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ANADROMOUS FISHERIES SURVEY OF THE NEW AND WHITE OAK RIVER SYSTEMS

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Completion Report for Project AFC - 9

14 November 1975

QL628.N8S56 1975

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1975

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INTRODUCTION

The importance of anadromous species to the total commercial finfish landings in North Carolina is shown by statistics of the National Marine Fisheries Service (Table 1). For the 13-year period 1960 to 1972, anadromous species accounted for an average of 46 percent of the total edible finfish landings.

A total of seven anadromous species enter North Carolina waters including the striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), blueback herring (*A. aestivalis*), alewife (*A. pseudoharengus*), Atlantic sturgeon (*Acipenser oxyrhynchus*), and shortnose sturgeon (*A. brevirostrum*). All seven species are considered both sport and commercial fish and are taken by standard commercial fishing gear. Significant recreational fisheries employ such devices as bow nets, staff nets, dip nets, gill nets, and seines as well as hook and line fishing. The activity provides both products for public consumption and significant recreational and social events affecting large numbers of resource users.

Several studies of anadromous fish stocks have been completed in North Carolina. Stevenson's (1899) earlier surveys were updated in a report of the shad fisheries by Walburg and Nichols (1967). Specific surveys have been conducted in the Neuse River (Walburg, 1957) and several reports have been prepared on the Cape Fear River (Davis and Cheek, 1967; Nichols and Louder, 1970). The North Carolina Division of Marine Fisheries began work in the Albemarle Sound region in 1971 and in the Tar-Pamlico River system in 1974. Baker (1968) published a reconnaissance survey of anadromous fish stocks in the inland waters of North Carolina. Little information is available on the two remaining medium-sized streams of the southern coastal area: New River and White Oak River. The New River was briefly mentioned in Stevenson's (1899) survey as supporting a shad population. Walburg and Nichols (1967) made reference to the capture of some American shad in the White Oak River. Both the New River and the White Oak River are shown as supporting runs of striped bass, American shad, and river herring in Baker's (1968) reconnaissance of inland fishing waters. Other than these brief general comments, there is virtually no information on the populations of anadromous fishes inhabiting these river systems.

Management of the anadromous fish resources in these river systems requires an information base which can be obtained only through detailed field investigations. The investigations of this project were necessary to provide information needed to maintain and manage the anadromous fish stocks. Information on basic populations, spawning areas, nursery areas, and utilization of the resource will become vital if the resource base becomes threatened.

Objectives of this project were as follows:

1) Job I - To determine the distribution of migrating and spawning adult anadromous fishes.

2) Job II - To determine spawning areas and periods of major spawning activity for anadromous species.

3) Job III - To determine nursery areas and growth and movements of juvenile anadromous fishes.

The project was conducted from 1 October 1973 to 30 June 1975.

Table 1 - Relative importance of anadromous fish in North Carolina as shown by commercial landings (from published data: NMFS, Branch of Statistics, Beaufort, N. C.; N. C. Division of Marine Fisheries, Morehead City, N. C.

Year	Total edible finfish (lbs)	Anadromous fish (lbs)	Percent anadromous fish
1960	30,470,000	14,308,000	47
1961	30,029,000	13,490,000	45
1962	31,887,000	16,037,000	50
1963	32,348,000	16,864,000	52
1964	24,562,000	9,183,000	37
1965	33,538,000	14,658,000	44
1966	32,567,000	14,130,000	43
1967	40,880,000	21,250,000	52
1968	36,102,000	18,467,000	51
1969	41,099,000	22,282,000	54
1970	29,832,000	14,974,000	50
1971	31,380,000	14,991,000	48
1972	48,239,000	13,190,000	27

STUDY AREA

The New and White Oak River systems are located in the south-central coastal area of North Carolina (Figure 1). Both watersheds lie entirely within the lower coastal plain and are mostly swamp drainages with agriculture, forestry, and commercial fishing as the predominant industries. Both rivers are relatively small and drain directly into the Atlantic Ocean in the Onslow Bay area.

The New River watershed encompasses about 113,000 ha, lying almost entirely in Onslow County. It drains Wolf Swamp and Hell and Purgatory Pocosins, then flows southeast for 86 km to empty into the Atlantic Ocean through New River Inlet (Figure 2). New River is the most developed of the two systems with the city of Jacksonville located on its banks. The lower half lies within the Camp Lejune Marine Base. The major tributaries are Southwest Creek, Northeast Creek, Halfmoon Creek, Jenkin Swamp, and Mill Swamp and consist of swamp drainages with highly stained waters.

The river has an average width of 2 1/2 km below Jacksonville, and the average water depth is 1.9 to 2.4 m. The bottom is primarily organic silt except for sandy shoal areas around the shorelines. Between Jacksonville and river kilometer 43.4, the river flows through a hardwood swamp with dense vegetation along its banks where the channel is clogged with stumps and logs. From river kilometer 43.4 to N.C. Highway 24, a total of 30.8 km, the river was channelized for flood control in 1970 (Figure 2). The lower 13 km of the channelized section is about 15 m wide, with a depth of 0.6 to 1.8 m, and a bottom type of detritus, sand, and limestone rock. From County Road 1314 to below U. S. Highway 258 (5 km), the river is 15 m wide with a rock and sand bottom and is 0.3 to 1.5 m deep. From U. S. Highway 258 to N. C. State Highway 24 (12.1 km), the stream is about 9 m wide with a sand bottom and a depth of only 8 to 15 cm during low flow periods. At N. C. Highway 24, a cement culvert under the roadbed may form a barrier to upstream migration except under high water stages. Some tributaries in the channelized section are connected to the river only through culverts which are not functional for water exchange except under extreme flood conditions. The river is seperated from its natural flood plain by dikes approaching 3 m in height. Above N. C. Highway 24, the river is very small and shallow with a sand and mud bottom.

The New River system is mostly tidal except for the extreme upper reaches of the river and its tributaries. Normal stream flow velocities are very slow except during flood stages.

The White Oak River watershed is slightly smaller than the New River watershed and forms the border between Onslow, Carteret, and Jones Counties (Figure 2). It arises in Hoffman Forest and flows approximately 78 km to empty into the Atlantic Ocean through Bogue Inlet. Approximately 77 percent of the watershed is covered by Hoffman Forest and Croatan National Forest. There is very little development in the watershed, with Swansboro being the largest town. The river is highly stained from swamp drainage. Its major tributaries are Hunter Creek, Grant Creek, Pettiford Creek, Starkey Creek, Black Swamp, and Holston Creek,

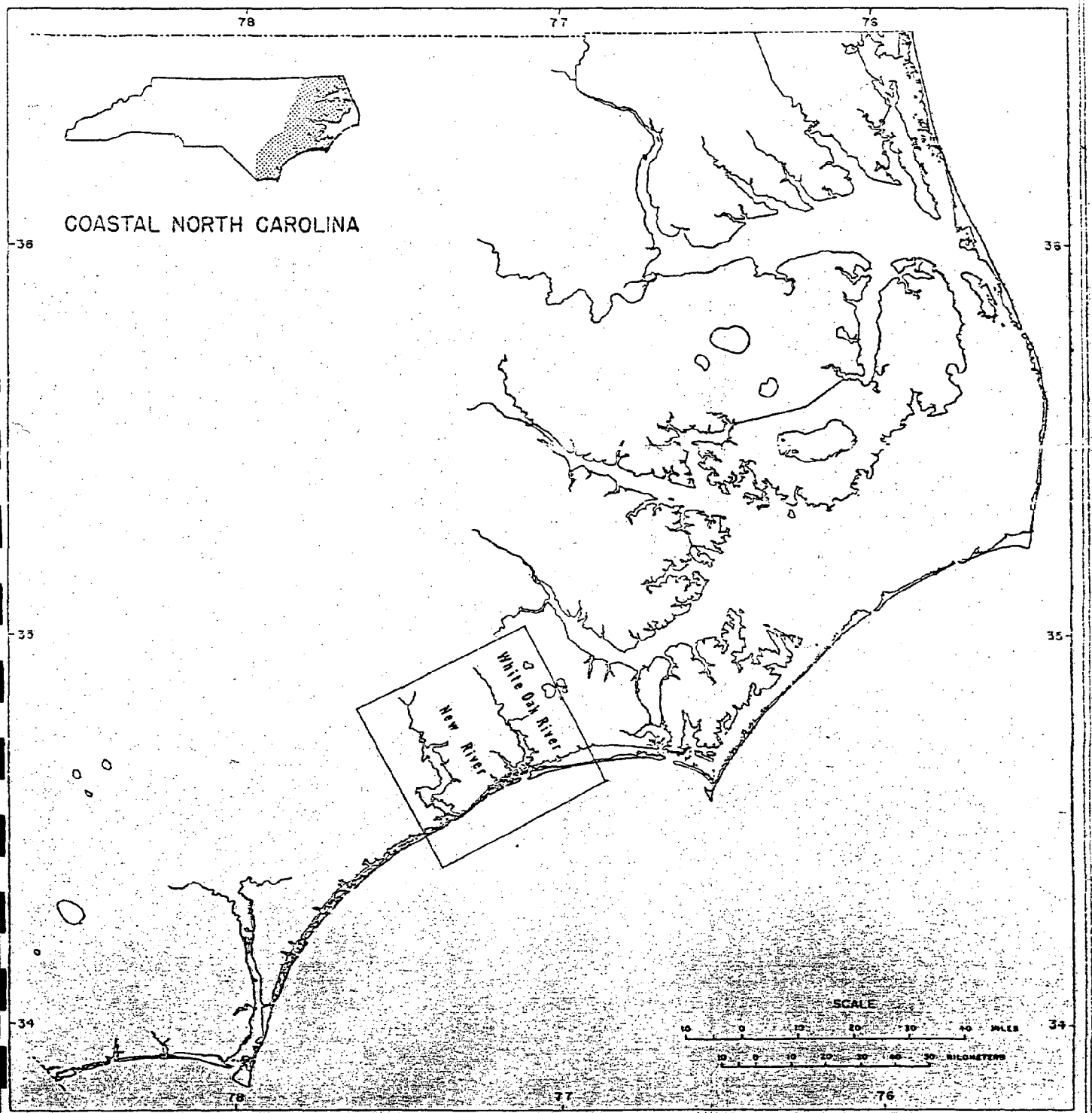


Figure 1.—Location map of the New and White Oak River Systems.

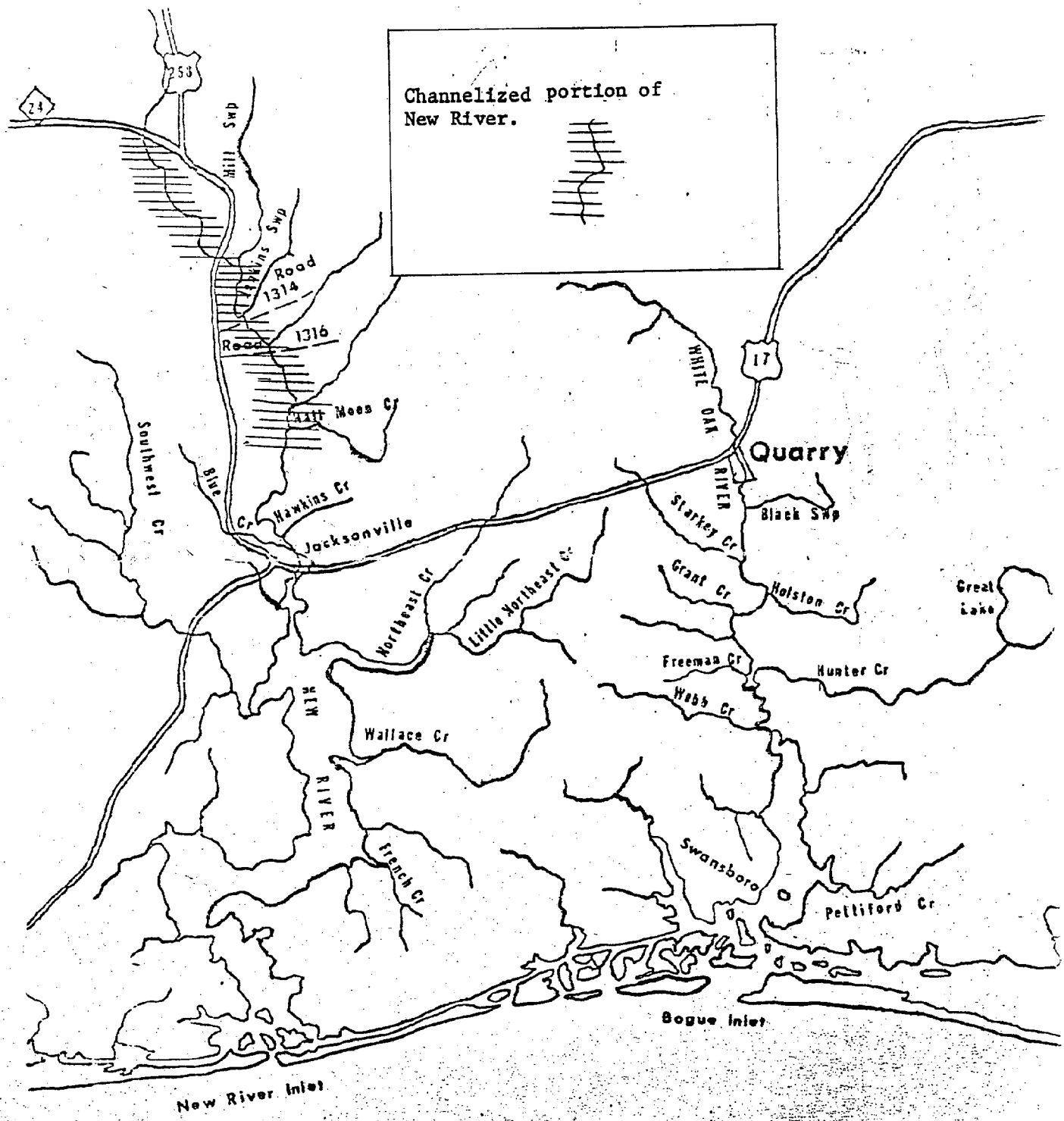


Figure 2 - Map of the New and White Oak River Systems.

which are small and densely vegetated. The river itself is about 1.5 km wide from the Atlantic Ocean to the vicinity of Webb Creek. The depth is about 1.2 m with numerous oyster reefs and a narrow obscure channel. The bottom type is primarily sand and mud with sand shoals along the edges. From Webb Creek to Crant Creek, the river is about 3.7 m deep, 150 m wide, and meanders. The bottom type is primarily mud and detritus and is boardered by fresh and brackish marsh. Above Grant Creek, the river flows through hardwood swamp at a depth of 1.5 to 4.3 m. Below U. S. Highway 17, the river flows through seven distinct lakes of the Martin Marietta Belgrade Quarry. They comprise approximately 60 ha of water and range from 4.5 to 9.5 m in depth with steep sides and mud bottom. The lakes were dug between 1940 and 1960 during mining operations for limestone. Water flow is very slow in the lakes except where they are connected. From the Quarry to immediately above U. S. Highway 17, the river is narrow and from 0.6 to 1.2 m deep with a rocky bottom. The flow is very swift in riffles areas. Above U. S. Highway 17, the river is a small typical swampy stream.

The White Oak River system is predominantly tidal except for the region above the limestone quarry and the headwaters of the tributaries. The stream velocity is slow, but is greater than in the New River watershed.

A detailed survey and description of the New and White Oak River systems was prepared by the North Carolina Wildlife Resources Commission (Davis and McCoy, 1965).

MATERIALS AND METHODS

Intial sampling indicated three basic ecological zones in each river consisting of high salinity, brackish, and fresh areas (Figure 3). The high salinity zone consisted of the lower portion of the estuary and generally coincided with the open water areas. The brackish zone consisted of a transition area between the lower estuary and the fresh water zone. The fresh zone contained swamp areas exhibiting little or no salinity. Sampling and data recording was done on the basis of the three zones.

The time between 1 October 1973 and 30 June 1974 was an initial survey period. Sampling during this time was generally random with no permanent stations. Permanent stations were established and sampled regularly between 1 July 1974 and 30 June 1975.

Adult Sampling

Adult anadromous fish sampling was done on the basis of high density random sampling between 1 January and 30 June 1974 and representative stations were sampled between 1 January and 30 June 1975 with gill nets and trammel nets

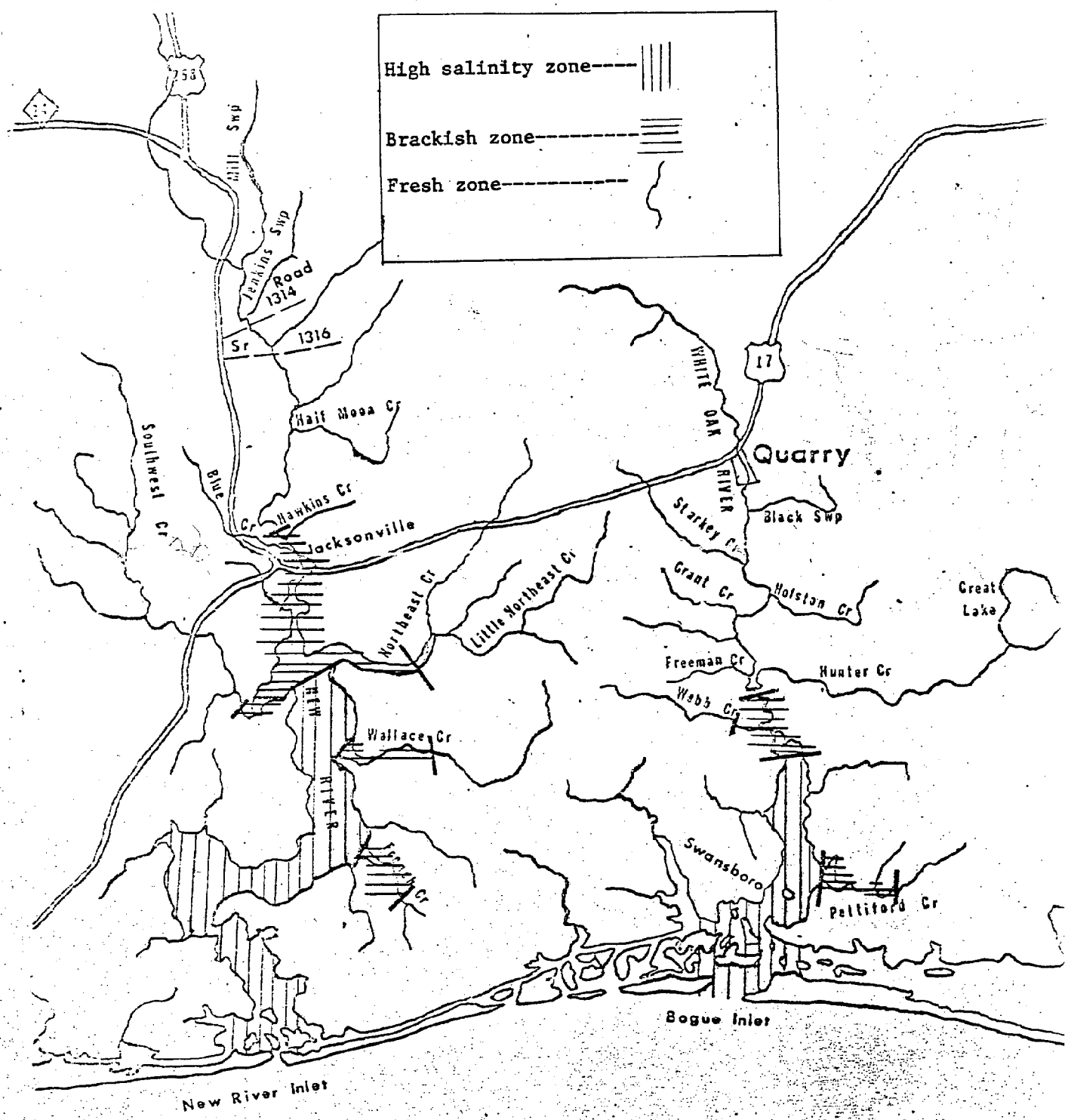


Figure 3 - Map of the three ecological zones in the New and White Oak Rivers.

(Figure 4). Gill nets of 45.9 and 9.2 m lengths with mesh sizes of 6.4 cm, 7.0 cm, 8.3 cm, 10.2 cm, 12.4 cm, 13.3 cm, and 14.0 cm stretch mesh were used to sample adults. The 45.9 m nets were used in the high salinity and brackish zones, while the 9.2 m lengths were used in the fresh zone and the tributaries. There was no high salinity zone sampling after March 1975. Trammel nets of 91.4 m lengths were used primarily to sample striped bass and sturgeon. All nets were anchored and left for a 24 hr period. Catch-per-unit-of-effort (C/E) was calculated on the basis of a Standard Fishing Unit (SFU) of 91.4 m of net set for 24 hours. The C/E for herring was based on the number of SFU of small mesh sizes, and shad C/E was based on the units of mesh sizes 10.2 cm and greater. One trammel net effort was based on 91.4 m of trammel net set for 24 hours.

The adult fish were sorted by species, weighed in grams, and fork lengths (FL) were measured in millimeters. The gonads of each individual were examined to determine sex and stage of development which was recorded as immature, mature, ripe, running-ripe, or spent.

Scales were taken from each individual and placed in envelopes and coded along with sex, length, and weight information. A large number of scales were taken from below the front of the dorsal fin. Scales were read with a binocular microscope and aging was done by the annuli and spawning mark method with the scale edge counted as a yearmark, as described by Marcy (1969), Beal (1968), Cating (1953), and Street and Adams (1969). Several clear scales from each fish were examined. Two readings of each set of scales was made, and those not agreeing were discarded.

Egg and Larval Sampling

Sampling for eggs and larvae was conducted between 1 March and 30 June 1974, and 17 March and 30 June 1975 with 1 m and 1/2 m plankton nets of 00 mesh. Where possible, a station was sampled for each five mile segment of river and major tributary (Figure 5). Sampling was conducted twice monthly in each river alternating weeks between rivers.

All samples were taken within 10 cm of the bottom and/or within 10 cm of the surface. Towed samples were of 5-minute duration and sets from bridges were of 10- to 15-minute duration depending upon the current velocites. No eggs were captured in any 15-minute sets so catch-per-effort was based on a 5-minute tow. Results of the 1 m and 1/2 m nets were treated separetely.

Samples were preserved in the field with 10% formalin. Eggs and larvae were sorted, identified, and counted in the laboratory. Blueback herring and alewife eggs and early larvae were lumped together as "river" herring due to an inability to distinguish between the two species.

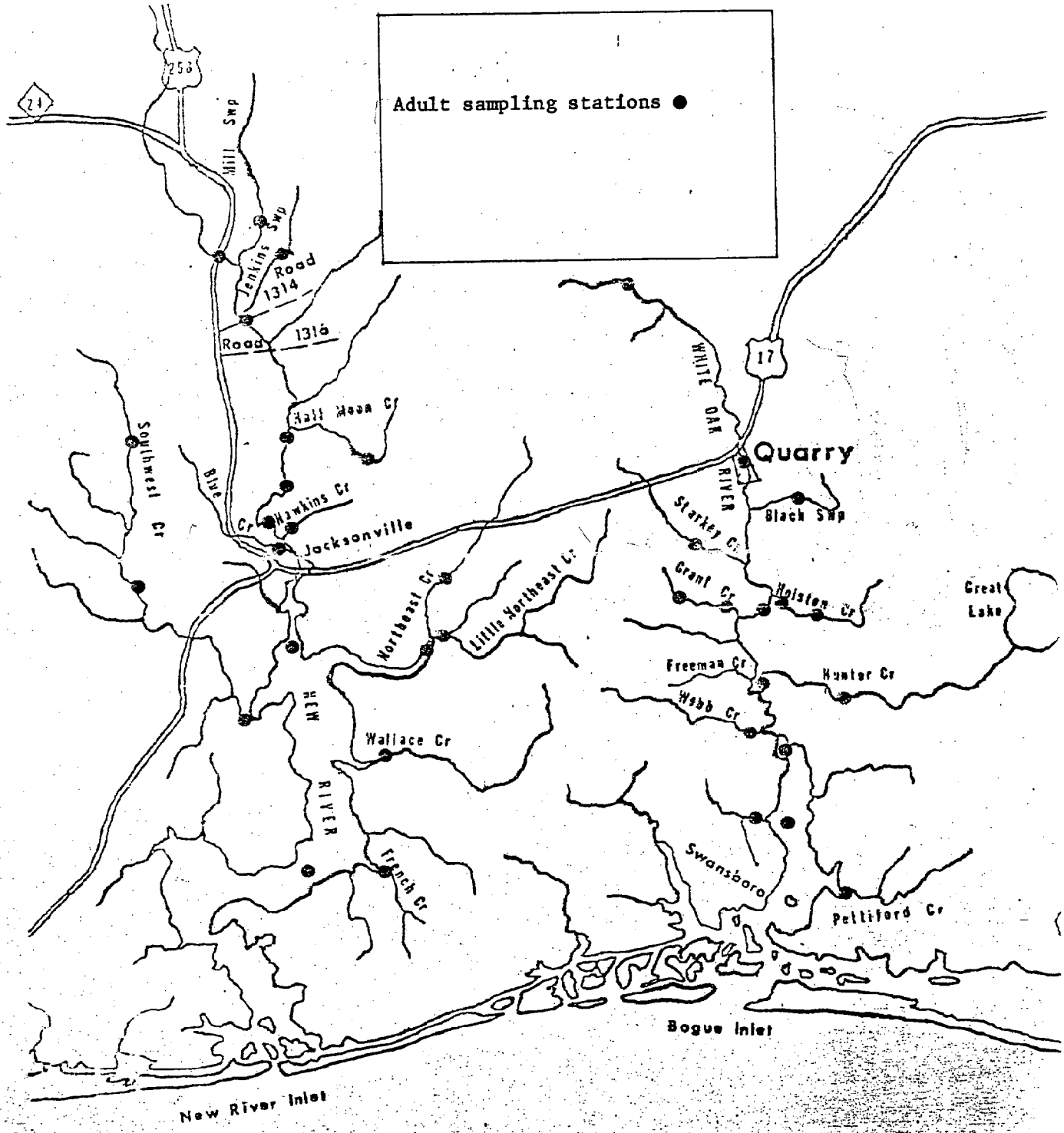


Figure 4 - Map of adult sampling stations - New and White Oak Rivers, 1975

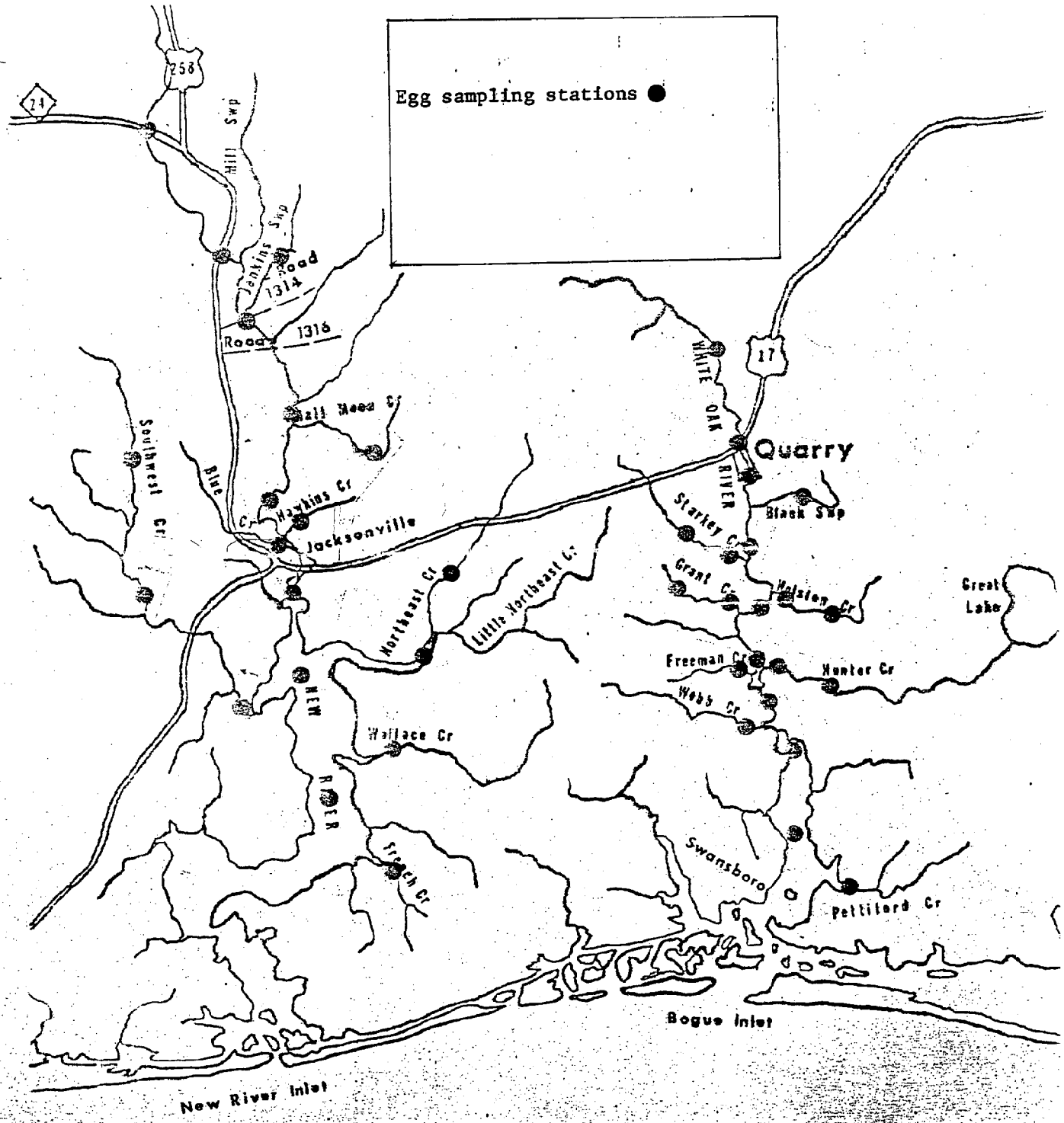


Figure 5 — Map of egg sampling stations — New and White Oak Rivers, 1974-75.

Juvenile Fish Sampling

Juvenile fish sampling was conducted from 1 October to 31 December, 1973 and from 1 July to 31 December, 1974. Initially, modified Cobb pelagic trawls of 1.8 m and 3.7 m width were used in open water areas and shoreline areas not suitable for conventional seining. Results showed the Cobb trawl to be selective and inefficient for capturing juvenile anadromous fishes. A modified bottom trawl also produced unsatisfactory results. A modified wing trawl of 7.9 m head rope length was designed and tested in July of 1974. This gear showed the most satisfactory results and was subsequently employed as the standard gear. It had a mesh size ranging from 10.2 cm in the wings to 0.63 cm in the tail bag. All samples with the wing trawl were taken on the surface by using surface doors. A standard effort with the modified wing trawl consisted of one 10-minute tow.

All other samples were taken with 0.63 cm mesh bag seines of 18.4 m and 6.1 m lengths. One haul with a 18.4 m or 6.1 m seine constituted one 18.4 m or 6.1 m seine effort.

All samples were preserved in the field with 10% formalin and were later sorted as to species, weighed to the nearest gram, and fork lengths measured in millimeters. A subsample of 30 fish was taken in large samples. Incidental species such as spot, croakers, sunfish, etc. were counted, weighed, measured, and recorded as to species.

Random sampling was conducted between 1 October and 31 December, 1973 primarily using the 18.4 m seine. From 1 July to 31 December, 1974, sampling was done regularly at established stations (Figure 6). Each river was sampled two weeks per month alternating weeks between rivers. There were a total of 26 stations in the New River making 52 samples per month. The White Oak River had 25 stations resulting in 50 samples per month.

RESULTS AND DISCUSSION

Adult Distribution

New River

A distribution of adult anadromous fishes was determined by employing a total of 219.75 SFU of gill net effort in both river systems. A total of 480 adult anadromous fishes was captured. Blueback herring and alewife were most numerous with fewer numbers of American shad, hickory shad, Atlantic sturgeon, and striped bass.

During 1974 and 1975 in New River, a total of 95.75 SFU of gill net effort and 9 trammel net sets produced a total of only 66 anadromous fish, for an average catch of 0.7 fish per gill net SFU. No adult anadromous fish were caught in any trammel net samples. The catch consisted of 46 blueback herring, 7 alewife, 9 American shad, and 4 Atlantic sturgeon.

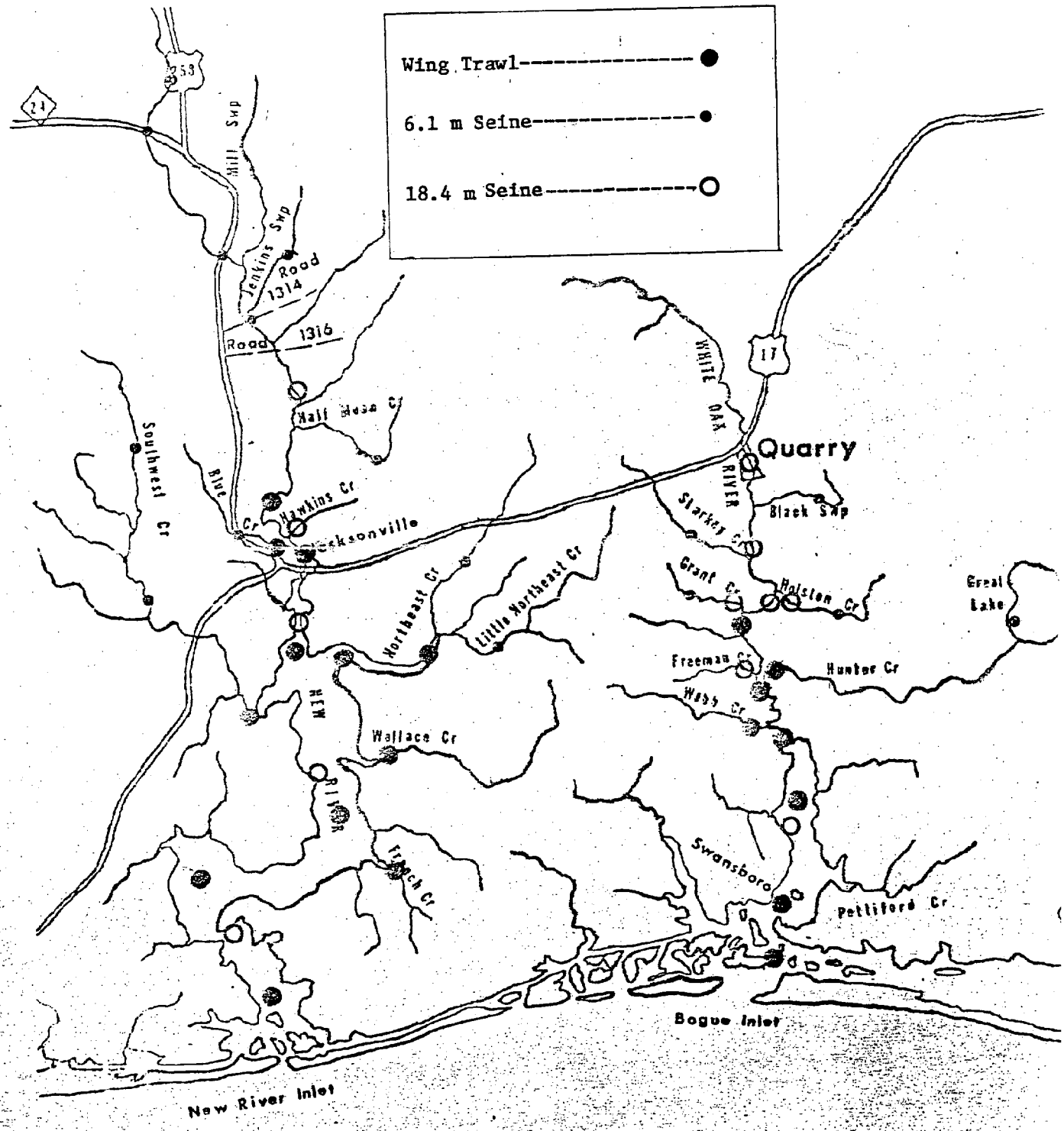


Figure 6 - Map of juvenile fish sampling stations, New River and White Oak River, 1974

Blueback herring

Eight adult blueback herring were captured in the New River during the run of 1974 (C/E=0.3). They first entered the river in January with the peak occurrence in the fresh zone in April.

In 1974, they were found up to the lower channelized section of the river where they were observed to be in a ripe condition. None were taken in the tributaries, and by the end of April no adult blueback herring were seen in the river.

In 1975, 38 blueback herring were captured (C/E=22). They were found in the swamp below the channelized part and in certain tributaries. Only one was caught in the channelized section. Blueback herring were observed using Northeast Creek, Little Northeast Creek, Blue Creek, and Hawkin Creek. Hawkin Creek had the highest single C/E which was 5.8. Blue Creek and Little Northeast Creek had a higher C/E than the main run of the river (Table 2).

Alewife

One adult male alewife was caught during the 1974 run in New River. During the 1975 run, five alewife were found in Blue and Hawkin Creeks. Blue Creek contained a larger run with 2.4 catch per SFU (Table 2). Their peak occurrence was during January and February.

American shad

In 1974, four adult American shad were captured for a C/E of 0.3. They were taken up to County Road 1316 and were in a ripe condition. None were found in the tributaries. During the 1975 run, four American shad were captured for a C/E of 0.3. None were found in the fresh zone of the river where they occurred in greatest numbers the previous year. Three of the four were found in Southwest and Little Northeast Creeks (Table 2). They were found in the river system from February through April.

No adult striped bass or hickory shad were captured in the New River. A single Atlantic sturgeon was captured during March, 1974 while three were caught during March and April of 1975.

It is apparent the New River system has limited anadromous fish resources. Only a few blueback herring, alewife, American shad, and Atlantic sturgeon were found in the river. A relocation of the distribution of anadromous resources appears to be occurring. They appear to be switching from the upstream, utilized in 1974, to the downstream tributaries used in 1975. This could be due to alterations caused by channelization of the upstream area.

White Oak River

In the White Oak River, a total of 124.0 SFU of gill net and seven trammel net sets produced a total of 636 anadromous fish for an overall gill net catch of 5.1 fish per SFU. No adult anadromous fish were caught in any trammel net

Table 2 - Catch per Standard Fishing Unit for adult blueback herring, alewife, and American shad by area, New River, 1974-75

Species	Area	Catch per SFU 1974	1975
Blueback herring	New River	0.3	1.1
	Northeast Creek	0.0	1.0
	Little Northeast Creek	0.0	2.5
	Blue Creek	0.0	1.2
	Hawkin Creek	0.0	7.9
Alewife	New River	0.1	0.0
	Blue Creek	0.0	2.4
	Hawkin Creek	0.0	0.8
American shad	New River	0.2	0.0
	Southwest Creek	0.0	0.1
	Little Northeast Creek	0.0	1.3

samples. The catch consisted of 487 blueback herring, 90 alewife, 49 American shad, 2 hickory shad, 3 striped bass, and 5 Atlantic sturgeon.

The average catch per SFU for blueback herring was 7.3; for alewife, 1.4; for American shad, 0.9; for hickory shad, 0.04; for striped bass, 0.03; for Atlantic sturgeon, 0.04.

Blueback herring

In 1974, 177 adult blueback herring were captured for a C/E of 5.3. They were found in the White Oak River up to the Quarry Lakes and occurred in the river from January through May. None were found in the tributaries.

During the 1975 run, 310 adult blueback herring were captured for a C/E of 10.3. This suggests that the run of 1975 was about twice as large as the 1974 run. Again they were found up to the Quarry Lakes and occurred in the river from January through May (Figure 7). Blueback herring were also found in Hunter, Webb, Grant, and Holston Creeks. Unlike the New River, the catches were small compared to the main stem of the river. Holston Creek had the highest number of blueback herring in any tributary with a C/E of 2.2 compared to an 11.4 C/E in the main stem of the river (Table 3).

Alewife

In 1974, 10 adult alewife were caught in the White Oak River for a C/E of 0.3. They occurred during April and May up to the Quarry Lakes. None were found in the tributaries.

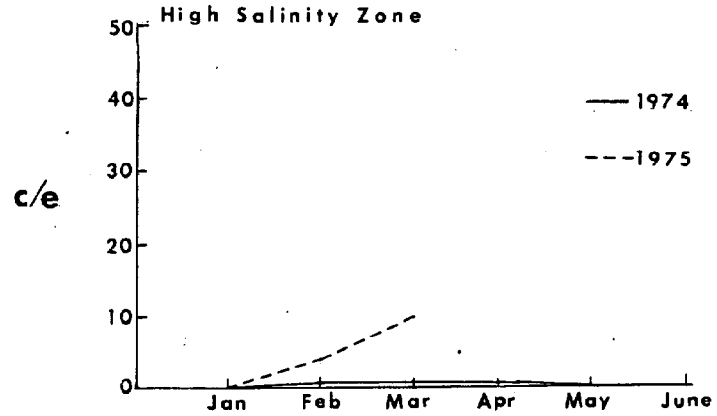
Adult alewife did not enter the river until March or April, well after the first blueback arrived. This was different from the reports of alewife arriving earlier in the Albemarle Sound area by Street and Pate (1975).

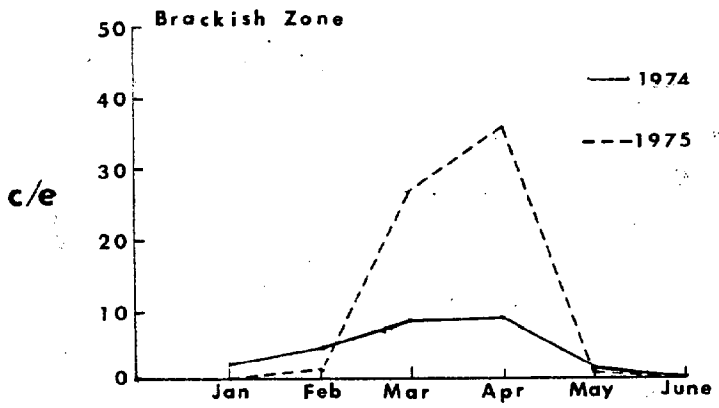
During the 1975 run, 80 adult alewife were captured for a C/E of 2.4, indicating a much larger run in 1975. They were found from February through May up to the Quarry Lakes (Figure 8). Alewife were also caught in Hunter, Grant, and Holston Creeks. They occurred in slightly greater numbers in the tributaries than in the river. Grant Creek had the highest number with a C/E of 3.7 to a C/E of 2.8 in the main stem of the river (Table 3).

American shad

Twenty-one adult American shad were caught in 1974 for a C/E of 1.2. They occurred from February through May up to the Quarry Lakes. None were found in the tributaries.

In 1975, 28 American shad were found for a C/E of 0.7, indicating a smaller run than in 1974. They again occurred from February through May up to the Quarry Lakes (Figure 9). Pettiford Creek was the only tributary containing American shad with a catch of 0.7 per SFU.





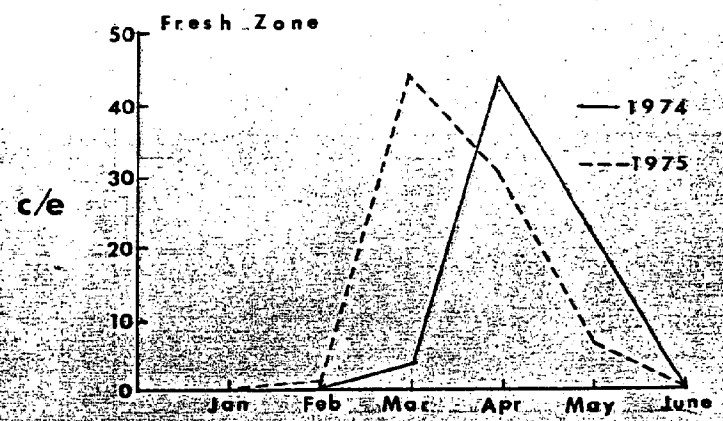
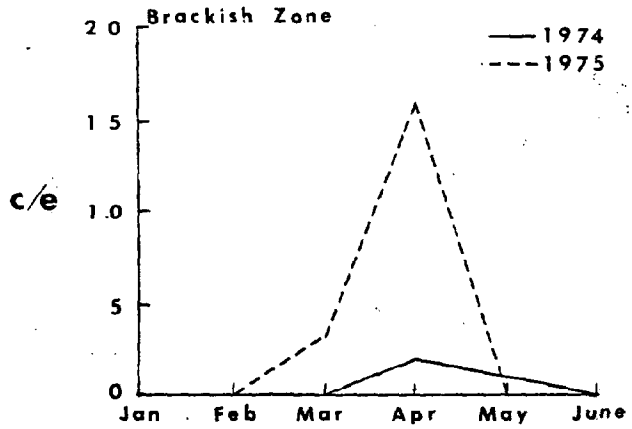


Figure 7.—Catch per SFU of adult blueback herring by year, White Oak River, 1974-75

Table 3 - Catch per Standard Fishing Unit of adult blueback herring, alewife, and American shad by area, White Oak River 1974-75

Species	Area	Catch per SFU 1974	1975
Blueback herring	White Oak River	7.3	11.4
	Hunter Creek	0.0	1.3
	Holston Creek	0.0	2.2
	Grant Creek	0.0	0.7
	Webb Creek	0.0	1.6
Alewife	White Oak River	0.3	2.8
	Hunter Creek	0.0	0.6
	Holston Creek	0.0	3.4
	Grant Creek	0.0	3.7
American shad	White Oak River	1.7	0.8
	Pettiford Creek	0.0	0.7



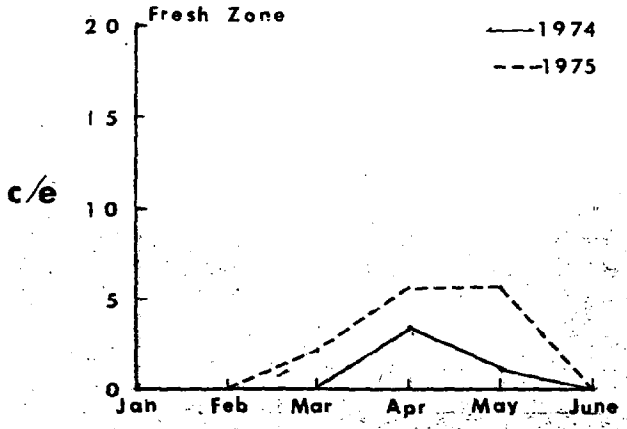
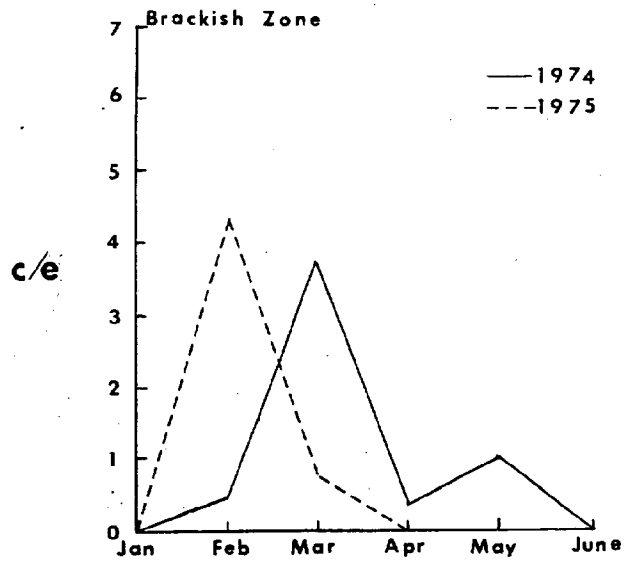


Figure 8.—Catch per SFU of adult alewife by year, White Oak River, 1974-75.



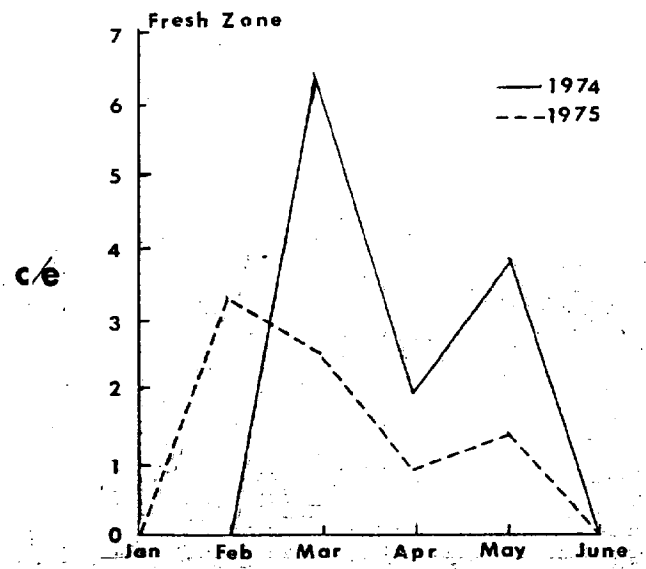


Figure 9.—Catch per SFU of adult American shad by year, White Oak River, 1974-75.

Other anadromous fishes

Two adult hickory shad were found in the White Oak River. One was caught in January 1974 and one in May 1975. While no striped bass were found in 1974, three were captured in March of 1975 in the lower part of the river. Five Atlantic sturgeon were found in April of 1975 in the lower part of the river. None were captured in 1974.

Adult Utilization

New River

The New River contains little or no anadromous fishery. Only a few American shad and herring were caught incidental to other fishing operations and were usually sold. The value is extremely minor compared to the overall New River fishery.

White Oak River

The White Oak River supports a recreational dip net and gill net fishery mainly for herring. Fishing is primarily confined to the Quarry Lakes and may involve 25-30 local people per night with catches of 50-100 pounds per person during the peak. The incidental catches of anadromous fish by commercial fishermen is minor, with little value to the White Oak River fishery.

Age and Spawning Frequency

New River

Due to the small number of adult anadromous fish sampled in the New River, no definite conclusions can be made as to their age or spawning frequency.

Blueback herring

Only thirty adult blueback herring had scales suitable for aging. The ages of both males and females ranged from four to six years with ages four and five dominating. The mean fork lengths for each age group generally agreed with those found by Street and Pate (1975) in the Albemarle Sound area (Table 5). However, due to the small sample size from the New River, no adequate comparison can be made.

The ratio of males to females was about equal.

Spawning repetition by blueback herring in New River was extremely low. Only 10 percent contained spawning marks which differs greatly from the 50 percent found by Street and Pate (1975). None were found containing more than one spawning mark (Table 6).

Alewife

Seven alewife from the New River had readable scales. Ages were four and five, with age five predominating. All males were age five while females were

Table 5 - Total number, percent of total sample, mean fork length, and length range for each age group by sex for blueback herring, New River, 1974-75

Sex	Age	Total number	Percent of total sample	Mean fork length(mm)	Length range(mm)
Female	IV	7	50	246	240-253
	V	7	50	249	237-255
		14			
Male	IV	9	56	233	226-246
	V	5	31	250	241-256
	VI	2	13	268	267-268
		16			

Table 6 — Age and spawning frequency of blueback herring from New River, 1974-75

No. times spawned	0		1		Total	
Age	M	F	M	F	M	F
IV	9	7	0	0	9	7
V	4	6	1	1	5	7
VI	1	0	1	0	2	0
Total	14	13	2	1	16	14
Percent	(88)	(93)	(13)	(7)		

ages four and five. The fork lengths were not comparable to those found by Street and Pate (1975), probably due to the small sample size (Table 7). Eighty-five percent of the alewife were repeat spawners. One virgin female was found while all males had spawned previously. None were found to spawn more than once.

American shad

Five American shad from the New River proved suitable for aging. The males were age four and five while all of the females were five. Their mean fork lengths were not comparable to those found by Street and Pate (1975) (Table 8). All were found to be virgin.

White Oak River

Blueback herring

Of the blueback herring scale samples taken in the White Oak River, 318 could be read. They ranged in age from three to seven years with 91 percent of the males being ages four and five, and 57 percent of the females being age five. Their fork length agreed closely with those found by Street and Pate (1975) in the Albemarle Sound area (Table 9).

The male to female sex ratio was 0.88:1, quite different from that found by Street and Pate (1975). This is probably due to the selectivity of gill nets used in this study.

The number of virgin blueback herring was higher than that found in the Albemarle Sound area with 79 percent being virgin. Females were observed to repeat more than males. Only four females (1.3 percent) had more than one spawning mark. Males first spawned at ages four and five while most females first spawned at age five (Table 10).

Alewife

Fourty-two scale samples from alewife were useable. Males ranged in age from three to five years with 72 percent being age four. All females were ages four and five, with age four predominating. The fork lengths agreed with those found by Street and Pate (1975) (Table 11).

The number of virgin fish was higher than expected, with 92 percent virgin males and 94 percent virgin females. None were found to have spawned more than once. Both males and females were found to first spawn predominately at age four (Table 10).

Of the alewife found in the White Oak River, 60 percent were males and 40 percent females. This sex ratio differs greatly from that expected, but the sample is so small that no conclusions can be made.

American shad

A total of thirty-five scale samples of American shad were suitable for aging. Females ranged in age from four to seven years with age five making up 56 percent.

Table 7 - Total number, percent of total sample, mean fork length, and length range for each age group by sex for alewife, New River, 1974-75

Sex	Age	Total number	Percent of total sample	Mean fork length(mm)	Length range(mm)
Female	IV	1	33	240	
	V	2	67	289	280-297
		3			
Male	V	4	100	266	262-267

Table 8 - Total number, percent of total sample, mean fork length, and length ranges for each age group by sex for American shad, New River, 1974-75

Sex	Age	Total number	Percent of total sample	Mean fork length(mm)	Length range(mm)
Female	V	3	100	465	441-498
Male	IV	1	50	398	
	V	1	50	387	

Table 9 — Total number, percent of total sample, mean fork length, and length range for each age group by sex for blueback herring, White Oak River, 1974-75

Sex	Age	Total number	Percent of total sample	Mean fork length(mm)	Length range(mm)
Female	IV	38	23	242	202 - 262
	V	97	57	258	234 - 277
	VI	31	18	265	235 - 281
	VII	3	2	280	260 - 281
		169			
Male	III	2	1	219	208 - 229
	IV	68	46	237	223 - 253
	V	67	45	247	227 - 272
	VI	12	8	249	236 - 269
		149			

Table 10 - Age and spawning frequency of blueback herring, alewife, and American shad from White Oak River, 1974-75

Blueback herring

No. times spawned	0		1		2		Total	
Age	M	F	M	F	M	F	M	F
III	2	0	0	0	0	0	2	0
IV	63	37	5	1	0	0	68	38
V	51	77	16	19	0	1	67	97
VI	5	14	7	14	0	3	12	31
VII	0	1	0	2	0	0	0	3
Total	121	129	28	36	0	4	149	169
Percent	(81)	(76)	(19)	(21)		(3)		

Alewife

No. times spawned	0		1		Total	
Age	M	F	M	F	M	F
III	2	0	0	0	2	0
IV	16	12	2	1	18	13
V	5	4	0	0	5	4
Total	23	16	2	1	25	17
Percent	(92)	(94)	(8)	(6)		

American shad

No. times spawned	0		1		Total	
Age	M	F	M	F	M	F
IV	10	2	0	0	10	2
V	8	9	1	0	9	9
VI	0	4	0	0	0	4
VII	0	1	0	0	0	1
Total	18	16	1	0	19	16
Percent	(95)	(100)	(5)			

Table 11 - Total number, percent of total sample, mean fork length, and length range for each age group by sex for alewife, White Oak River, 1974-75

Sex	Age	Total number	Percent of total sample	Mean fork length(mm)	Length range(mm)
Female	IV	13	76	256	249-266
	V	4	24	272	260-289
		17			
Male	III	2	8	231	225-237
	IV	18	72	241	225-261
	V	5	20	250	242-255
		25			

Table 12 - Total number, percent of total sample, mean fork length, and length range for each age group by sex for American shad, White Oak River, 1974-75

Sex	Age	Total number	Percent of total sample	Mean fork length(mm)	Length range(mm)
Female	IV	2	13	417	391-442
	V	9	56	474	452-485
	VI	4	25	481	467-492
	VII	1	6	520	
		16			
Male	IV	10	53	406	363-431
	V	9	47	449	416-482
		19			

Their fork lengths agreed or were slightly smaller than those found by Street and Pate (1975) (Table 12). All were found to be virgin except one five-year old male which had spawned once previously (Table 10). This is currently the southern-most confirmed report of an American shad repeating.

Hickory shad

Two male hickory shad were caught in the White Oak River. One 345 mm three-year-old was found in January, 1974, and one 318 mm four-year-old was found in May, 1975. Both were virgin.

Striped bass

Three striped bass were found in March, 1975. Two were three-year-old females measuring 394 mm and 401 mm. The other was a 712 mm seven-year-old female.

Spawning Area Survey

New River

Spawning in the New River appeared to be very slight. In 1974, only two river herring eggs were taken in 8 samples using the 1-meter egg net and 100 samples using the 1/2-meter egg net. They occurred in only one sample during the week of 6 May below County Road 1316. This indicates the lower channelized section as being the spawning grounds for river herring (Figure 10). Five hickory shad eggs were captured during the week of 20 May below N.C. Highway 24. Spawning was probably limited to this point by the barrier presented by the culvert under Highway 24 (Figure 11). No American shad eggs were captured, but one running-ripe-female taken in the channelized area indicated that some spawning occurred in the altered section of the river (Figure 12). No anadromous fish larvae were taken.

During 1975, 69 river herring eggs and two larvae were taken in 95, 1/2-meter egg net samples. No river herring eggs were found in the river. Sixty-six eggs were caught in Hawkin Creek and three were found in Blue Creek during May. Two herring larvae were also found in Blue Creek during May (Figure 10). No running-ripe female herring were found. No eggs or larvae of other anadromous fish were found. However, one running-ripe female American shad was taken in Little Northeast Creek indicating it to be a spawning area. Although no eggs or running-ripe females were found in Southwest Creek, the presence of adults indicates American shad possibly spawn there. Also, the presence of adult blueback herring indicates these possibly spawn in Northeast and Little Northeast Creeks.

All egg-netting results indicate very poor spawning success for all anadromous species in New River. The prior location of spawning grounds is not known; however, the section of river presently channelized does not appear to offer suitable spawning habitat.

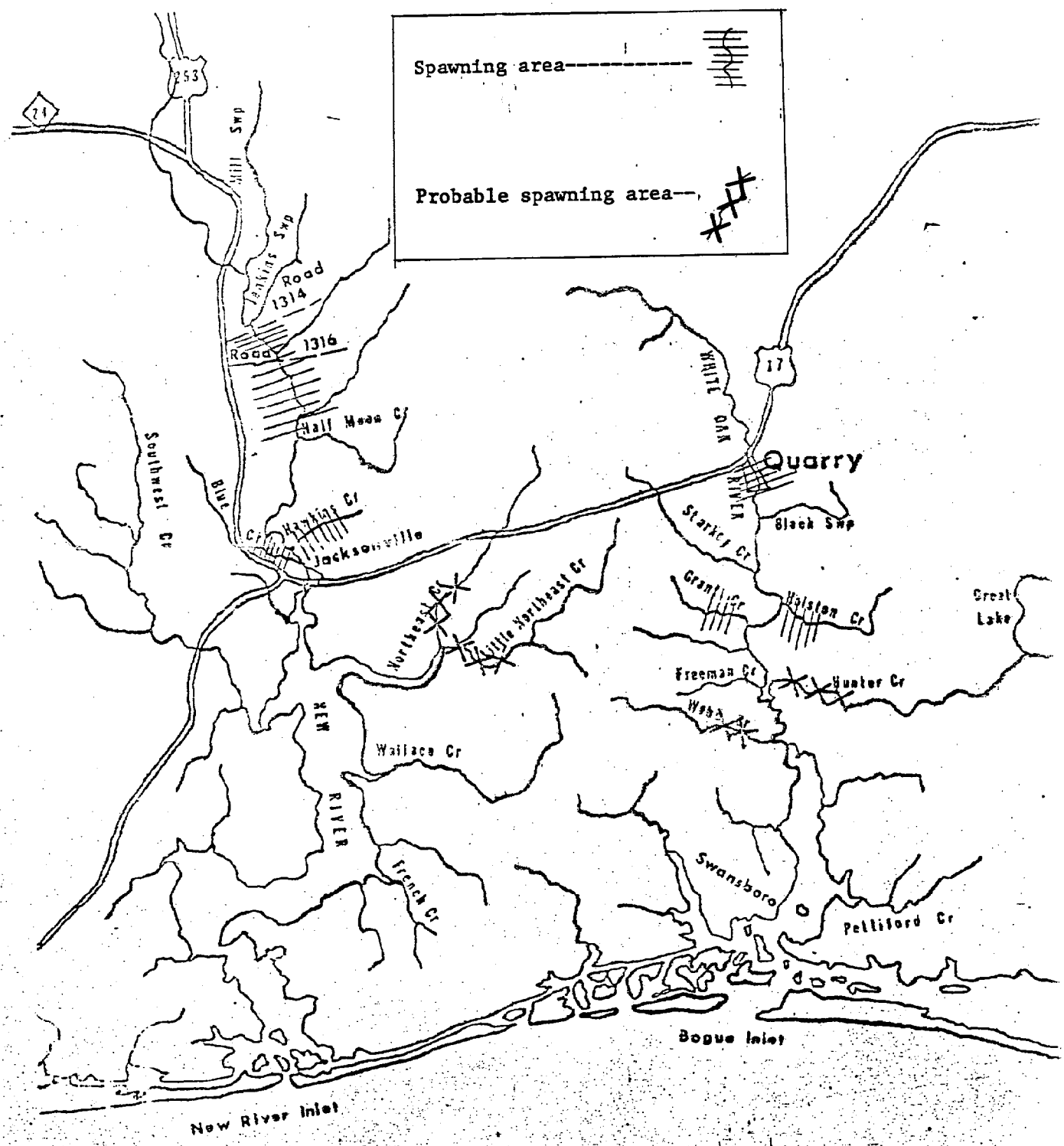


Figure 10— Map of spawning areas for river herring, New and White Oak Rivers, 1974-75.

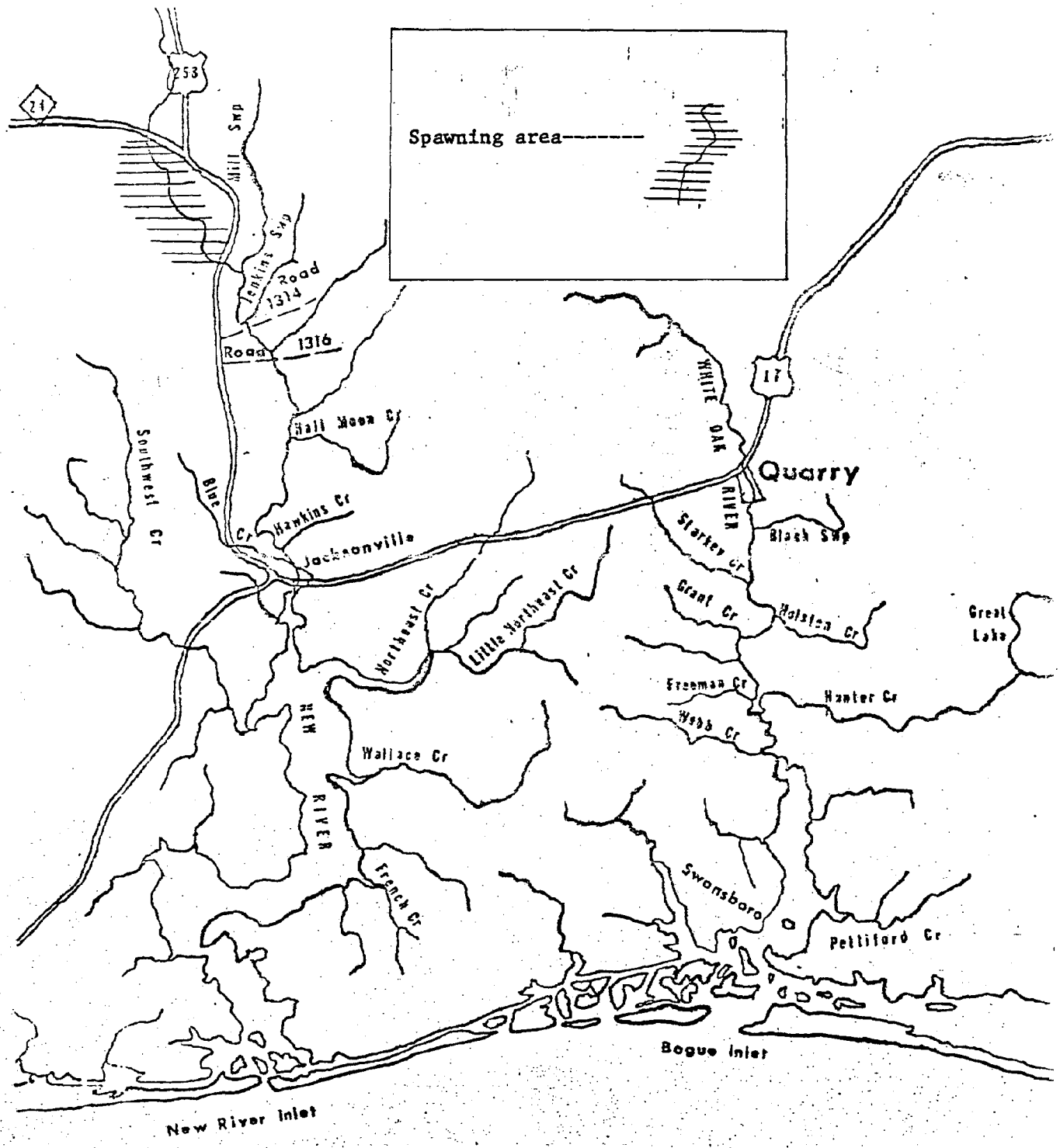


Figure 11 - Map of spawning area for hickory shad, New River, 1974

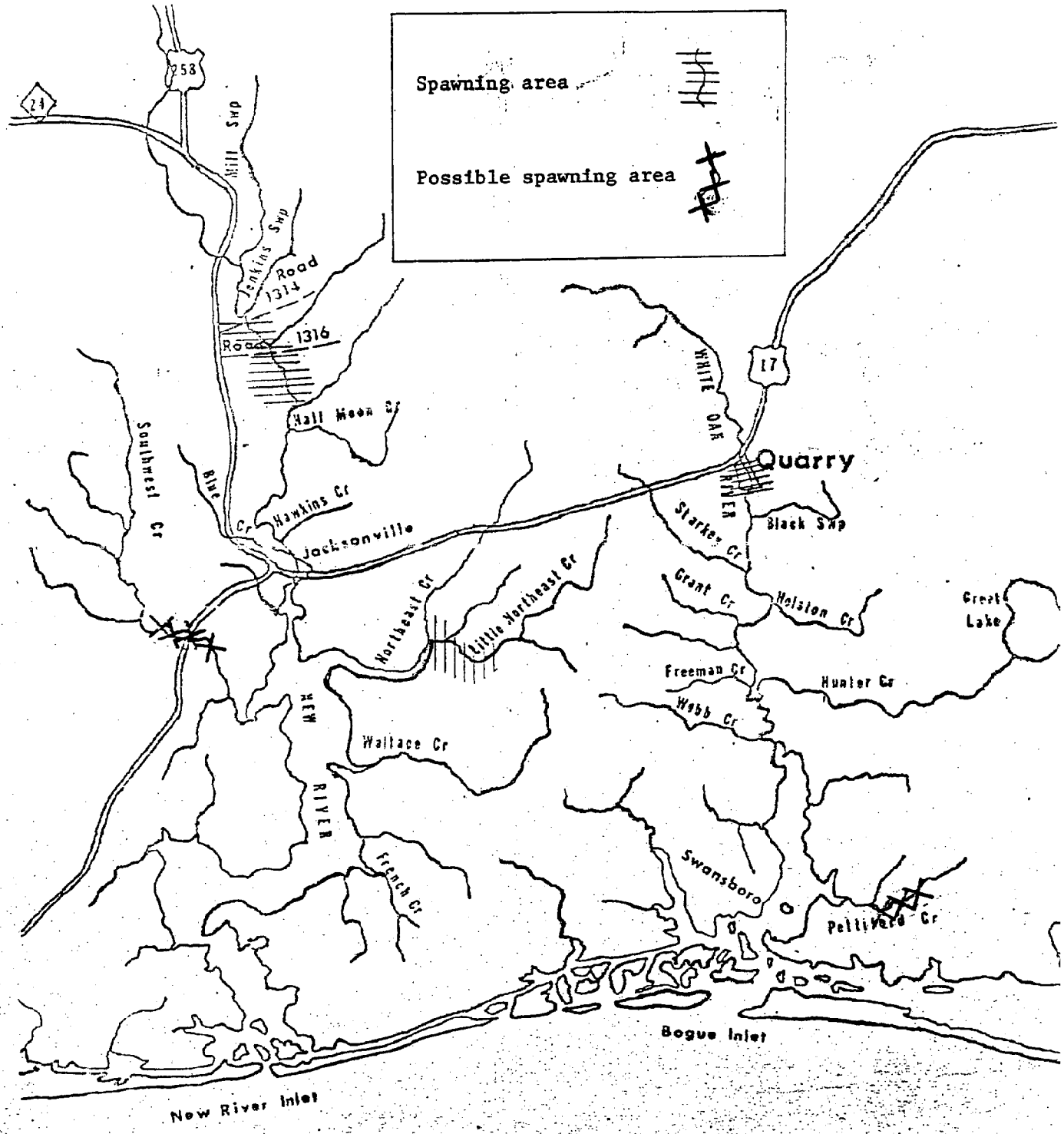


Figure 12 - Map of spawning area of American shad, New and White Oak Rivers, 1974-75

White Oak River

During 1974, a total of 2,083 river herring eggs were taken in a total of 10 samples using the 1-meter egg net and 105 samples using the 1/2-meter egg net. All were found in the Quarry Lakes. No other anadromous fish eggs were taken.

River herring began spawning the week of 2 April and extended through the week of 13 May. Peak spawning occurred during the week of 29 April (Figure 13). During 1974, a total of 45 river herring larvae were taken in a total of 41 samples using the 1/2-meter egg net in the fresh zone of the White Oak River. They were caught from 2 May to 15 May in the Quarry Lakes. All were early pro-larvae and had a mean length of 3.5 mm. The peak capture of river herring larvae occurred on 15 May (Figure 14). During May, 90 percent of the blueback herring found in the Quarry Lakes were running-ripe, indicating this to be a major spawning area (Figure 10).

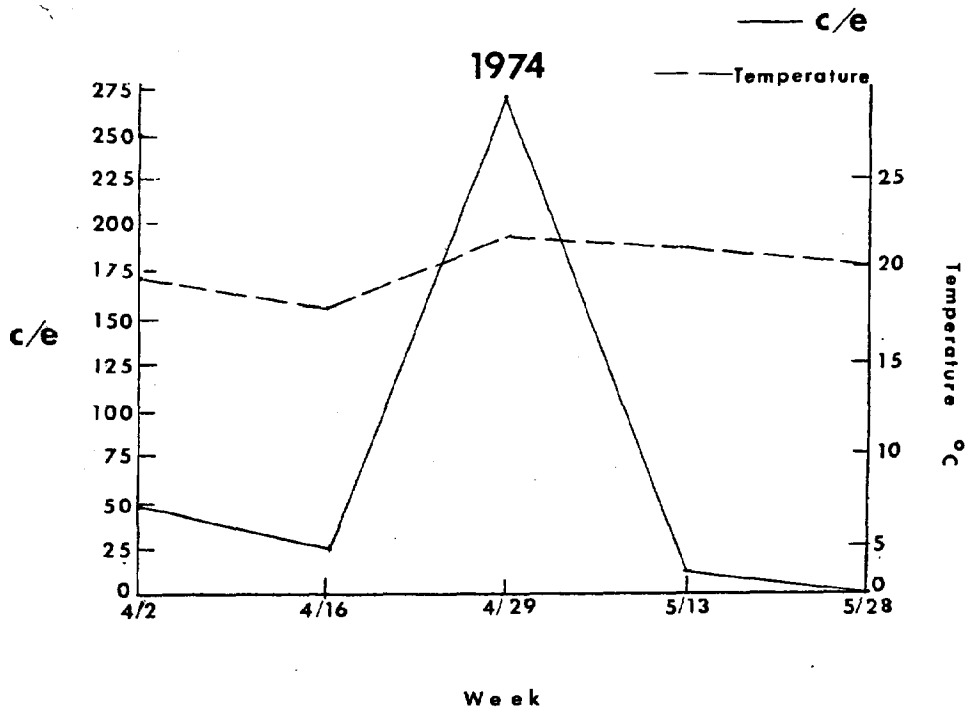
No other anadromous fish eggs or larvae were caught during 1974. The capture of a running-ripe female American shad in the Quarry Lakes indicates this to be a spawning area (Figure 12). No running-ripe female alewife were found, but their presence in the Quarry Lakes probably indicated this to be a spawning area.

During both years, spawning of river herring was observed taking place at the Quarry Lakes below U. S. Highway 17 and in the shallow, rocky region above the Quarry. Several schools of herring were observed "washing" along the edges, where the swift current produced rapids as it flowed over rocks. Herring were seen ascending a small waterfall (0.5 m in height) and spawning was observed taking place above the fall.

During 1975, 891 river herring eggs, 8 river herring larvae, 28 blueback herring larvae, 3 alewife larvae, and 1 American shad egg were captured in 87, half-meter egg net samples.

River herring spawning began the last week in March and lasted through May with peak spawning occurring during the first week in May (Figure 13). Spawning was observed in the Quarry Lakes as in 1974, but evidence also showed that spawning occurred in certain tributaries. River herring larvae found in Holston Creek and Grant Creek indicates these to be spawning areas (Table 13). The presence of adult river herring indicates spawning probably also occurs in Webb and Hunter Creeks, although no positive evidence was found.

American shad were found to spawn in the Quarry Lakes as indicated in 1974 (Figure 12). One egg was captured immediately above the Lakes during the first week in May. Also, running-ripe female American shad were observed in 1975 in the Lakes. The presence of adults indicated that spawning probably occurred in Pettiford Creek but no positive evidence was found.



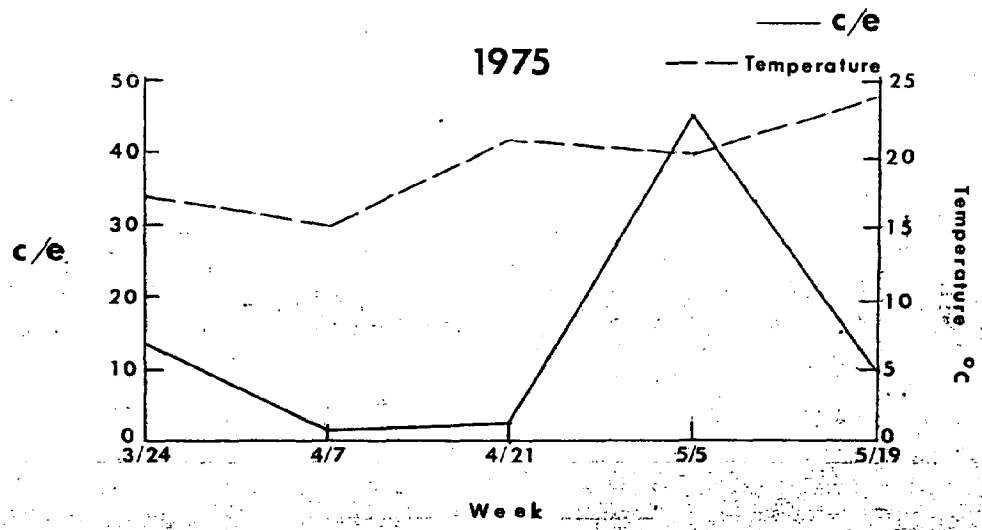
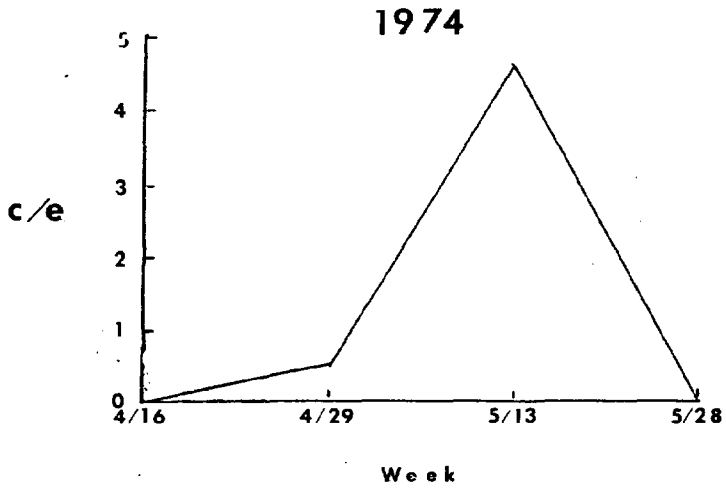


Figure 13.—Temperature and C/E for river herring eggs, fresh zone, White Oak River, 1974-1975.



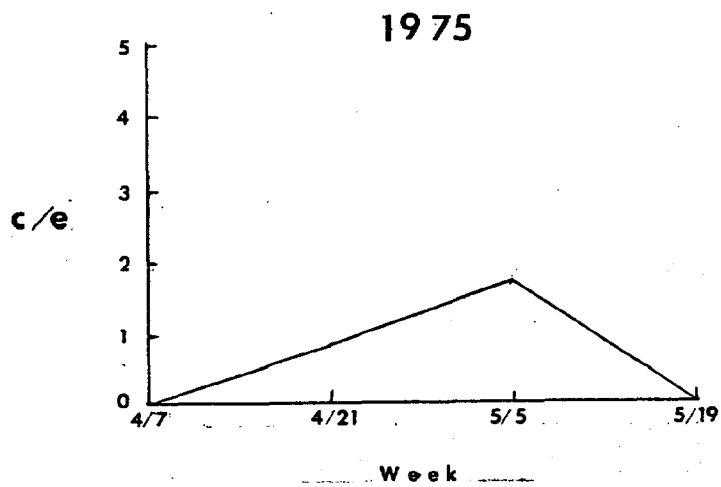


Figure 14.—C/E for river herring larvae, fresh zone, White Oak River, 1974-75

Table 13 - Evidence indicating spawning area locations, White Oak River, 1975

Location	Date	Species	Comments
Quarry lakes	3/26/75	River herring	112 eggs captured
	3/26/75	Blueback herring	Running ripe female-gill net
	4/10/75	River herring	20 eggs captured
	4/24/75	River herring	24 eggs captured
	4/24/75	Blueback herring	Running ripe female-gill net
	4/24/75	American shad	Running ripe female-gill net
	5/7/75	River herring	672 eggs captured; spawning activity observed
	5/19/75	River herring	63 eggs captured; spawning activity observed
	5/19/75	Blueback herring	Running ripe female-gill net
	5/19/75	American shad	1 egg captured
Holston Creek	5/5/75	River herring	1 larva captured
	5/5/75	Blueback herring	Running ripe female-gill net
	5/20/75	Blueback herring	24 larvae captured
Grant Creek	5/6/75	River herring	7 larvae captured
	5/20/75	Alewife	1 larva captured

Juvenile Fish Sampling

New River

A total of 90, 18.4 m seine efforts; 122, 6.1 seine efforts; 43, 1.8 m Cobb trawl efforts, and 130 wing trawl efforts produced 9 blueback herring, 2 alewife, and 2 American shad from October through December, 1973 and July through December, 1974. Catch data for each gear type are shown in Table 14. The 18.1 m seine and the modified wing trawl were found to be most successful at catching juvenile anadromous fish. The 6.1 m seine was used in the smaller tributaries and produced no juveniles.

Blueback herring

Juvenile blueback herring were found during October and November, 1973. None were captured during 1974. All of the blueback herring were found in the lower channelized section (Figure 15), and had a mean fork length of 51 mm in October 1973. The data obtained was inadequate to determine growth and movement.

Alewife

Only two juvenile alewife were found in 1973 (Table 14). Both were caught in the lower channelized section during October 1973 (Figure 15). None were found in 1974.

American shad

Two juvenile American shad were caught in the New River (Table 14). One was taken in October 1973 in the lower channelized part and one in October 1974 in lower Southwest Creek (Figure 16). This may indicate Southwest Creek as a possible nursery area.

Juvenile fish sampling indicates that the New River produced very few young-of-the-year anadromous fish during 1973 and 1974. The small catches of juveniles may be a result of reduced spawning and a lack of suitable nursery area habitat to maintain an anadromous population, but it will be very reduced.

White Oak River

From October through December, 1973 and July through December, 1974, a total of 352 blueback herring, 110 alewife, and 3 American shad were caught in 159, 18.4 m seine efforts; 81, 6.1 m seine efforts; 30, 1.8 m Cobb trawl efforts; and 83 wing trawl efforts. The C/E by gear is shown in Table 15.

Blueback herring

Juvenile blueback herring were found from July through November in the fresh zone of the White Oak River. Their peak occurrence was in October of both years, with catches dropping drastically afterwards (Figure 17). This indicates the seaward migration probably occurs after October. Three tributaries produced juvenile blueback herring. They were Webb, Grant, and Hunter Creeks with Hunter having the highest C/E (Figure 15 and Table 16).

Table 14.- Catch, effort, and catch-per-unit-effort (C/E) for 1973 and 1974 year classes of blueback herring, alewife, and American shad by gear, New River

	18.4m seine		Wing trawl		1.8m Cobb trawl	
Year	1973	1974	1973	1974	1973	1974
Effort	36	54		130	43	
Blueback herring						
Catch	9	0		0	0	
C/E	0.25					
Alewife						
Catch	2	0		0	0	
C/E	0.06					
American shad						
Catch	1	0		1	0	
C/E	0.03			0.01		

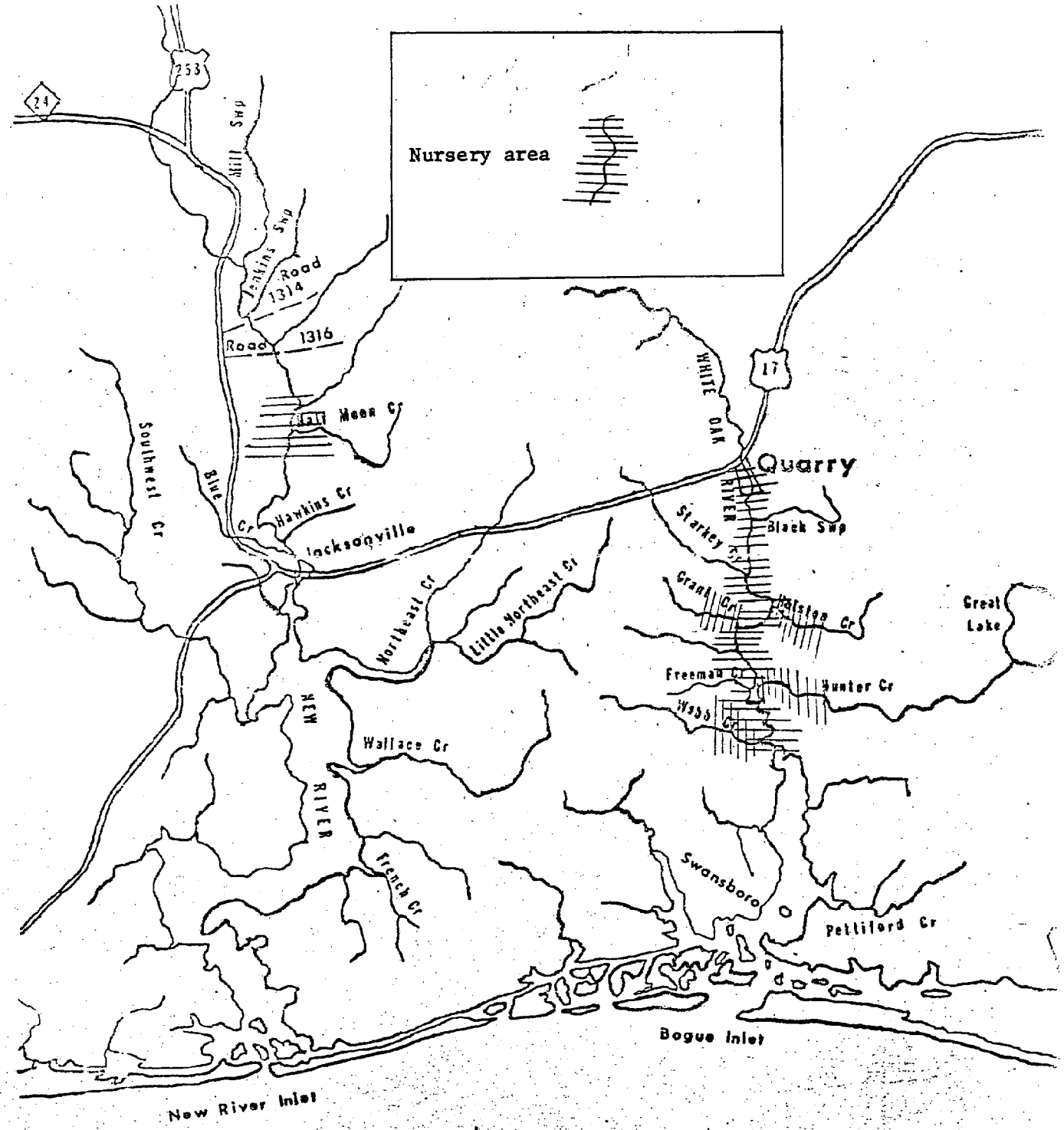


Figure 15 - Map of nursery area of blueback herring and alewife, New and White Oak Rivers

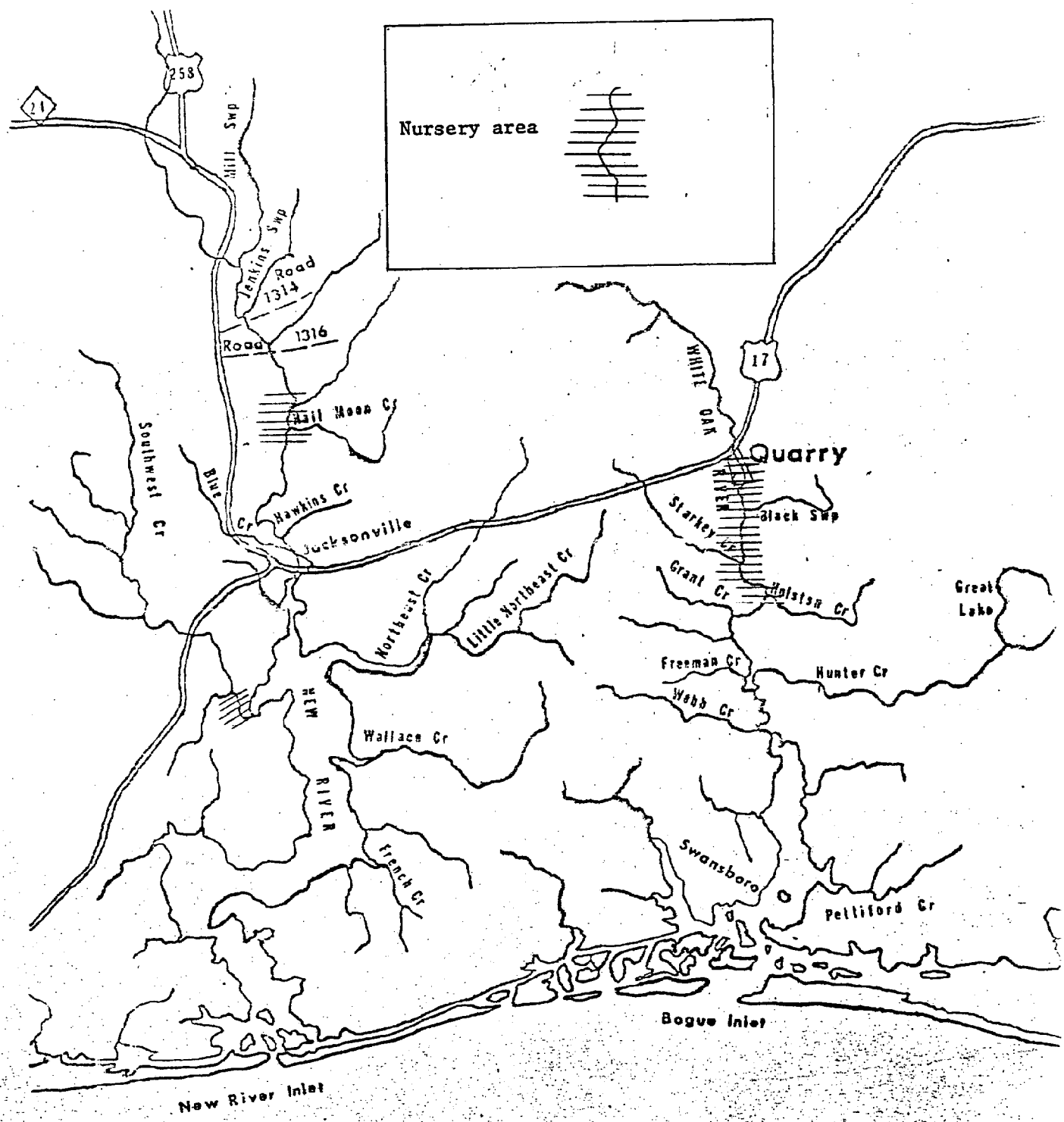


Figure 16 - Map of nursery area of American shad, New and White Oak Rivers

Table 15 - Catch, effort, and catch-per-effort (C/E) for 1973 and 1974 year classes of blueback herring, alewife, and American shad by gear in the White Oak River

	18.4m seine		Wing trawl		1.8m Cobb trawl	
Year	1973	1974	1973	1974	1973	1974
Effort	36	123		83	30	
Blueback herring						
Catch	224	87		35	6	
C/E	6.23	0.71		0.43	0.20	
Alewife						
Catch	1	42		67	0	
C/E	0.03	0.35		0.81		
American shad						
Catch	0	3		0	0	
C/E		0.03				

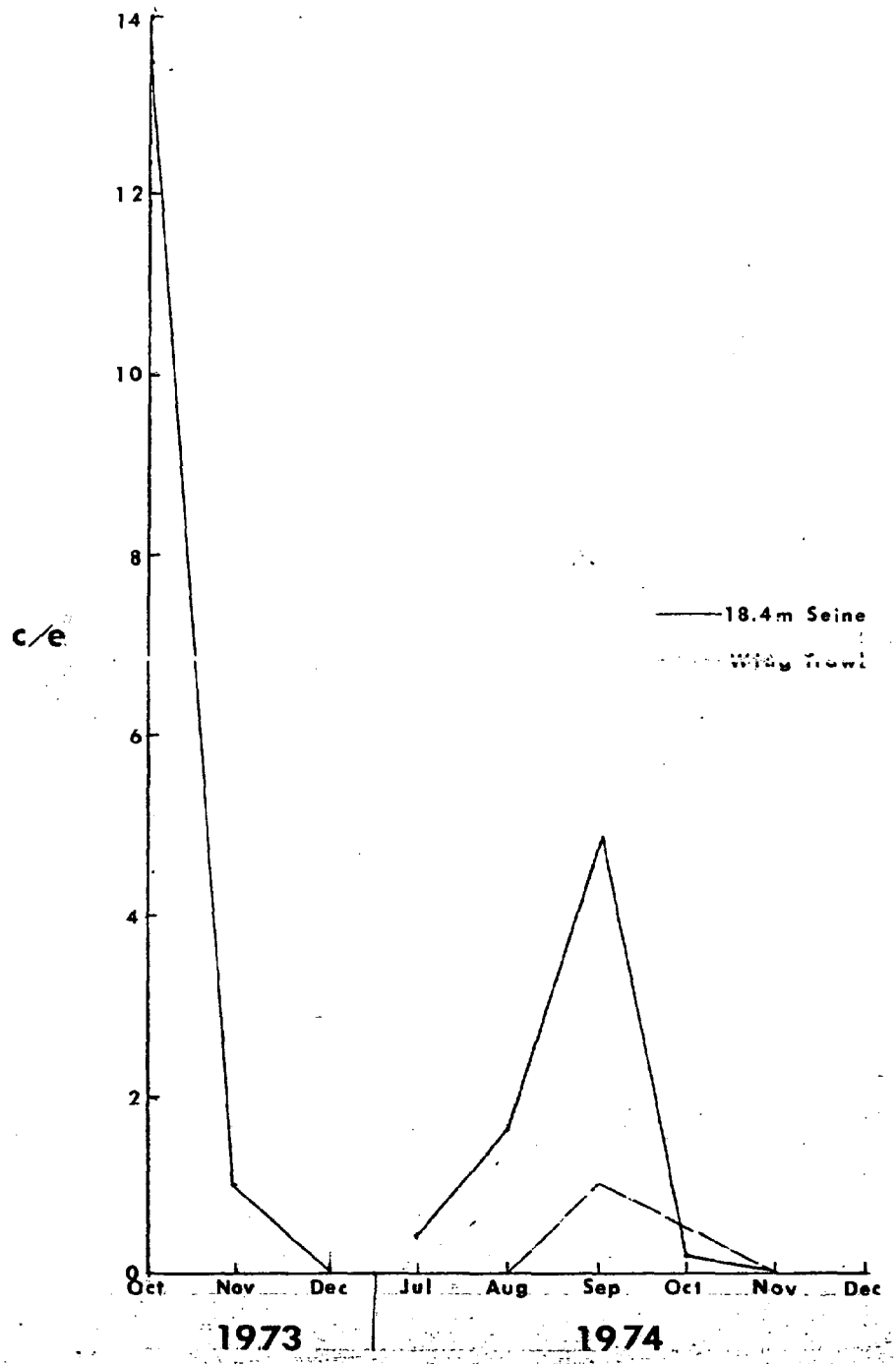


Figure 17.—Catch-per-unit-of-effort (C/E) of juvenile blueback herring, fresh zone, White Oak River, 1973-74.

Table 16 - Catch-per-unit-of-effort for blueback herring and alewife by gear and area, White Oak River, 1973-74

	Year	18.4 m seine 1973	18.4 m seine 1974	Wing trawl 1974
Blueback herring	Brackish zone	0.7	0.0	0.0
	Fresh zone	11.6	1.2	0.3
	Hunter Creek			0.9
	Webb Creek			2.0
Alewife	Brackish zone		1.0	0.4
	Fresh zone	0.1	0.4	1.9
	Grant Creek		0.1	
	Holston Creek		0.6	
	Webb Creek			0.1
	Hunter Creek			3.6

The mean fork lengths by month for blueback herring were larger than those found by Street and Pate (1975) in the Albemarle Sound area (Figure 18). This is probably due to their use of 3.2 mm mesh gear as opposed to the 6.4 m mesh gear used in this study.

Alewife

Juvenile alewife were found in greatest concentrations in the fresh zone in September. Afterwards, their numbers decreased, indicating the seaward migration occurs after September (Figure 19). The nursery area for alewife generally corresponded with that for blueback herring (Figure 15), but with a higher concentration of individuals occurring in the lower part of the river (Table 16). They were also found using the lower parts of Webb, Hunter, Grant, and Holston Creeks with Hunter Creek containing the highest concentration (Table 16).

The mean monthly fork length for alewife ranged from 47 mm in July to 81 mm in December. This agreed with those found by Street and Pate (1975) in the Albemarle Sound area (Figure 20).

American shad

Juvenile American shad were taken only in July of 1974. It appeared they left the spawning grounds and immediately moved down stream on a seaward migration. They were found from the spawning grounds down to the vicinity of Holston Creek during a one week period in July (Figure 16). At this time the mean length of the juvenile fish was 59 mm.

The White Oak River apparently produces enough juvenile anadromous fish to maintain an exploitable population. The nursery grounds of the three species combined, covers over 30 km of river from the Quarry Lakes to the Webb Creek area.

SUMMARY AND CONCLUSIONS

New River

The New River appears to contain very low anadromous fish stocks. As a result, there is little or no utilization of anadromous fish. The reduced population is probably due to the 30.8 km of channelized stream and the large amount of development of the New River watershed. Personal communication with commercial fishermen indicated significant anadromous populations once existed.

The drastic reduction in anadromous fishes in the New River is probably due to reduced recruitment. Low spawning and juvenile success as seen in 1973 and 1974 is probably due to a lack of suitable habitat which places the anadromous stocks in serious danger. The future of the New River anadromous population will depend upon the ability of the tributaries to provide suitable habitat to maintain recruitment since the habitat previously found in New River above Jacksonville no longer exists.

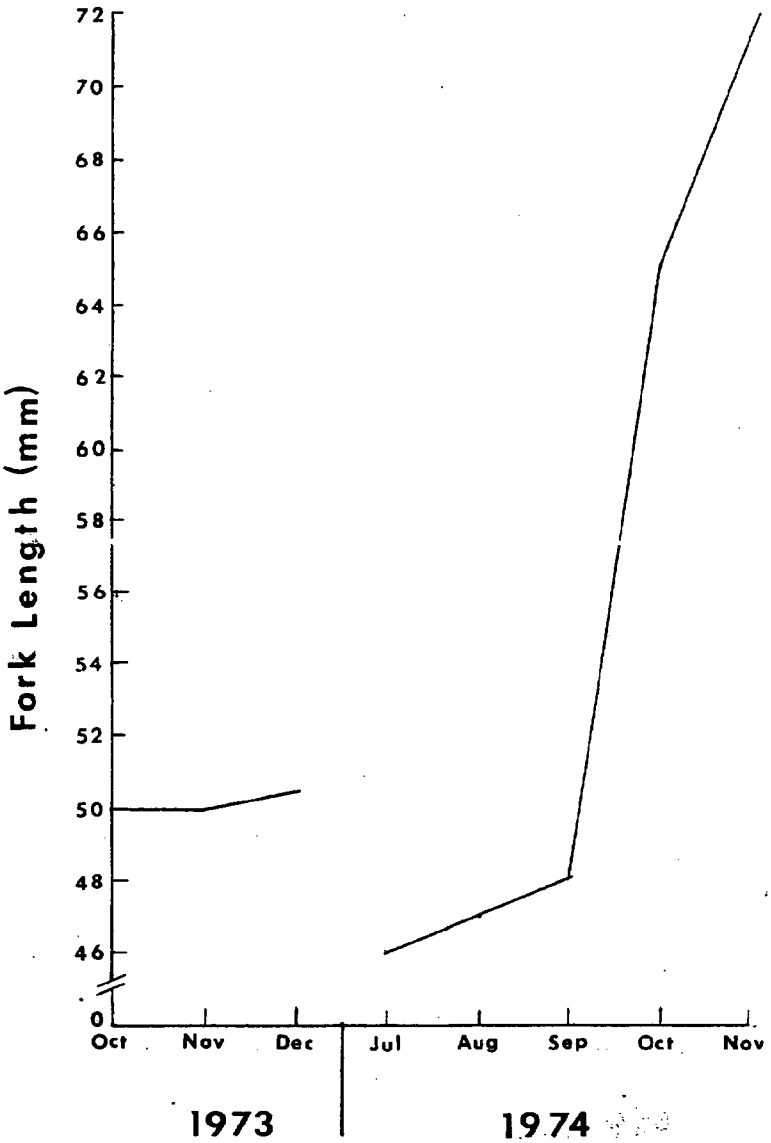


Figure 18.—Mean fork length of juvenile blueback herring by month, White Oak River, 1973–74.

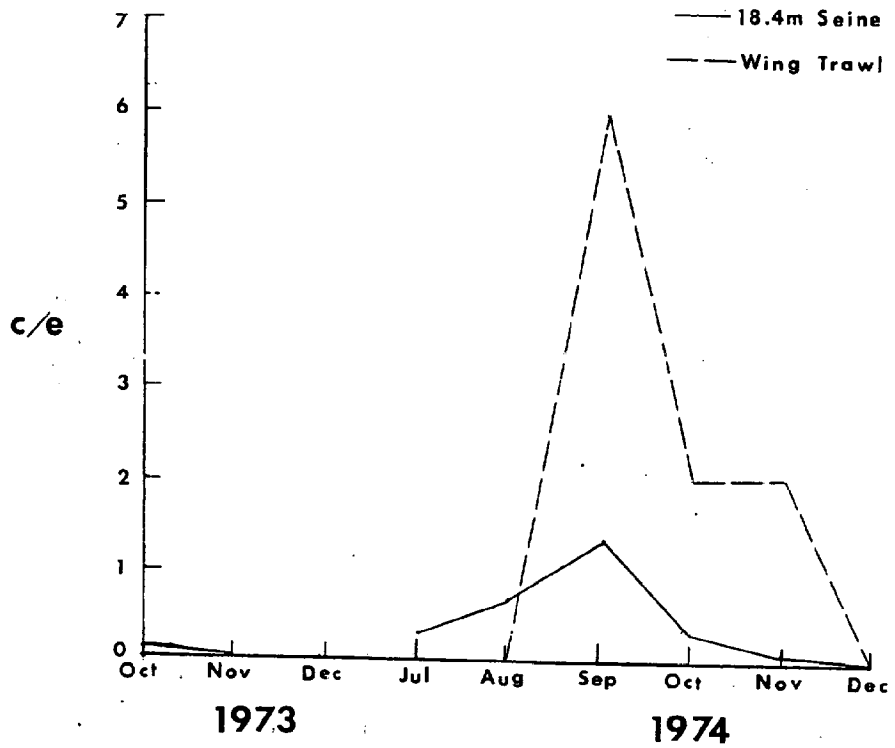


Figure 19.--Catch-per-unit-of-effort (C/E) of juvenile alewife, fresh zone, White Oak River, 1973-74

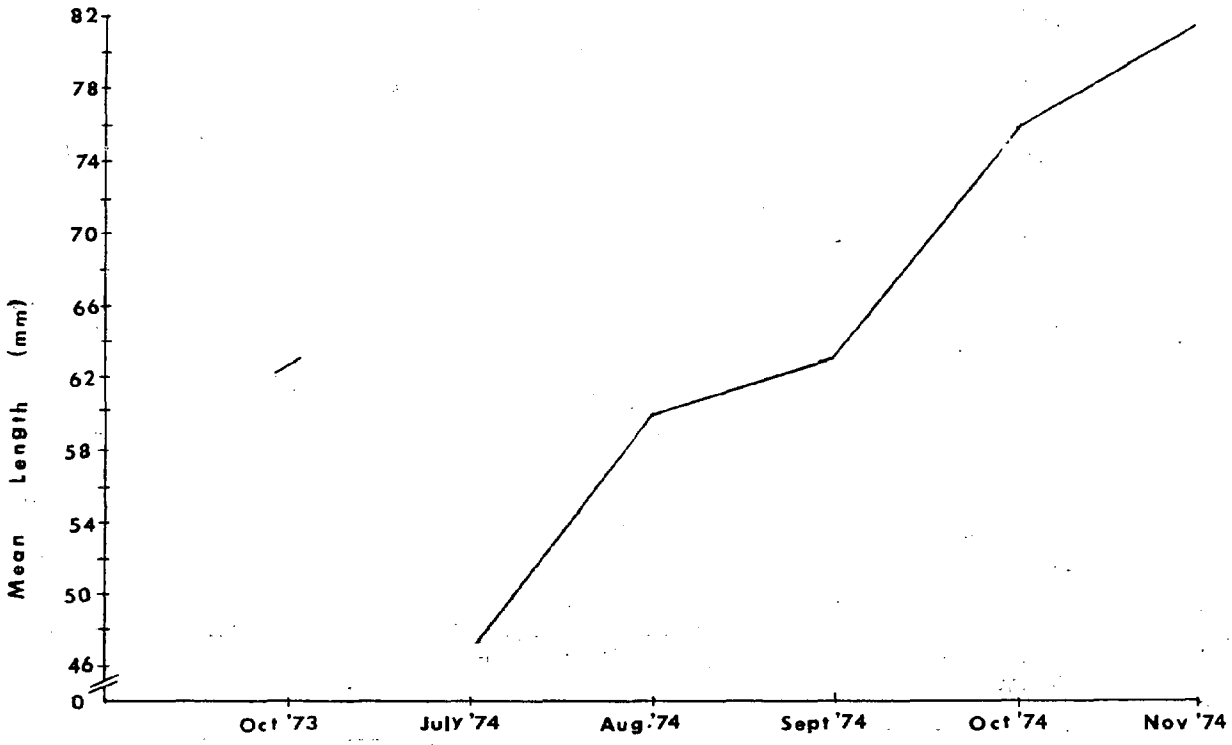


Figure 20.—Mean monthly fork length of alewife, White Oak River, 1973-74

White Oak River

The White Oak River supports a substantial run of blueback herring and smaller runs of alewife, American shad, and hickory shad. Adult blueback herring entered the river in January; they were predominantly four and five year old fish, and most were virgin. Juvenile blueback were found to use the Martin Marietta Belgrade Quarry Lakes, the river below, and certain tributaries as nursery grounds. Their seaward migration was found to occur in October.

Adult alewife entered the river in April and were predominantly ages four and five; the vast majority were virgin. Only a few juvenile American shad were found.

All three species of anadromous fish used the Martin Marietta Belgrade Quarry Lakes as spawning areas during April and May. Although the lakes represent an altered environment, they still appear to support adequate populations of anadromous fish. In addition, in 1975, river herring were found to use Holston and Grant Creeks as spawning areas with spawning probably occurring in Hunter and Webb Creeks.

The White Oak River currently supports a small recreational dip net and gill net fisnery. These appear to have little or no impact upon the anadromous fish populations. The greatest problem facing anadromous fish populations in small rivers is flood control activities such as channelization and watershed development. The impact of such alterations is seen vividly in New River. As a result, it is recommended that future channelization projects be given closer scrutiny especially where anadromous fish resources are involved.

ACKNOWLEDGEMENTS

This project was made possible by the efforts of many of the Division of Marine Fisheries personnel: Walter F. Godwin and Michael W. Street; Fisheries Technicians James J. Bahen, Gerry Davis, and Morris Allison; Lab Technicians Elizabeth Griffin and Dianne Craig; Preston Pate, who assisted in aging scale samples; Secretary Elizabeth Wainwright; and to the many students at Cape Fear Technical Institute who assisted in the field and lab work. Gratitude is expressed to the Martin Marietta Company and its staff at the Belgrade Quarry who provided easy access to the lakes and information. Finally, appreciation is extended to all the commercial and recreational fishermen of the New and White Oak Rivers for their valuable information.

LITERATURE CITED

Baker, W. D. 1968.
A reconnaissance of anadromous fish runs into the inland fishing waters of North Carolina. Final Report of Federal Aid in Fish Restoration, Project AFCS-3. N. C. Wildlife Resources Commission, Raleigh, N. C., 33p.

Beal, Kenneth Lee. 1968.
Age and growth of the blueback herring (*Alosa aestivalis*) (Mitchill). Appendix I. M. S. Thesis, College of William and Mary, Virginia, 82p.

Cating, James E. 1953.
Determining age of Atlantic shad from their scales. U. S. Fish and Wildlife Service, Fishery Bulletin. 54(85):187-199.

Davis, James R. and Randall P. Cheek. 1967.
Distribution, food habits, and growth of young clupeids, Cape Fear River system, North Carolina. Proceedings of the 20th Annual Conference of the Southeastern Association of Game and Fish Commissioners, p. 250-260.

Davis, James R. and E. G. McCoy. 1965
Survey and classification of the New, White Oak, and Newport Rivers and tributaries, North Carolina. Final Report for Project F-14-R, Job I-T. North Carolina Wildlife Resources Commission, Raleigh, N.C., 12p. and Appendix.

Marcy, Barton C. 1969.
Age determinations from scales of (*Alosa pseudoharengus*) (Wilson), and (*Alosa aestivalis*) (Mitchill), in Connecticut waters. M. S. Thesis, University of Connecticut, 26p.

Nichols, Paul R. and Derrell E. Lauder. 1970
Upstream passage of anadromous fish through navigation locks and use of the stream for spawning and nursery habitat, Cape Fear River, N.C., 1962-1966. U.S. Fish and Wildlife Service, Circular 352, 12p.

Stevenson, Charles H. 1899.
The shad fisheries of the Atlantic coast of the United States. U. S. Commissioner of Fish and Fisheries, Report for 1898, p. 101-269.

Street, Michael W. and Preston P. Pate. 1975.
Anadromous fisheries research program, Northern coastal region, Section I. Final Report for Project AFCS-8. N. C. Division of Marine Fisheries, Morehead City, N. C., 173p.

Street, Michael W. and John G. Adams. 1969
Aging of hickory shad and blueback herring in Georgia by the scale method. Georgia Game and Fish Commission, Marine Fisheries Division, Contribution Series No. 18, 13p.

Walburg, C. H. and P. R. Nichols. 1967
Biology and management of the American shad and status of the fisheries, Atlantic Coast of the United States, 1950. U. S. Fish and Wildlife Service, Special Science Report - Fisheries Number 550, 105p.

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