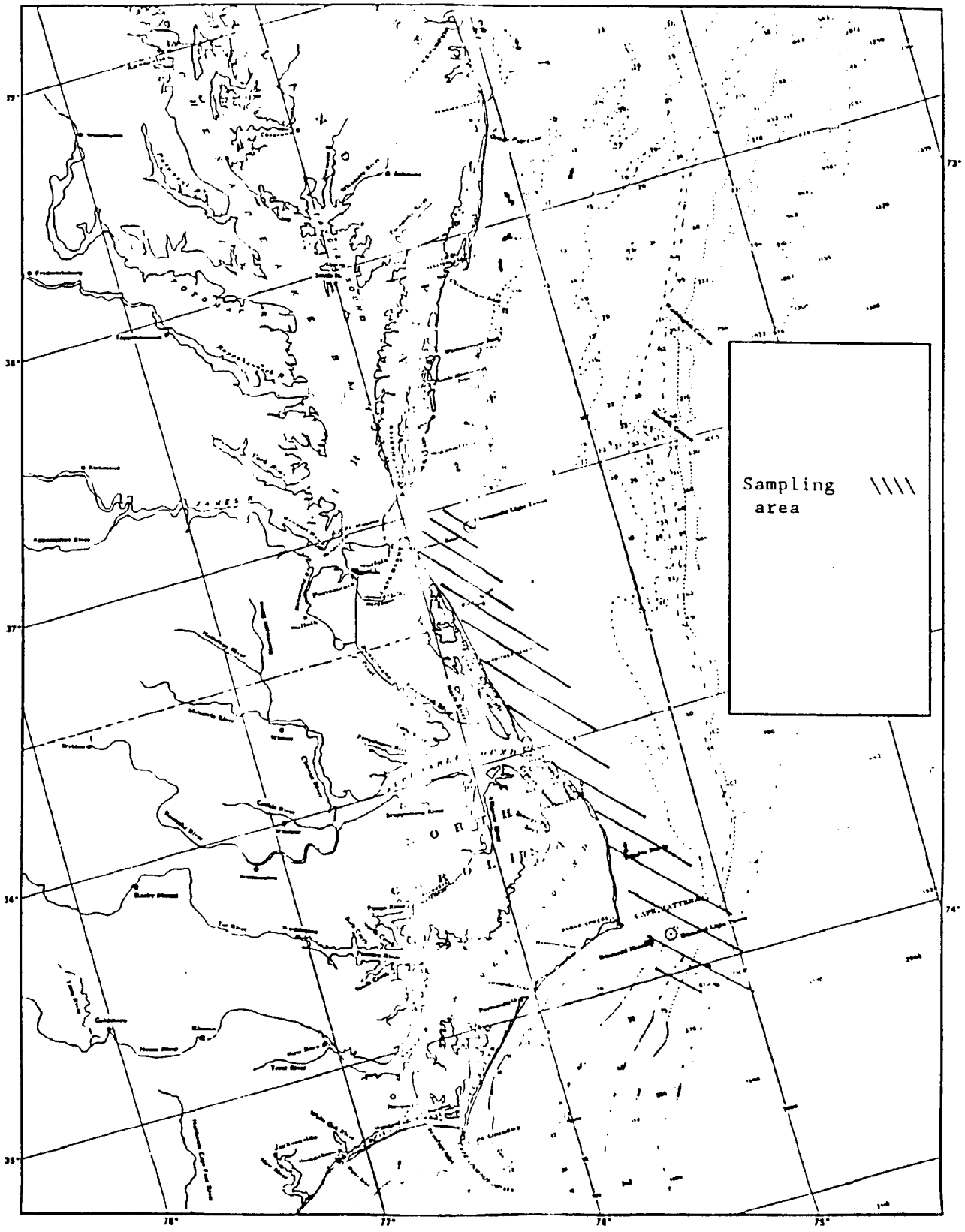

Figure 13. Locations where striped bass were tagged and released during North Carolina Cooperative Tagging Surveys off Virginia and North Carolina, 1988-1991.

Table 9. Percent year class composition of striped bass collected off the North Carolina coast, during the Cooperative Tagging Surveys January 1988-1991 (MD DNR 1988, 1989, 1990, and 1991).

Year class	1988 survey No.	1988 survey Percent of total	1989 survey No.	1989 survey Percent of total	1990 survey No.	1990 survey Percent of total	1991 survey No.	1991 survey Percent of total
1987					14	4.7		
1986					38	12.8	20	3.2
1985	2	0.2	5	2.5	36	12.2	95	15.1
1984	74	6.2	29	14.4	84	28.4	217	34.5
1983	545	45.9	52	25.9	50	16.9	206	32.8
1982	330	27.8	78	38.8	55	18.6	77	12.3
1981	82	6.0	18	8.9	9	3.0	11	1.8
1980	59	5.0	9	4.5	5	1.7	2	0.3
1979	4	0.3	3	1.5	4	1.4		
1978	19	1.6	1	0.5	0	-		
1977	0	-	1	0.5	0	-		
1976	3	0.3	0	-	0	-		
1975	4	0.3	1	0.5	0	-		
1974	24	2.0	0	-	1	0.3		
1973	7	0.6	4	2.0				
1972	1	0.1						
1971	27	2.3						
1970	6	0.4						
1969	0	-						
1968	1	0.1						
Total	1,188		201		296		628	

Commercial Harvest-Winter 1990

Amendment No. 4 of the ASMFC Striped Bass Plan established guidelines to achieve an 80% reduction in the historical coastwide commercial harvest. North Carolina's proposed Atlantic Ocean commercial season under these guidelines was for 20 days or a harvest cap of 96,000 pounds, whichever occurred first. Amendment No. 4 (1989), also established a 28 in (711 mm) minimum size limit for the Atlantic Ocean and MFC adopted the minimum size limit (NC DEHNR, DMF 1991).

During the six day Atlantic Ocean striped bass season (February 12 and 19-23, 1990), approximately 106 fish weighing 1,198 lb were landed. Most of the fish were landed by haul seines on the first day of the season. Only one fish was taken by trawl. One haul seine crew, fishing just north of Corolla, NC on 12 February, landed over 400 fish, 75 of which were harvested. All the undersized fish were released without any observed mortality.

One hundred and four fish were sampled to determine size, sex, and age composition of the harvest. Scales from four of these fish were unsuitable for ageing. The year class contributions to the harvest are shown in Table 10. The 1983 year class (age VII) dominated the sample comprising 20% of the male and 18% of the females. A sex ratio of 0.89:1, male to female, was determined from the Atlantic Ocean sample.

Fish in the 701-800 mm size interval were most abundant. Male striped bass ranged in length from 712 to 912 mm (28 to 35.9 in) and weighed 3.9 to 8.2 kg (8.5 to 18 lb). Females ranged in length and weight from 711 to 968 mm (28 to 38 in) and 3.5 to 10.4 kg (7.7 to 22.9 lb). As a result of the 28 inch (711 mm) minimum size limit, the various size classes present in the population are not adequately represented by the harvest.

Prior to opening the commercial season, 18 fish were confiscated by the DMF from a gill net fisherman. Two fish were greater than the 28 in (711 mm) minimum size limit. The 1984 and 1986 year classes (ages VI and IV) dominated this sample, accounting for 35.3% and 29.3%, respectively.

Fall 1990/Winter 1991

Since the 1990 winter commercial season harvest was so small, an experimental fall ocean season was proposed to the ASMFC and accepted for 26 November-December 1990. The landings for this season totaled 9,797 lb.

An Atlantic Ocean commercial season was proposed for winter 1991 and approved for 4-25 February. The DMF personnel sampled 11 striped bass caught in haul seines on 4 February 1991, near Corolla, NC. The majority of the striped bass landed during this season were from ocean trawlers. A total of 2,586 lb was

taken during the February season. The total landings of striped bass for these two seasons, November-December and February, combined was 11,185 lb. This was far short of the 96,000 lb quota.

A total of 151 striped bass was sampled from these two seasons. Eighty-seven fish were sampled to determine size, sex, and age composition of the harvest. A sex ratio of 0.78:1, male to female was determined. The 1983 (age VIII) and 1984 (age VII) year classes dominated the sample comprising 32.2% and 31% of the total, sexes combined (Table 10).

The lengths reflect the harvested fish in excess of the size limit, with one exception. One male was measured at 683 mm (26.9 in). Striped bass in the 701-800 mm size interval were the most abundant. Males ranged in length from 683-953 mm (26.9 to 37.5 in) and weighed 3.5-8.9 kg (7.7 to 19.6 lb). Female fish ranged in length and weight from 711 to 984 mm (28 to 38.7 in) and 3.9 to 9.7 kg (8.6 to 21.4 lb).

The sixty-four striped bass sampled from trawlers during the November-December 1990 season, were not included in the age/sex specific data, because sex was not recorded. These fish ranged in length from 730 to 957 mm (28 to 37.7 in) and weighed from 3.6 to 9.5 kg (7.9 to 20.9 lb).

Recreational Season

The winter recreational season, was open 12 February-18 March 1990, with a 28 inch TL minimum size limit and a one fish/day creel limit. The minimum size limit and creel were based on guidelines established by ASMFC Amendment No. 4 (ASMFC 1990). No striped bass samples were obtained from the recreational fishery.

An Atlantic Ocean recreational season was opened 19 November through 31 December 1990, with very few fish caught. The season reopened in January 1991 and continued through 31 March 1991. The size limit and creel remained as in 1990. In February 1991, three fish were caught by hook-and-line near Oregon Inlet and sampled. Length ranged from 720 to 895 mm (28 to 35 in) and weight ranged from 4.5 to 8.4 kg (9.9 to 18.5 lb). The ages of these fish ranged from 7-9 years old.

CONCLUSIONS

Obtaining striped bass samples from the bycatch of existing North Carolina ocean fisheries is not a feasible method for assessing the size and age composition of the stocks. Striped bass are not frequently encountered in directed fisheries for other species such as flounders and weakfish. These

Table 10. Number and percent at age class composition, by sex, for striped bass sampled from the Atlantic Ocean commercial fishery, 1990 and 1991.

Year class	Winter 1990				Fall 1990/Winter 1991			
	Number		Percent of total		Number		Percent of total	
	M	F	M	F	M	F	M	F
1986					0	1	-	1.2
1985	0	1	-	1.0	1	6	1.2	6.9
1984	8	14	8.0	14.0	16	11	18.4	12.6
1983	20	18	20.0	18.0	16	12	18.4	13.8
1982	8	17	8.0	17.0	4	15	4.6	17.2
1981	5	3	5.0	3.0	0	5	-	5.8
1980	3	2	3.0	2.0				
1979	1	0	1.0	-				
Total	45	55			37	50		
	100				87			

species rarely inhabit the same areas at the same time as striped bass during the winter in North Carolina.

The North Carolina Cooperative Tagging Survey provides a unique fishery independent opportunity to assess the composition of the Atlantic migratory population which winters off Virginia and North Carolina. Information on stock composition, migration, and growth rates gained from this survey is utilized in the coastwide striped bass management and restoration efforts directed by the ASMFC. However, it should be noted that all age groups may not be available in the Atlantic Ocean fishery and/or equally recruited to the trawls employed during these surveys.

In addition, the 1990 Cooperative Tagging Survey represented the best opportunity to assess the migratory striped bass stocks prior to the limited commercial and recreational fishery openings allowed by ASMFC. The survey proved invaluable to fisheries managers who were in the process of planning for an open season in North Carolina's coastal waters. It was largely responsible for North Carolina's decision to try an experimental and limited season in order to assess the impact of commercial gear on the large numbers of small fish present along the coast.

When combining the DMF data from the 1990 commercial harvest and the confiscated fish, it is evident that this information is similar to the 1990 Cooperative Tagging Survey. The 1991 sample data compared to the 1991 tagging survey supports the similarity as well. These data reflect the broad range of available year classes and confirms the abundance of the 1982-1986 year classes. This abundance is the result of recently implemented coastwide striped bass conservation efforts.

Concerns have been raised relative to North Carolina conducting a commercial fishery during the Cooperative Tagging Survey, potentially allowing the tagged fish to be harvested a short time after tagging. These concerns are not justified by the tag returns from the 1990 or 1991 commercial season as no recently tagged fish were captured. Seven tag returns from other tagging programs were reported during the February 1990 season; however no returns were recorded from fish released during the 1990 Cooperative Tagging Survey. Closing the striped bass season, during the Cooperative Tagging Survey period (January), would place an additional burden on the commercial fishery and the DMF's management of the fishery. During recent years the availability of harvestable numbers of striped bass off the North Carolina coast has been sporadic dependent on weather conditions and migration.

RECOMMENDATIONS

The authors recommend:

- Continuation of both the western and eastern Albemarle Sound juvenile abundance databases.
- Validation of the juvenile abundance indices be conducted to meet the ASMFC Striped Bass Study Management Board requirements.
- That the effects of river flow and water quality on year class formation be addressed through other projects.
- Combining adult striped bass utilization and migration (Study II) with spawning stock utilization and migration study (Study III), to form one study of migration and utilization for the Albemarle/Roanoke stock.
- That to satisfy the various informational needs relative to resource management, the striped bass management agencies must incorporate the appropriate methods to achieve utilization and migration information in conjunction with an annual stock assessment of the Albemarle/Roanoke spawning population.
- The North Carolina Cooperative for Anadromous Species Restoration, which includes the USFWS, WRC and DMF should continue to pool available resources.
- Specific projects need to be developed on hook-and-line release mortality and seasonal gear-related mortality.
- Sex determination and scales for ageing should not be taken from tagged fish in the Albemarle Sound area due to the probability of increased stress, infection and mortality. Age/length information can be used to estimate ages of tagged fish.
- Continued Phase II stocking programs to help sustain striped bass populations during low levels of abundance.
- Consideration should be given for a 24 inch TL size limit to allow more fish to reach sexual maturity. The Albemarle Sound gill net fishery must be managed to minimize the bycatch wastage of striped bass, as the losses may negate the potential gains from the increased size limit.
- Monitoring of the commercial harvest for size, age, and sex should be continued annually.
- Harvest quota management is recommended as the principal management component to control fishing mortality for the Albemarle/Roanoke striped bass population.
- Develop a recruitment based harvest control model (HCM), similar to Maryland Department of Natural Resources, for the Albemarle/Roanoke striped bass population.
- The Fishery Independent Gill Net Survey for the Albemarle Sound Striped Bass (NC Striped Bass Study Management Board, Work Order 90-1 and 91-1 and F-48) should continue to monitor the stock, since the fishery dependent data is not sufficient to adequately assess all segments of the population.
- A cooperative project should be developed between DMF and WRC to monitor the striped bass population on the spawning grounds. Intensive fishery-independent sampling, preferably electroshocking, should occur throughout the spawning season to establish a longer term data base to effectively describe the spawning population annually.

- Closing the spawning grounds to all harvest during the spawning season, as recommended in Amendment No. 4 to the ASMFC Striped Bass Fisheries Management Plan (ASMFC 1989). A spawning season closure would protect both mature and immature fish at a time when they are concentrated and vulnerable to harvest. This would have to be accomplished by actions of the WRC. Neither DMF nor MFC has jurisdiction on the spawning grounds.

- In the absence of a harvest closure in the Roanoke River spawning grounds, an annual harvest quota allocation must be continued for the entire river. The harvest quota management will aid in reducing effort and fishing mortality on adult striped bass.

- Continuation of the Cooperative Tagging Survey.

- An Atlantic Ocean Striped Bass season should include the months of December, January, and February.

- That the harvest season not be closed during the Cooperative Tagging Survey.

- Assessing and evaluating the undersized striped bass bycatch in the directed ocean fisheries.

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