ANADROMOUS FISHERIES RESEARCH PROGRAM

CAPE FEAR RIVER SYSTEM

PHASE II

by

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ABSTRACT

During 1 July 1977 to 30 September 1979 various life history stages of anadromous fishes were examined in the Cape Fear River, NC, below Lock and Dam #2. Nursery areas were tentatively mapped for American shad, blueback herring and alewife. Spawning areas for American shad, striped bass and river herring were identified. Sampling was carried out to determine growth, relative abundance and seaward migration of juvenile anadromous fishes. Adult American shad ranged in age from three to seven year. The male:female sex ratio was 1.2:1 in 1978 and 2.8:1 in 1979. Only two shad were found to have spawned previously. Blueback herring ages ranged from three to seven while striped bass ranged from two to eleven years. Catches from the American shad commercial and recreational fishery were examined for age, spawning frequency and sex ratio. Adult abundance, age composition and juvenile abundance were monitored in the Northeast Cape Fear River. There, adult American shad ranged in age from four to seven years; herring ranged from three to seven; hickory shad ranged from three to five; and adult alewife were four and five years old. The American shad male:female sex ratio in the spawning area was 2.6:1 in 1978 and 4:1 in 1979.

INTRODUCTION

Project AFCS-15 is the second phase of the Anadromous Fisheries Research Program in the Cape Fear River System. Phase one was conducted on the Northeast Cape Fear River during 1975-1977 (Sholar 1977). The objectives of this project have been to determine age and size composition of the commercial and recreational harvest of adults; determine movement, distribution and utilization of adults within the system; designate spawning and nursery areas for all anadromous species; and to determine growth and movement of juvenile anadromous fishes.

Anadromous fishes support important commercial and recreational fisheries in North Carolina. During 1961 through 1970, anadromous species represented approximately 48 percent of the total edible finfish landings in North Carolina (Street and Pate 1975). The catch of anadromous fishes by the recreational fishery is not precisely known, but is thought to be in the millions of pounds.

There have been several studies of anadromous fish stocks in North Carolina, and a few have looked at the Cape Fear River stocks. Nichols and Louder (1970) described the passage of anadromous fish through the three navigational locks and spawning and nursery areas of shad and herring. Davis and Cheek (1967) reported the distribution, food habits and growth of juvenile American shad, blueback herring and alewife in the Cape Fear, Northeast and Black Rivers. Davis (1967) also examined the recreational fishery and shad run above the first lock on the Cape Fear River. Baker (1968) discussed the recreational harvest of shad, river herring and striped bass. Walberg and Nichols (1967) described the shad fishery of the Cape Fear River System. Bayless (1963) reported on the fishery resources of the Northeast Cape Fear River.

These reports on the anadromous fish resources of the Cape Fear System have provided a general information base. Sound management of these stocks requires a detailed field survey of the anadromous fishery of this system followed by regular monitoring. A detailed study of anadromous fish stocks, utilization, and spawning and nursery habitat is required for a sound management program. Increasing public demands on the anadromous resource and on the Cape Fear System itself require detailed long-term information on which management decisions can be based. This project is designed to provide such information.

STUDY AREA

The Cape Fear River is formed by the convergence of the Deep and Haw Rivers at the Chatham-Lee County line. The river flows approximately 274 km in a south-southeasterly direction to the city of Wilmington and from there, 40 km south to the Atlantic Ocean. The main river drainage area encompasses an area of 15,708 sq km with an additional 7,988 sq km included in the drainage areas of the Deep and Haw Rivers. It is the largest river basin lying completely within the state of North Carolina. The Cape Fear River has five major tributaries--Upper Little River, Lower Little River, Rockfish Creek, Black River, and Northeast Cape Fear River, which is the largest of the tributaries. (Figure 1). The major tributaries which feed the Cape Fear River are dark, acid, swamp-drainage streams; however, the waters of the Cape Fear River itself are usually very turbid.

Three navigational dams and locks were built between 1913 and 1934. The dams prevented fish from entering the river above except during boat lockages or periods of high water. Although the dams were provided with fish ladders, anadromous fishes did not use them (Davis and Cheek 1967). However, through an agreement among NC Wildlife Resources Commission, US Army Corps of Engineers, and US Fish and Wildlife Service, fish are locked upstream through all three locks during the spawning run of anadromous fishes in the spring (Nichols and Louder 1970).

Most of the Cape Fear River is a typical Coastal Plain stream meandering through broad floodplain and forming a series of "pools" between the three navigational locks. The river narrows from a width of about 152 m at Wilmington to approximately 91 m at Lock and Dam # 1 at King's Bluff. The US Army Corps of Engineers dredges the river every three or four years to maintain an average depth of 3.6 m from Wilmington (Mile 0) to Mile Board 30. From there the river averages 2.4 m in depth to Fayetteville (US Army Corps of Engineers 1975). Land use above Lock and Dam #1 is primarily agricultural except for the more industrial areas of Elizabethtown and Fayetteville. The shoreline of the lower 70 km of the river to Wilmington is mainly brackish and fresh water marshes and hardwood swamps affected by semidiurnal tides. At Wilmington the tide range is 1.2 m but it lessens to about 0.3 m range at Lock and Dam #1. Two of the main zones of

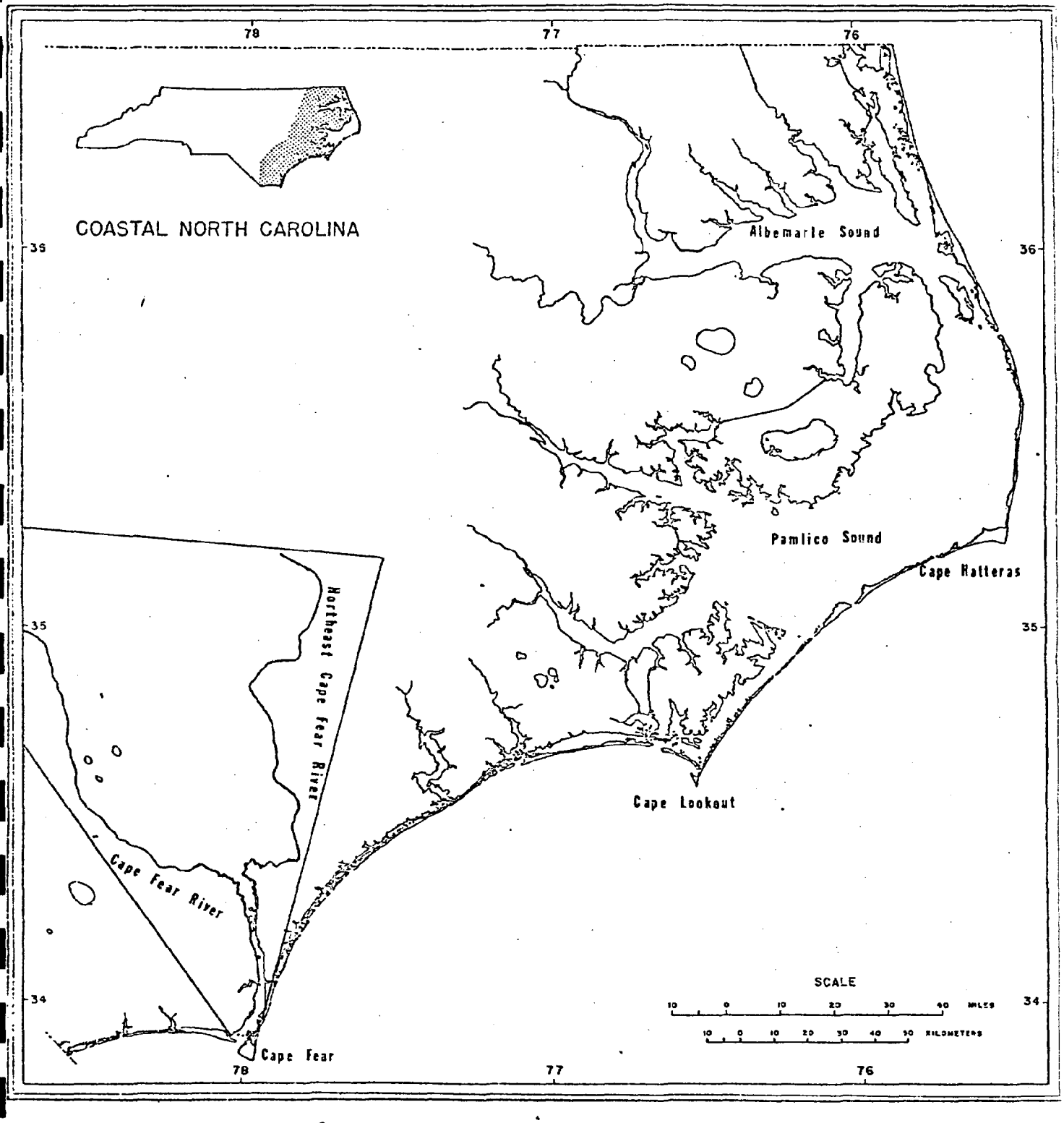

Figure 1.--Location Map of Cape Fear River and Northeast Cape Fear River

industrialization are the area around Wilmington and its harbour and further upstream, at the Riegel Paper Corporation Industrial Complex. Below Wilmington the river widens and salinity and tidal range increase towards the mouth (Figure 2).

The Northeast Cape Fear River is the major tributary of the Cape Fear River (Figure 3). The Northeast flows southwest from the town of Mount Olive approximately 200 km where it meets with the Cape Fear River at Wilmington. The Northeast watershed encompasses approximately 4,534 sq km, the majority of which is swampland. A more detailed description of the Northeast was given by Sholar (1977).

MATERIALS AND METHODS

Juvenile Survey

A survey of juvenile anadromous fishes was conducted during July - December 1977, June - October 1978, and June - September 1979. (termination of project segment). Samples were taken with a surface-towed Carolina wing traul with an 8 m headrope and a 3.2 mm mesh tail bag. During the preliminary survey (July-December 1977) random seines samples were also taken with an 18.4 m seine with bags of 3.2 mm bar mesh. From the preliminary survey 15 permanent stations were selected and a minimum of 35 stations were sampled monthly (Figure 4). A ten minute tow with the wing trawl was a standard unit-of-effort.

All alosids captured were preserved in the field with ten percent formalin and later sorted to species, measured (Fl, mm), and counted. Sub-samples of 30 specimens of each species were measured when large samples were encountered. Identification of specimens was based on Lippson and Moran (1974). Environmental data such at top and bottom temperatures, salinity, depth, bottom type, and river stage were taken at each station each month.

Adult Survey

Adult anadromous fish were sampled from January til June in both 1978 and 1979. Sampling was conducted with set gill nets and drift gill nets. Set nets measuring 45.9 m, 12.4 cm, 13.3 cm, 14.0 cm. and 15.4 cm were used. These nets were set in deeper water to catch shad while small mesh nets were set in

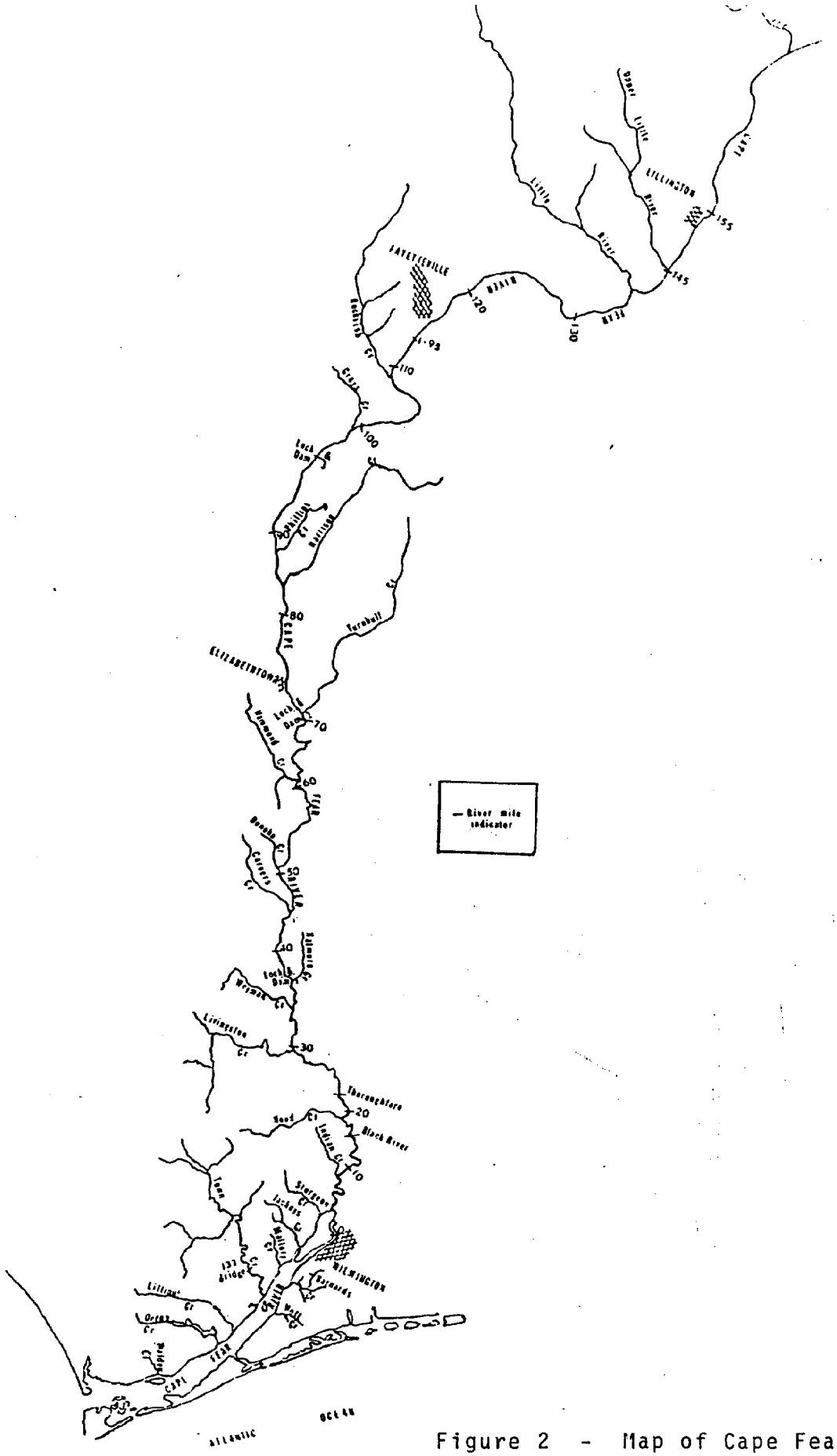

Figure 2 - Map of Cape Fear River, NC showing river miles and tributaries

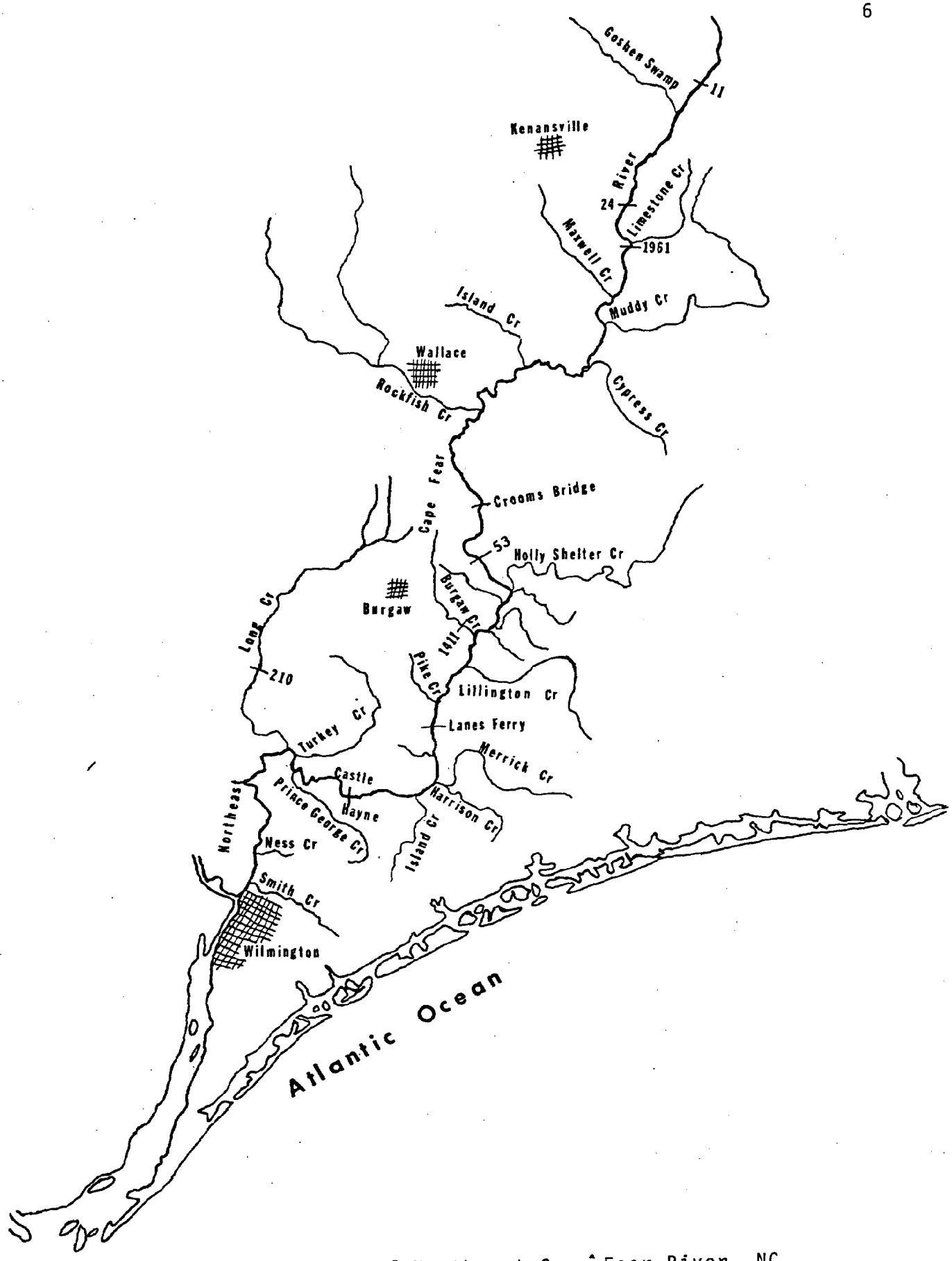

Figure 3 - Map of Northeast Cape Fear River, NC

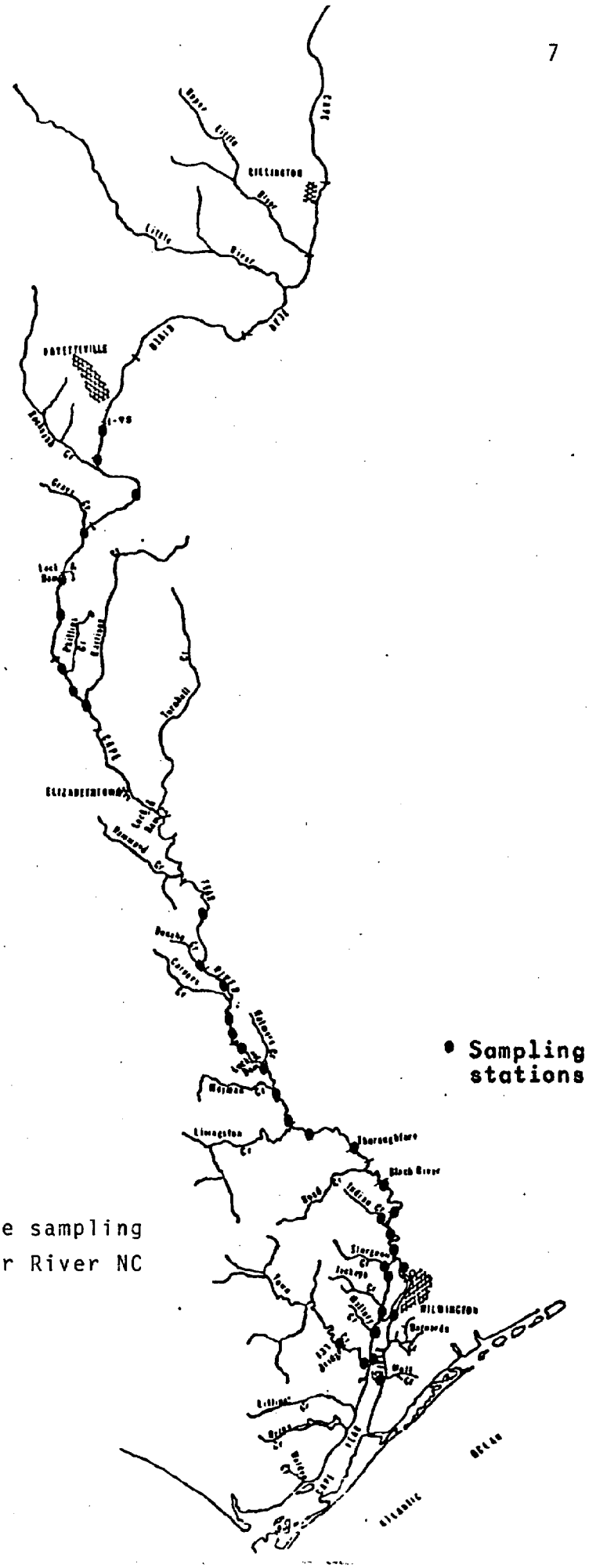

Figure 4 - Permanent, juvenile sampling stations, Cape Fear River NC 1978 - 1979

shallower water for river herring. The river was divided into two segments: below Lock and Dam #1 and between Lock and Dam #1 and Lock and Dam #2. Equal efforts of each mesh size were used to sample all segments of the population. The standard unit-of-effort was considered to be 91.4 m of net set for 24 hours. Catch per effort (C/e) of river herring was based on the amount of small mesh nets set, shad on large mesh nets, and striped bass and sturgeon on total units of nets set.

In addition, random samples were taken with drift nets for shad. Drift nets of 91.4 m and 45.9 m lengths with stretched mesh of 12.4 cm, 13.3 cm, 14.0 cm, and 15.4 cm were used. Drift nets were put out in suitable areas and fished for one or two hours. One standard unit-of-effort was considered to be 91.4 m of net fished for one hour.

All adults captured in set and drift nets were measured (fl, mm), weighed, sexed, and spawning condition noted as immature, mature, ripe, running ripe, or spent. Scale samples were also taken. Aging was done by the annuli and spawning mark method, with the scale edge counted as a year-mark as described by Cating (1953), Beal (1968), and Street and Adams (1969). Several clear scales from each fish were read with a binocular microscope and/or a microfilm reader. Two independent readings were made and those disagreeing were discarded.

Spawning Area Survey

The spawning survey was conducted during 15 March - 30 May 1978 and 1979. Half-meter plankton nets with #00 mesh were used to sample larvae and eggs. Samples were taken up to twice per month at selected juvenile stations and tributaries below Lock and Dam #1 in 1978 and below Lock and Dam #2 in 1979 (Figure 5). In addition, random samples were taken where spawning was suspected to occur. All samples were taken by towing the net for a minimum of five minutes at the top and where possible five minutes close to the bottom. A ten minute tow with a plankton net was considered to be one unit-of-effort. Samples were preserved in the field with ten percent formalin. After being sorted, samples were later preserved with three percent formalin and identified. Identification was based on Lippson and Moran (1974) and Chambers (1969). Due to the difficulty in distinguishing between alewife and blueback herring eggs and prolarvae, they were combined and called river herring. The occurrence of a running ripe female caught by a gill net was also considered to be evidence of a spawning area.

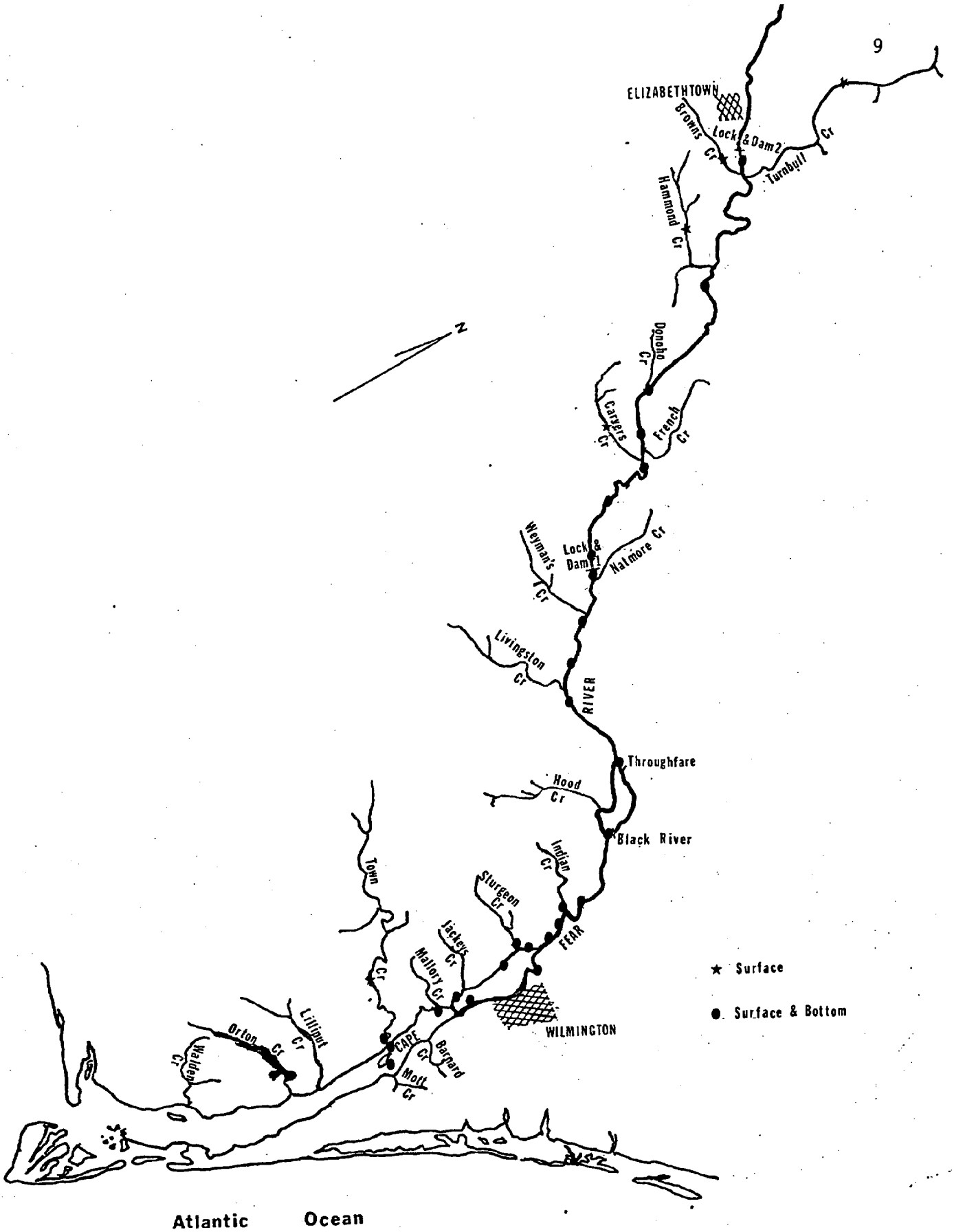

Figure 5 - Egg net sampling stations, Cape Fear River, NC 1978 - 1979 (1978 stations below Lock and Dam # 1

Commercial and Recreational Harvest

Harvest sampling was conducted at fish markets and fishermen's houses. Sampling was primarily limited to drift net catches. Samples were also taken whenever possible from fishermen on the river and at boat landings. These samples were considered unculled. Measurements (Fl, mm) and sex were taken along with scales for aging.

Tagging

Tagging of striped bass and sturgeon was done whenever a live specimen was obtained. Specimens were obtained primarily from set gill nets. Fish were tagged with small FT-2 Floy Dart tags. Measurements and, in the case o striped bass, scales were taken from the tagged fish. Rewards of up to $25.00 were offered for the return of tags and information. Tagging was publicized with posters.

Monitoring of Northeast Cape Fear River

Juveniles

A monitoring study of juvenile anadromous fish was conducted during July - December 1977 and July - September 1979. Samples were taken with a surface-towed Carolina wing trawl with an 8 m headrope and a 3.2 mesh tail bag. Ten stations were sampled monthly (Figure 6). A ten minute tow with th wing trawl was a standard unit-of-effort. All alosids captured were treated in the juvenile survey of the Cape Fear River. Similar environmental data we taken.

Adults

Adult anadromous fish were monitored for five weeks (last two weeks in March, first three weeks in April) in 1978 and 1979, by use of a commercial h seine operated one day each week. The seine was located approximately 8 km below the North Carolina Highway #53 bridge (Figure 6). The seine was 68.6 with 6.4 cm stretched mesh. All adults captured in the haul seine were coun measured (Fl, mm), sexed, and spawning condition noted as immature, mature, running ripe, or spent, and a scale sample taken. Scales were treated and re as in the adult survey of the Cape Fear River.

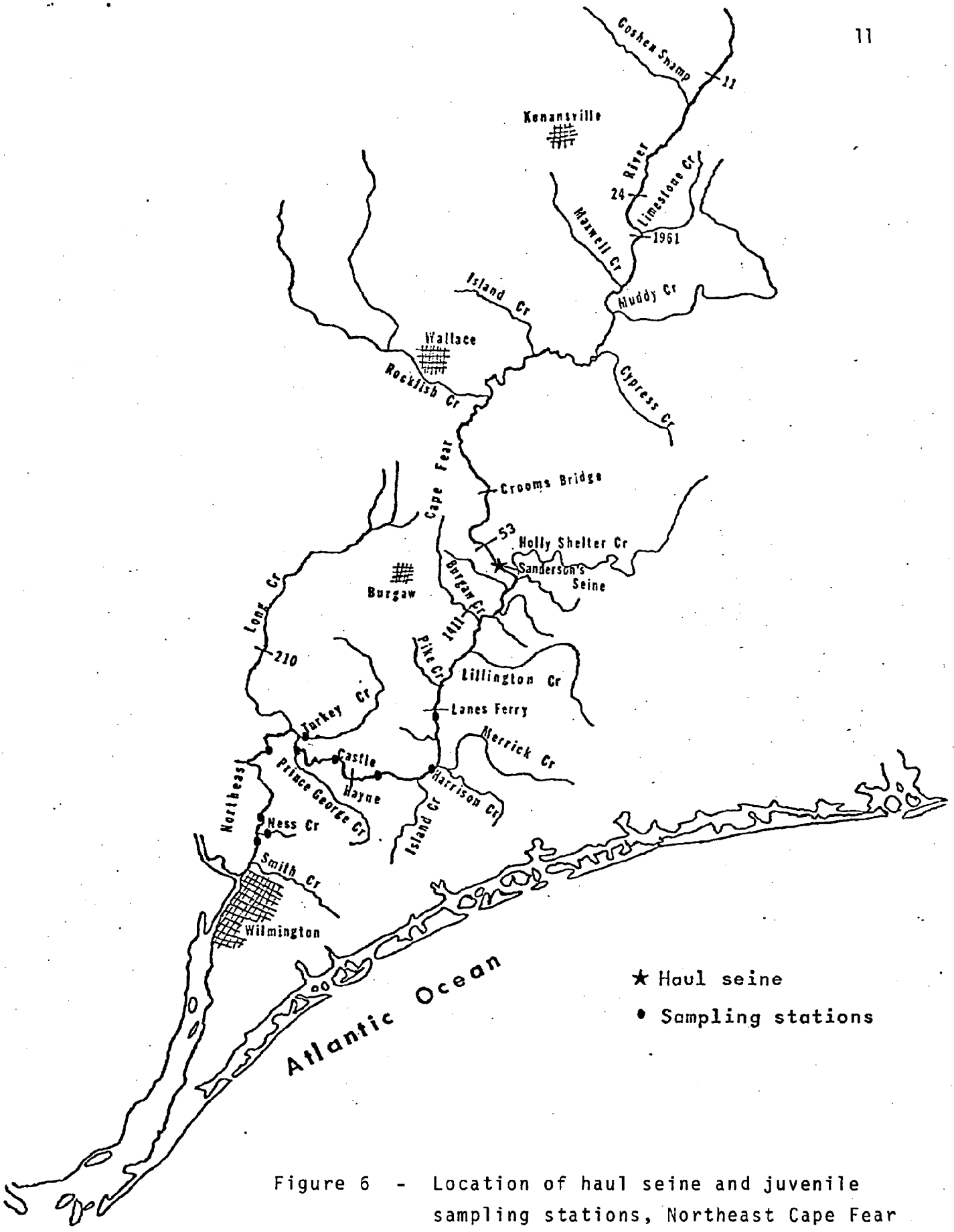

Figure 6 - Location of haul seine and juvenile sampling stations, Northeast Cape Fear River, NC, 1978 - 1979.

RESULTS AND DISCUSSION

Juvenile Survey

A preliminary survey of juvenile anadromous fish was conducted during July - December 1977 from below Wilmington to above Interstate 95 at Fayetteville. Up to 45 trawls and random seines were taken each month with trawls being far more productive. From the preliminary survey, 35 stations were selected as permanent monitoring stations and sampled monthly between June and December 1978 and June and September 1979 when the project ended. The surface-towed wing trawl was an effective sampler for anadromous clupeids. The demersal habits of striped bass and sturgeon prevented them from being sampled at the surface. However, logs and other obstructions on the river bottom prevented effective bottom samples, and a true picture of juvenile distribution of striped bass and sturgeon was not found.

Juvenile American shad, blueback herring, alewife, hickory shad, and striped bass were caught. The data show that the majority of juvenile anadromous fish are caught between June and September. A comparison of the relative abundance of juvenile anadromous fish at established stations from June - September 1978 and 1979 is shown in Table 1.

American Shad

American shad juveniles were found throughout the Cape Fear River up to Gray's Creek (below Fayetteville) (Figure 7). The major concentration of shad was from the Wilmington area to Lock and Dam #1. Davis and Cheek (1967) reported that young shad were found up to 17 miles above Lock and Dam #3. Juvenile shad remained in the river until December 1977 and 1978 (Figure 8) with a seaward migration occurring in November when water temperatures dropped (Figure 9).

Growth rates in the Cape Fear appeared to be greater than those in the Northeast Cape Fear River (Figures 10 and 23). Juvenile American shad reached a mean length of 89 mm (Fl) in November 1977, and 77 mm in December 1978, somewhat larger than observed by Davis and Cheek (1967) during their 1964-1965 study of the Cape Fear River. Figure 10 shows the mean monthly fork length for juvenile American shad during 1977 - 1979.

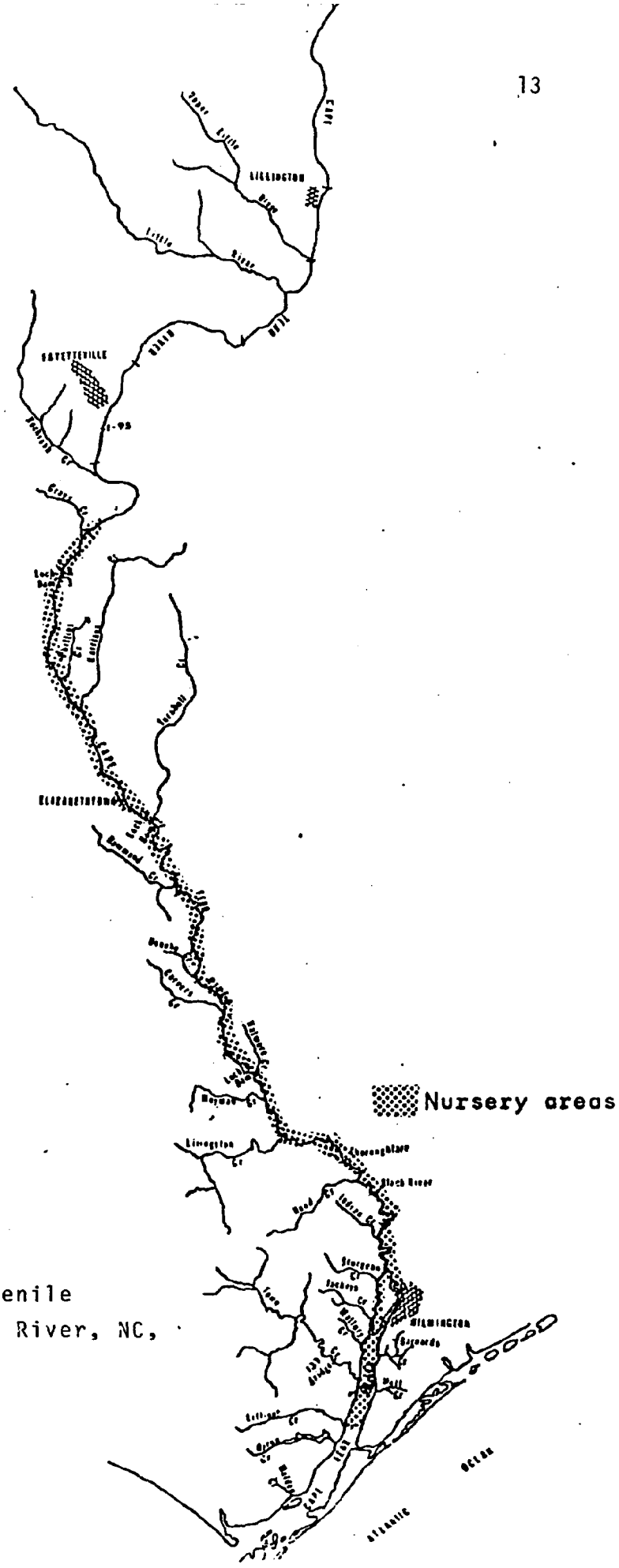

Figure 7 - Nursery areas of juvenile American shad, Cape Fear River, NC, 1977 - 1979.

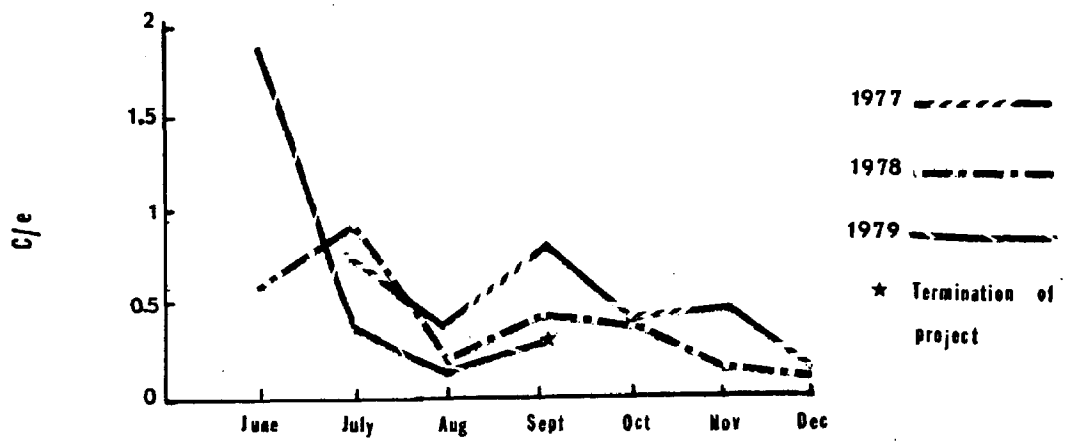

Figure 8 - Catch per effort juvenile American shad Cape Fear River, NC, 1977 - 1979.

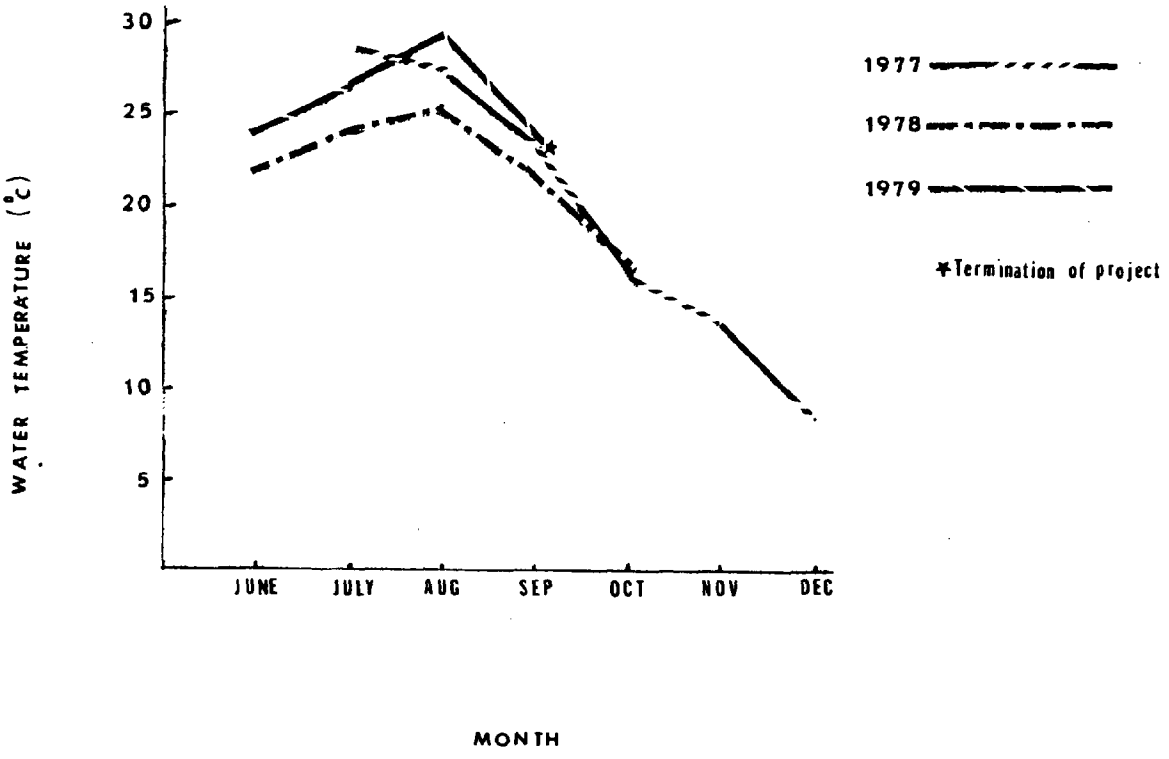

Figure 9 - Mean monthly water temperatures during June - December 1977 - 1979, Cape Fear River, NC.

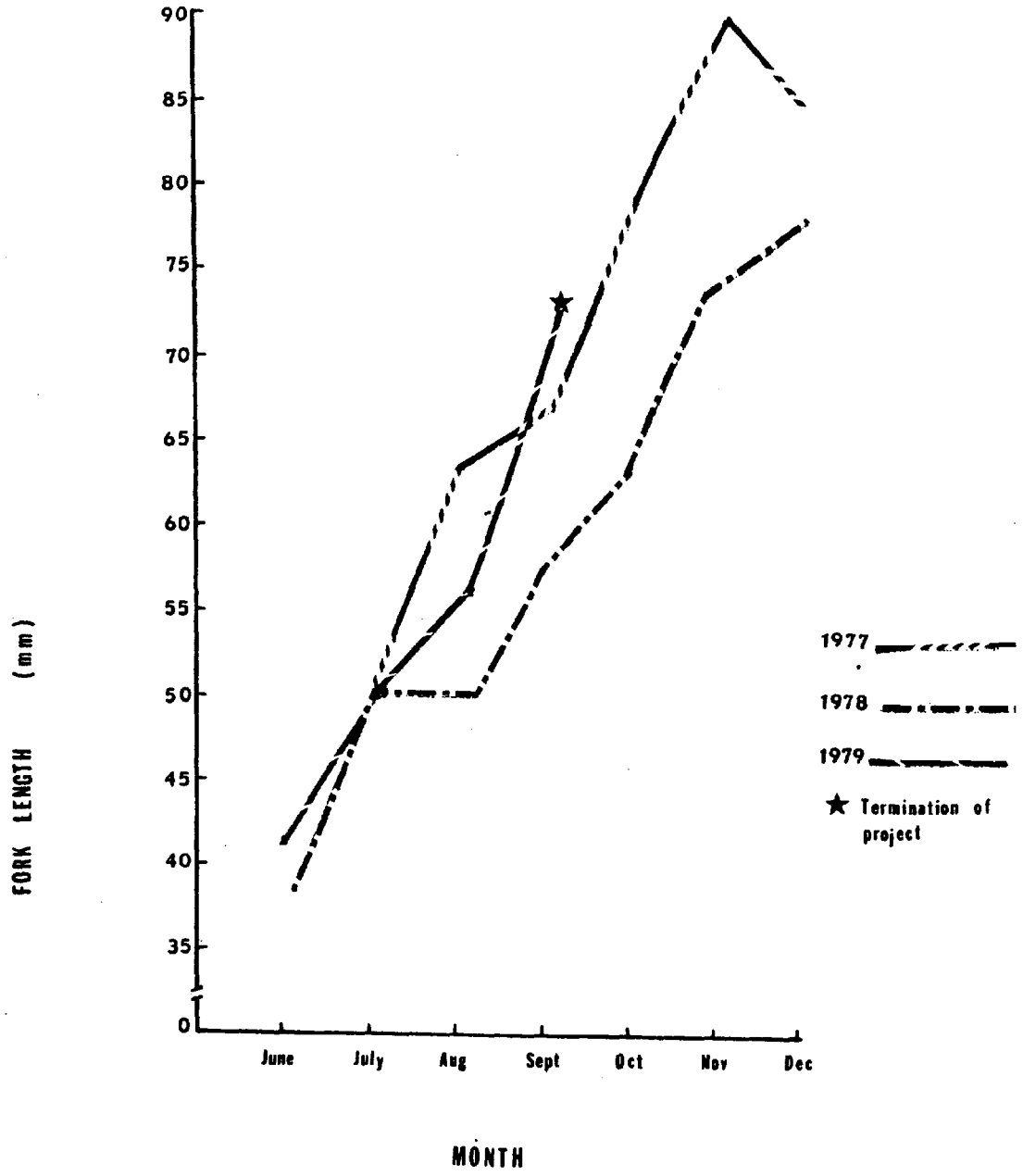

Figure 10 - Mean monthly fork length of juvenile American Shad, Cape Fear River, NC, 1977 - 1979.

Table 1 - A comparison of the relative abundance of juvenile anadromous fish, in the Cape Fear River, NC, June - September 1978 - 1979.

Species	1978 Effort - 140		1979 Effort = 140	
	Catch	C/E	Catch	C/E
American shad	79	.56	90	.64
Blueback herring	786	5.6	513	3.7
Alewife	8	.05	0	0
Hickory shad	6	.04	1	.007
Striped bass	0	0	0	0
Atlantic sturgeon	0	0	1	.007

Blueback herring

Blueback herring juveniles were found throughout the Cape Fear River to above the Interstate 95 bridge at Fayetteville (Figure 11). They were also found in most of the major tributaries (Table 2). The major abundance of blueback juveniles was in the tributaries rather than the river, similar to the situation which Sholar (1977) described in the Northeast Cape Fear River. In 1977 their peak occurrence was in September with migration taking place in late November.

In 1978, the peak occurrence was in July, with seaward migration taking place in October-November. In 1979 peak catch occurred in August (Figure 12). Juvenile blueback reached a mean length of 67 mm in December 1977 and 68 mm in December 1978 (Figure 13). These values are greater than the sizes observed by Davis and Cheek (1967).

Alewife

Juvenile alewife were found throughout the river system to above Interstat 95 near Fayetteville (Figure 14). Alewife juveniles were found only in the river but not in great numbers anywhere. (Table 2). Alewife juveniles were caught in the river until August 1978, but catch was greater during July of 197 and June and July of 1978. During August 1978 juvenile alewife reached a mean length of 43 mm (Fl). No alewife were caught in 1979.

Hickory Shad

Juvenile hickory shad were collected only during the months of either June or July 1977-1979. Hickory shad juveniles were found from above Interstate 95 near Fayetteville to Town Creek below Wilmington (figure 15). Juveniles were probably migrating out of the river to offshore nursery areas as proposed by Godwin and Adams (1969). During 1977 - 1979 a total of nine hickory shad juveniles were caught ranging from 31-55 mm. During July, 1977, hickory shad reache a mean fork length of 53 mm.

Striped Bass

Two juvenile striped bass were caught during July 1977. Their mean length was 37 mm (Fl).

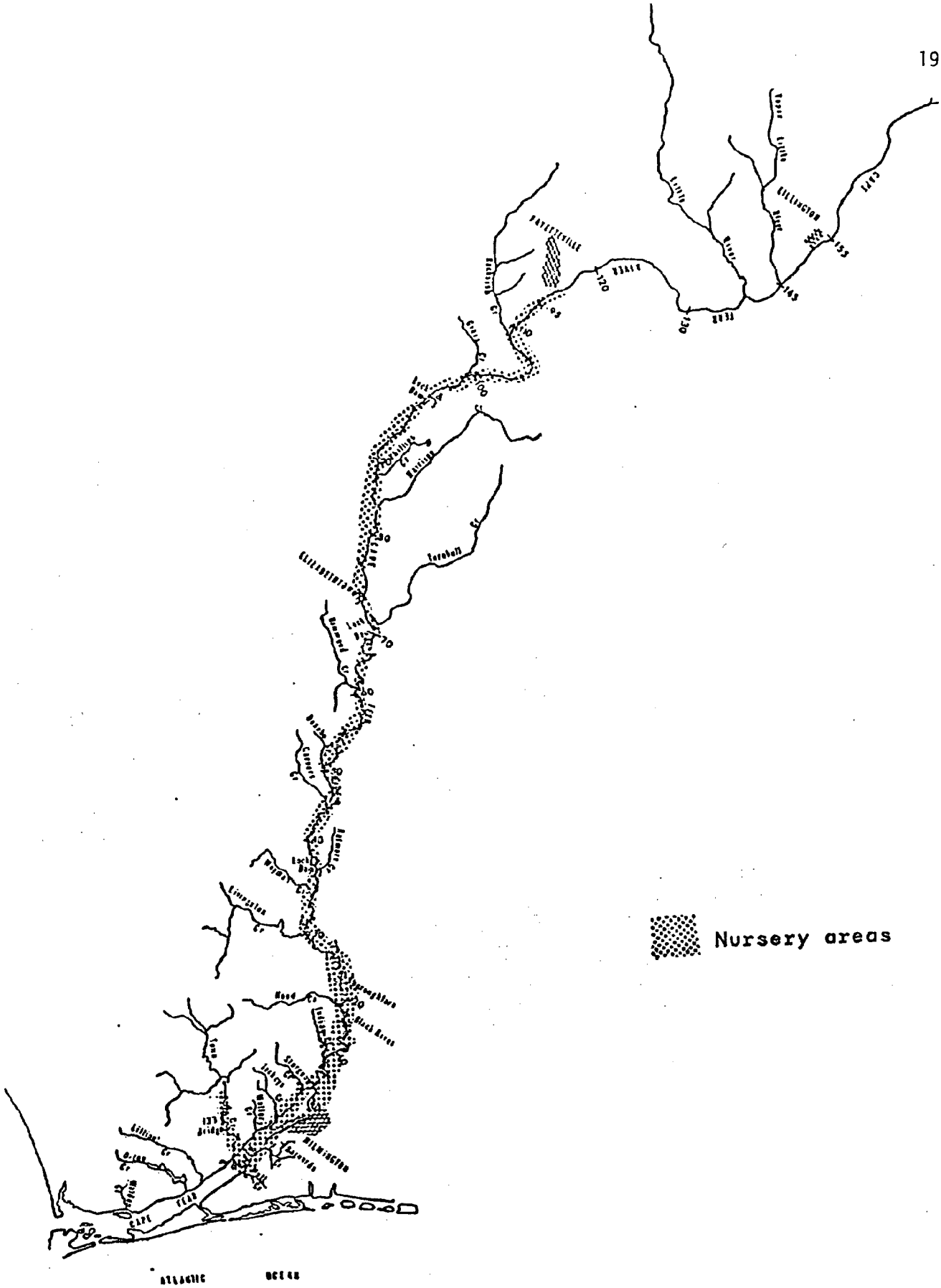

Figure 11 - Nursery area for juvenile blueback herring, Cape Fear River, NC, 1977 - 1979.

Table 2 - Relative abundance of juvenile anadromous clupedis in the tributaries as compared to the Cape Fear River, 1978 - 1979.

	American shad				Blueback herring				Alewife			
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979
	Catch		C/E		Catch		C/E		Catch		C/E	
River	242	71	2.14	.63	215	296	1.90	2.64	11	0	.09	0
Sturgeon Creek	17	11	4.25	2.75	65	0	16.25	0	0	0	0	0
Lower Cartwheel Branch	2	1	.50	.25	591	41	147.7	10.25	0	0	0	0
Alligator Creek	13	1	3.25	.25	46	0	11.5	0	0	0	0	0
Indian Creek	7	5	1.75	1.25	50	110	12.5	27.5	0	0	0	0
Town Creek	0	0	0	0	11	53	2.7	13.5	0	0	0	0
Horseshoe Bend	1	1	.25	.25	0	14	0	3.5	0	0	0	0

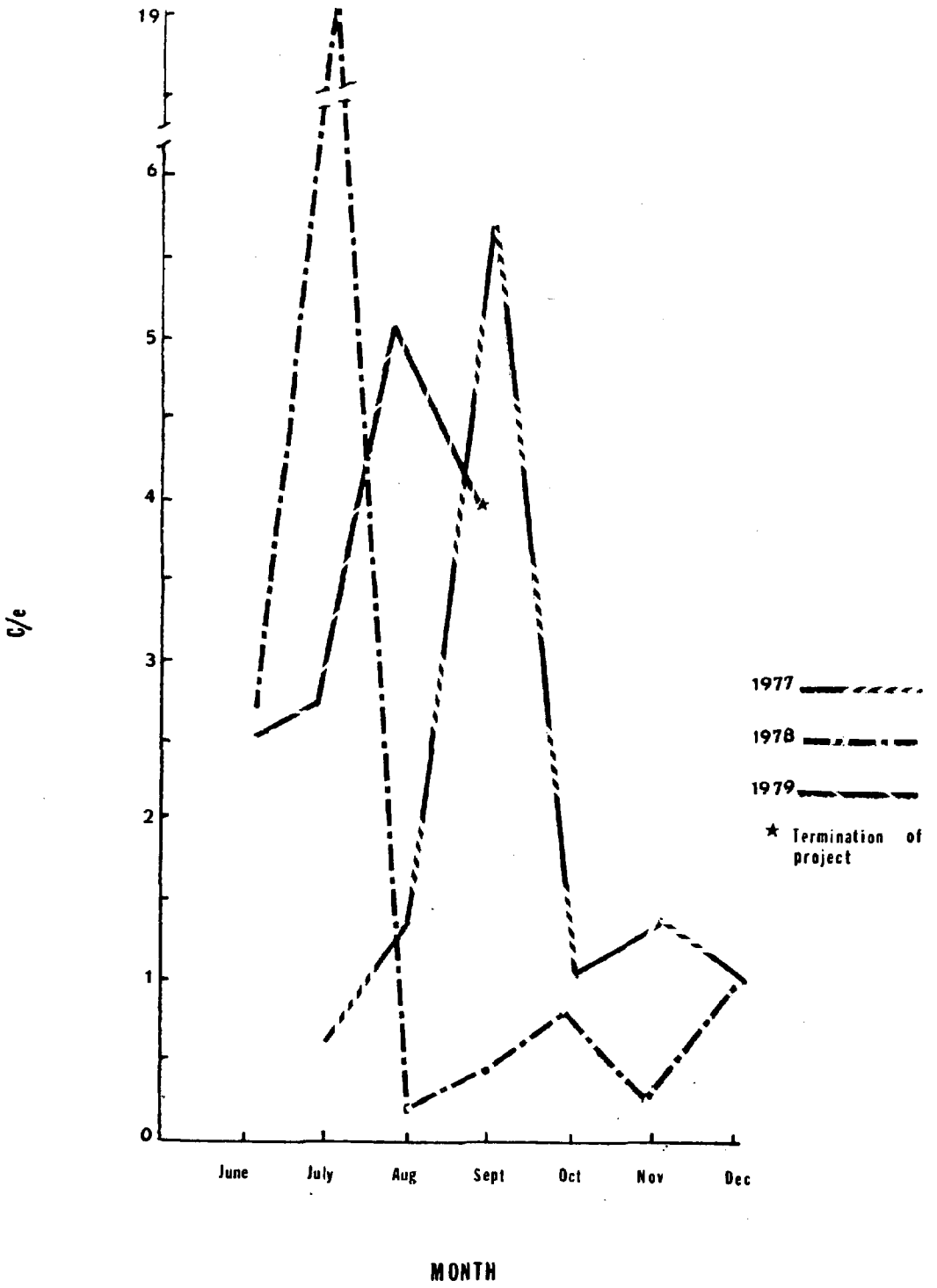

Figure 12 - Monthly catch per effort for juvenile blueback herring, Cape Fear River, NC, 1977 - 1979.

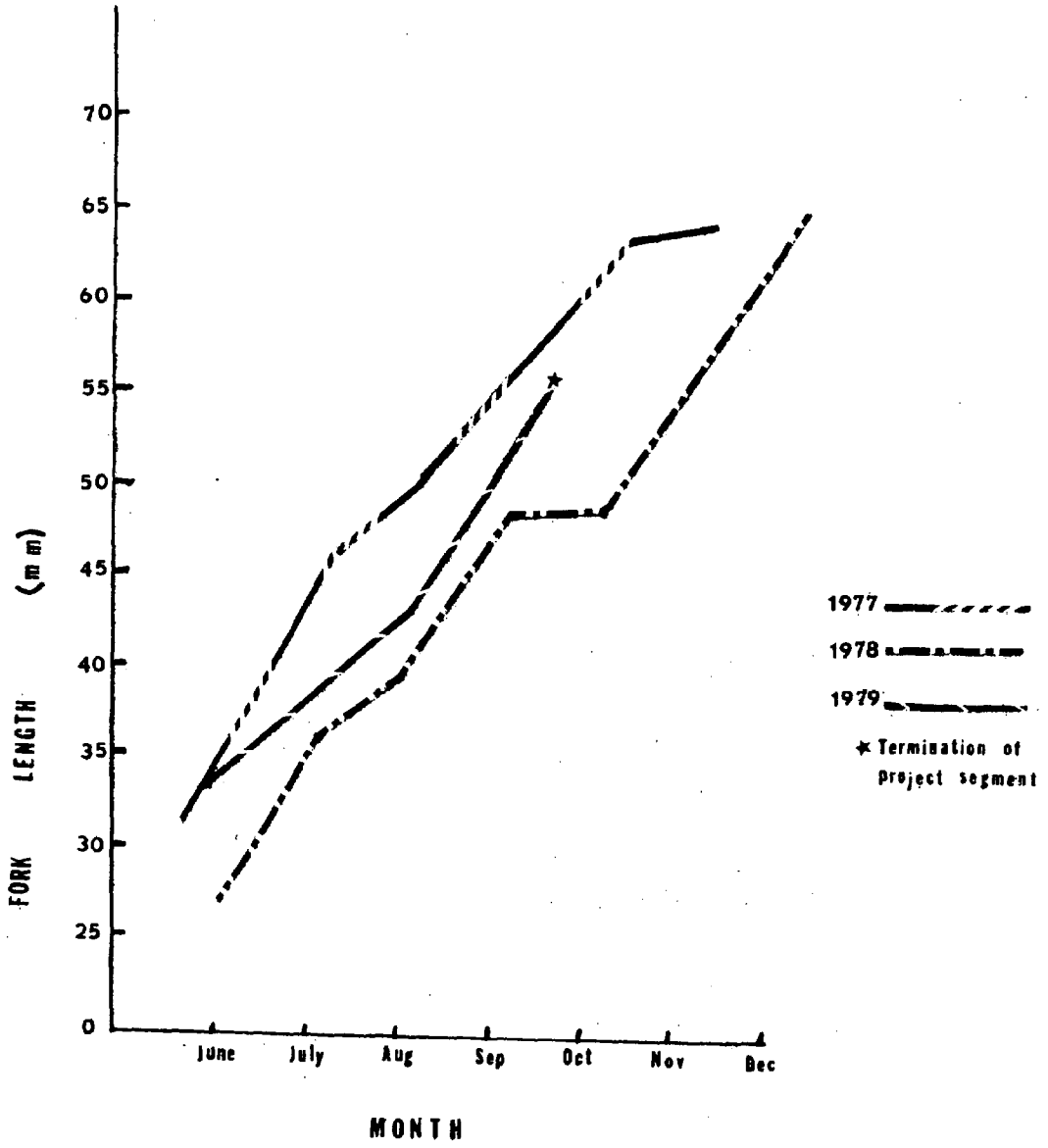

Figure 13 - Mean monthly fork length for juvenile blueback herring, Cape Fear River, NC, 1977 - 1979.

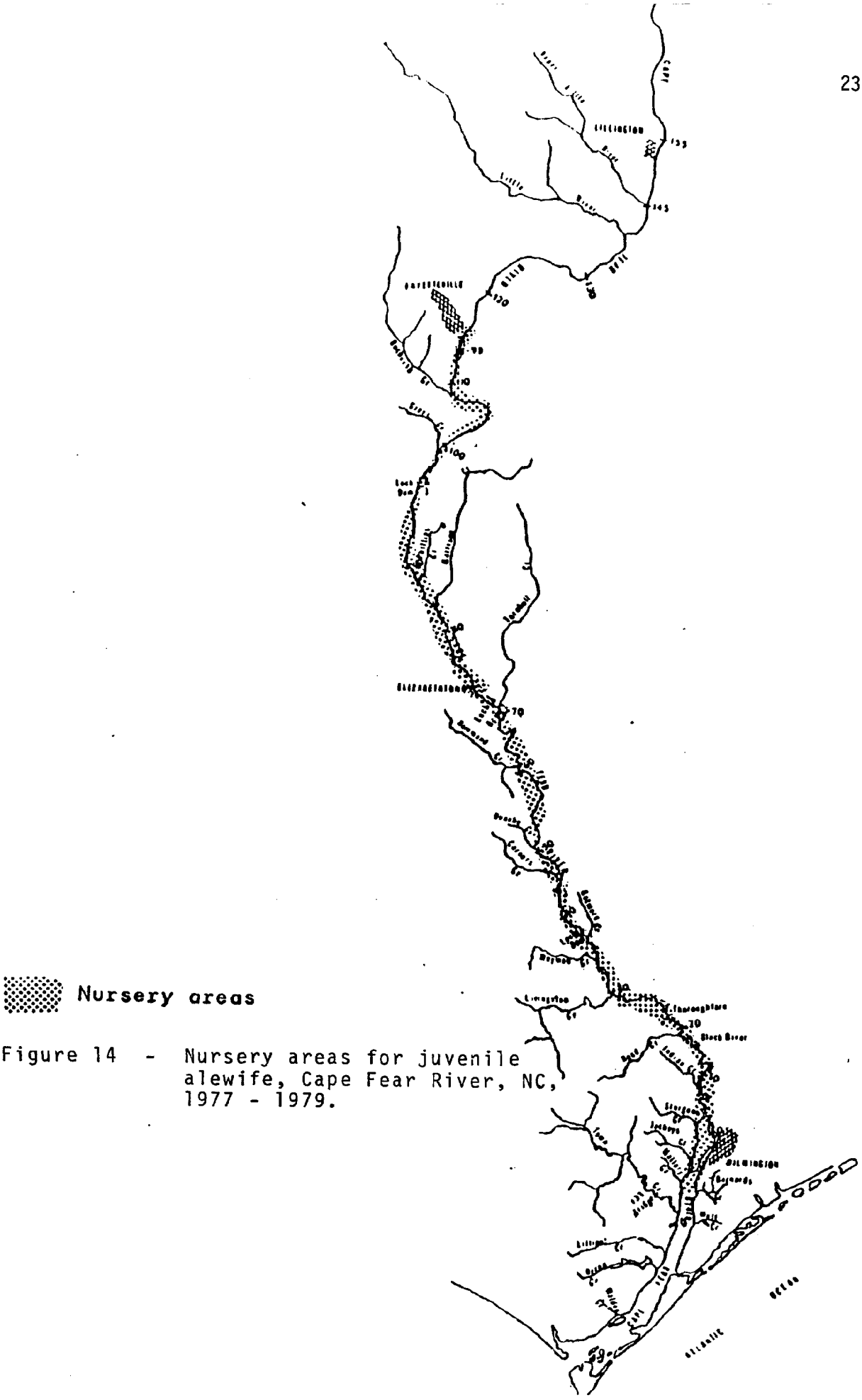

Figure 14 - Nursery areas for juvenile alewife, Cape Fear River, NC, 1977 - 1979.

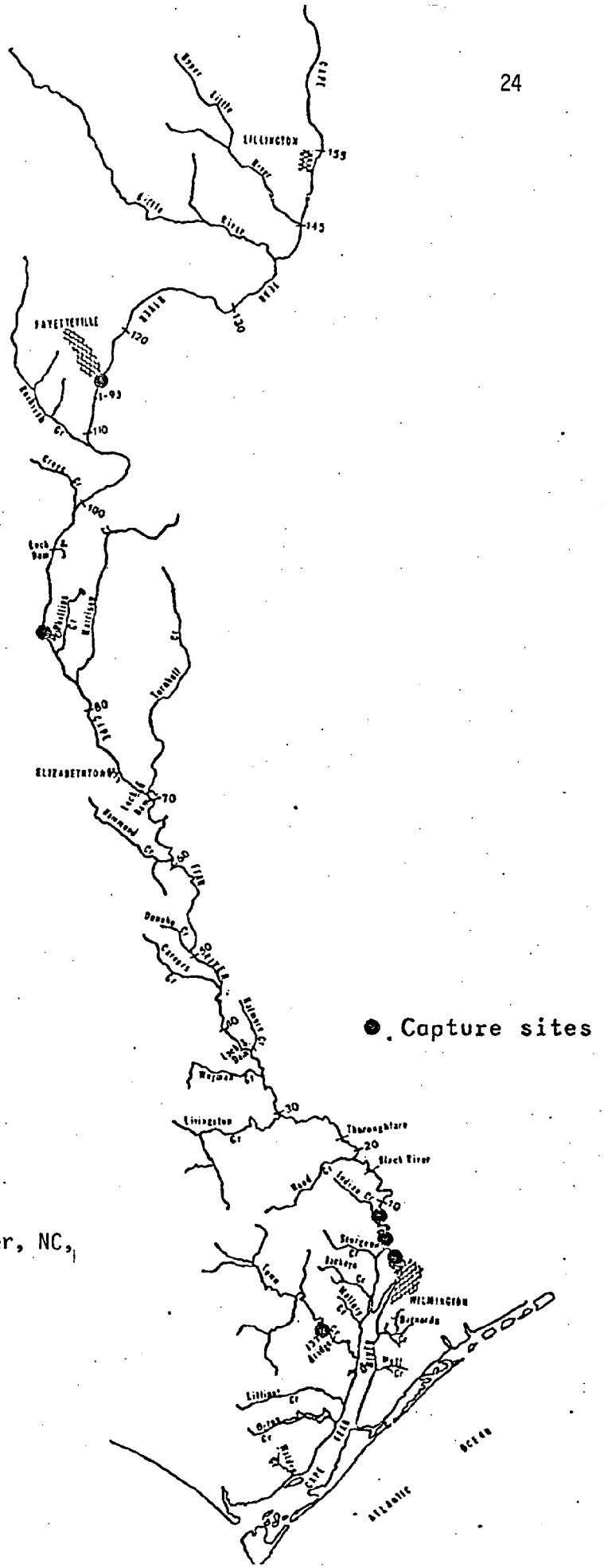

Figure 15 - Capture sites for juvenile hickory shad, Cape Fear River, NC, 1977 - 1979.

Atlantic Sturgeon

An immature Atlantic sturgeon was caught in Mallory Bay below Wilmington in September 1979. Its fork length was 605 mm.

Adult Survey

From January through June 1978, a total of 28 American shad, 48 blueback herring, 48 striped bass, 3 sturgeon and 1 alewife were caught in set nets and drift nets in the area below Lock and Dam #1. During January to June 1979, in the area below Lock and Dam #2, a total of 65 American shad, 28 blueback and 21 striped bass were caught in set nets and drift nets.

Abundance and Distribution - Set Nets and Drift Nets

American Shad

Sampling adult American shad with anchored gill nets in the main river channel was impractical due to high current velocities. Anchor gill nets had to be set in river "oxbows" or "bays" below Lock and Dam #1 where the water was shallower and the currents slower. Above Lock and Dam #1 there were no suitable areas in the main channel for anchor nets. The drift net proved to be the best method of capture for American shad, but the nets could only be fished at a few locations. Adult American shad were found up to Lock and Dam #2. The adults found above Lock and Dam #1 often had net scars and a few fish had fish hooks or "shad darts" in their mouths. This situation indicated intense fishing pressure below Lock and Dam #1.

American shad first appeared in the lower river in February and remained until May. Figure 16 shows the monthly catch per effort for drift nets.

Blueback Herring

Blueback herring were first caught in February and remained until May (Figure 17) with peak abundance in April. Adult blueback herring were found from Walden Creek (1977 samples) near the mouth of the Cape Fear River to Brown's Creek directly below Lock and Dam #2, as well as in most of the other tributaries.

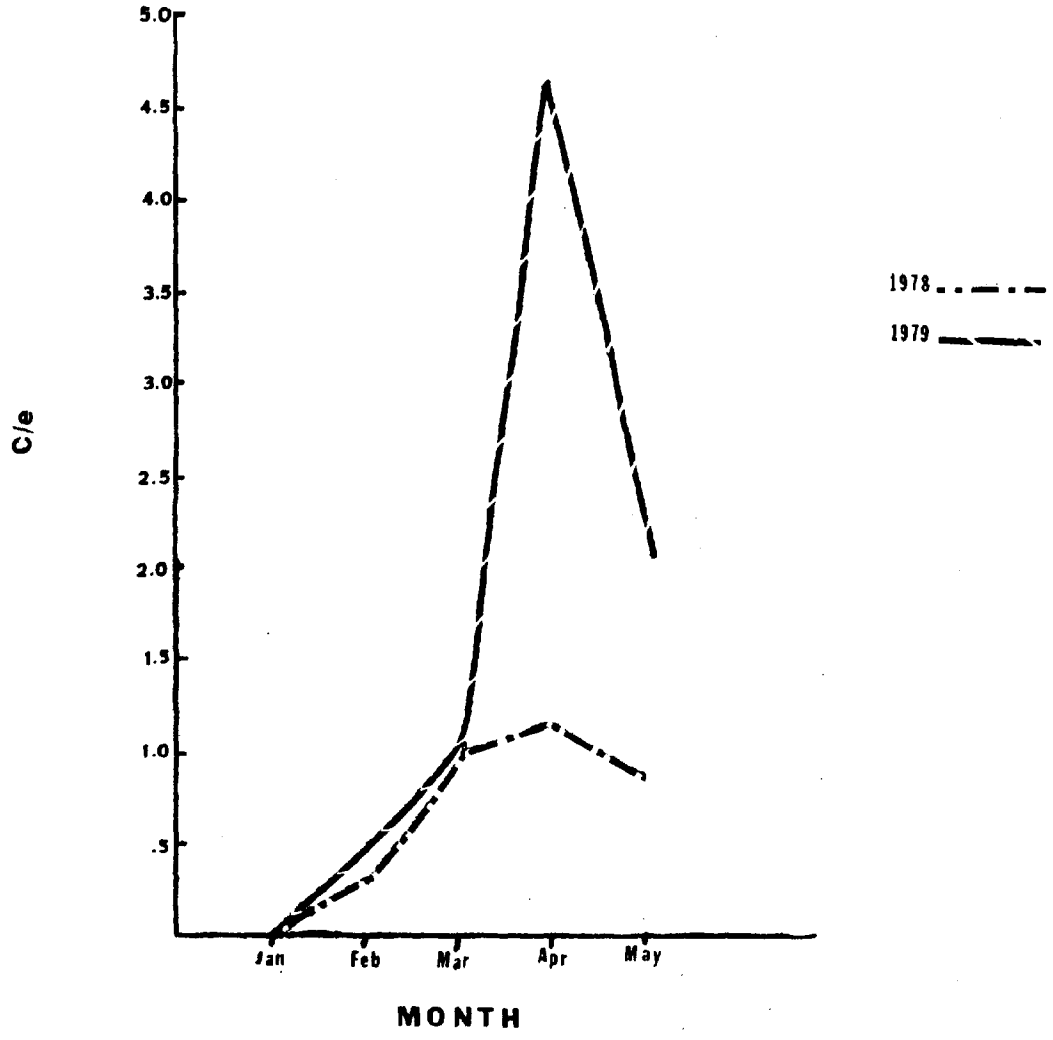

Figure 16 - Drift net catch per effort for adult American shad by month, Cape Fear River, 1978 - 1979.

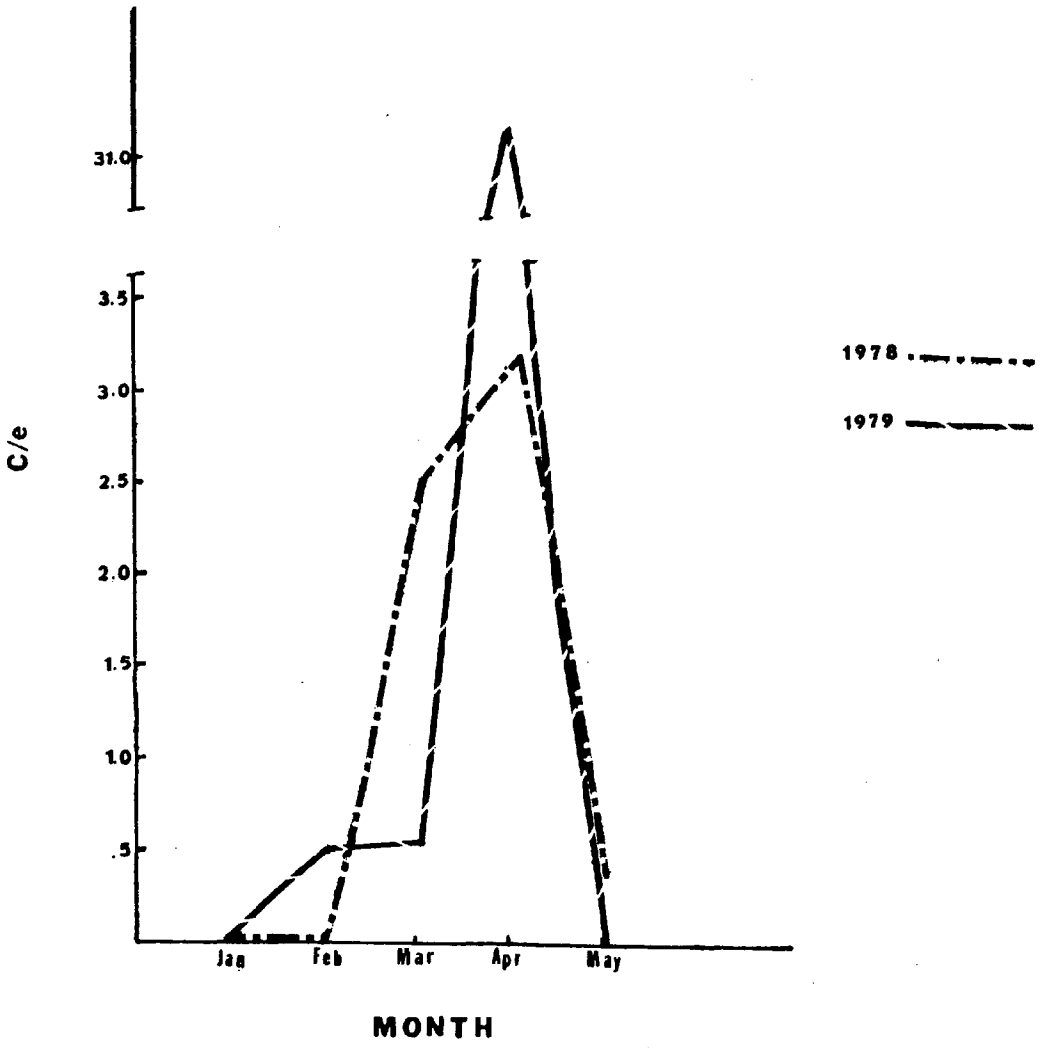

Figure 17 - Set gill net catch per effort for adult blueback herring by month, Cape Fear River, NC, 1978 - 1979.

Alewife

Only one adult alewife was caught, a four year old female taken in the oxbows of the river above the Throughfare in 1978. Adult alewife probably use some of the tributaries in the river; however, none were found in 1979.

Striped Bass

Adult striped bass were found in the Cape Fear River from January through May with greatest abundance in January of both years (Figure 18). Striped bass were found up to Hood Creek; however, Nichols and Louder (1970) reported passing striped bass through Lock and Dam #2 near Elizabethtown. The majority of striped bass were caught just above or below the city of Wilmington in bays or oxbows.

Age and Spawning Frequency

American Shad

Since anchor gill nets were not very effective in capturing adult anadromous fishes, the majority of length, age and spawning frequency data comes from the fish captured by drift netting. In 1979 samples, adult American shad ranged in age from three to six years. Most male shad were four years old and females were five (Table 3). The 1979 male:female sex ratio was 2.8:1. This differs from the 1978 data in which the male:female sex ratio was 1.2:1 and the dominant ages of both male and female shad was a year younger than in 1979. Perhaps improved fishing techniques in the second year of sampling allowed less escapement of the younger, smaller shad than in the previous year.

In the Cape Fear River, American shad appeared to spawn only once. This situation agrees with data from the Northeast Cape Fear River (Sholar 1977). There were no repeaters found in gill net samples, and only two repeaters were found in commercial samples, one each year.

Blueback Herring

Blueback herring ranged in age from three to six years old. Females were four and five years old while males were predominately five years old (Table 4). The male:female sex ratio was 1:1.2 in 1979 and 1.1:1 in 1978.

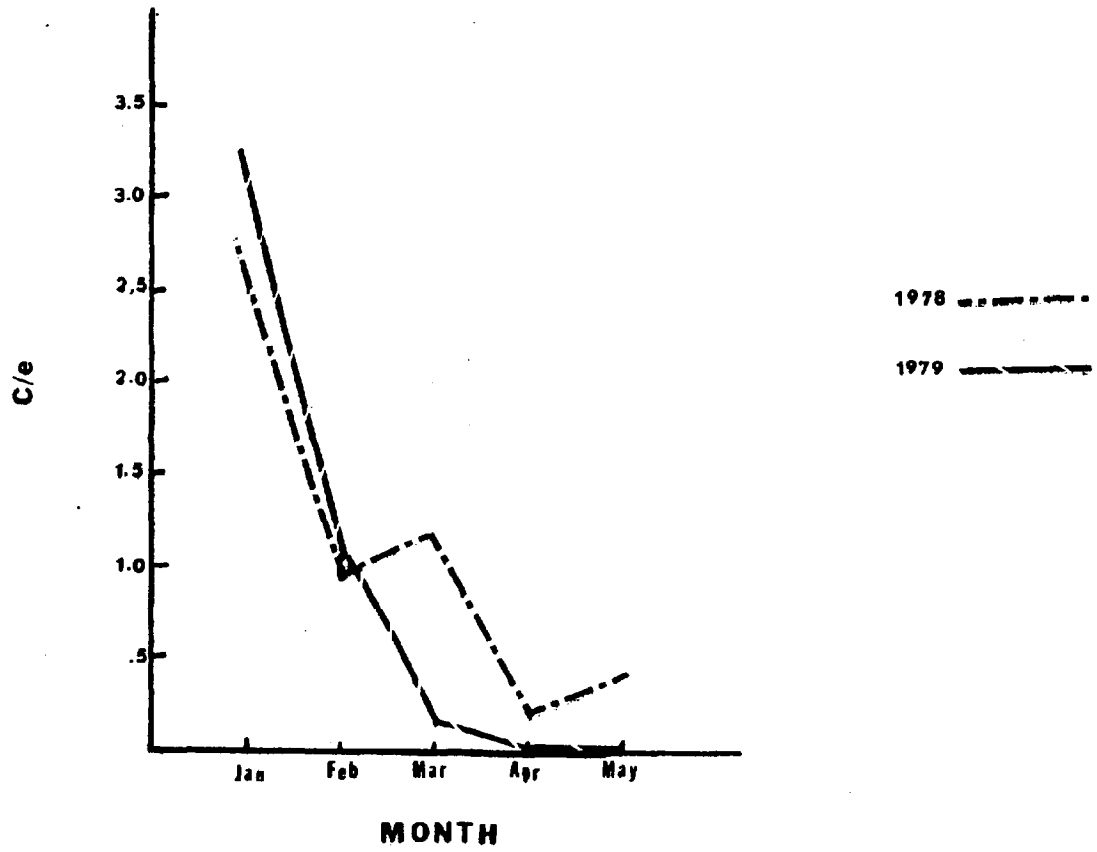

Figure 18 - Set gill net catch per effort for adult striped bass by month, Cape Fear River, NC, 1978 - 1979.

Table 3 - Total number, percent of total sample, mean fork length, and fork length range for each age group by sex for American shad, Cape Fear River, NC, 1978 and 1979.

	Age	Number	Percent of Sample	Mean fork length (mm)	Length range (mm)
Male	III	1	1	380	———
	IV	42	59	403	374-430
	V	27	39	430	410-460
	VI	1	1	440	———
		71			
Female	III	0			
	IV	6	18	424	395-430
	V	14	43	461	438-480
	VI	12	36	490	455-510
	VII	1	3	525	———
		303			

Table 4 - Total number, percent of total sample, mean fork length, and fork length for each age group by sex for blueback herring, Cape Fear River, NC, 1978 and 1979 (years combined).

Sex	Age	Number	Percent of sample	Mean fork length (mm)	Length range (mm)
Male	III	1	04	228	--------
	IV	10	35	252	235-265
	V	16	57	259	250-270
	VI	1	04	287	--------
		28			
Female	IV	11	33	254	235-275
	V	12	35	272	263-285
	VI	9	26	280	270-290
	VII	2	6	290	280-295
		34			

Approximately 29% of the Cape Fear Fiver bluebacks had spawned previously in 1979, while 31% of the fish examined in 1978 were repeaters. Virgin fish accounted for 74% of the females and 67% of the male bluebacks in 1979 (Table 5). The repeat rate of spawners in the Cape Fear River appears higher than that in the Northeast Cape Fear River. No bluebacks were found to have more than three spawning marks in either 1978 or 1979.

Striped Bass

Striped bass caught in Division nets ranged in age from four to eleven years of age (Table 6). Sex ratio, when determined, was 1:1.7 male:female in 1979, the sex ratio in 1978 was approximately 1:1.

Commercial and Recreational Harvest

American Shad

American shad are primarily harvested by drift gill nets in the Cape Fear River. The drift gill nets range from 45.7 m to 91.4 m in length, usually with 14 cm stretched mesh. Some fishing is done with anchored gill nets, mainly in the oxbows of the Cape Fear River where the current is slower than in the main river channel. Almost all commercial and recreational fishing takes place below Lock and Dam #1.

Fishing began in mid-February and lasted until mid-May. During the middle of March prices for shad were good, a"roe" shad would sell for $5.00 and a "buck" for around $3.00. Prices usually dropped in April when the catch increased. The 1979 catch of shad in the Cape Fear,approximately 52,000 pounds, was greater than the 1978 catch of 42,000 pounds. This increase, however, might be attributed to a better catch reporting system.

The majority of gill netters fished part time to supplement their income from other jobs.

Anchor gill net fishermen usually set their nets in February and left them until May. The nets were not taken up during the whole season, but were fished and cleaned once or twice a day. There is also a recreational hook-and-line fishery for shad directly below Lock and Dam#1.

Most of the samples come from drift net and hook-and-line fishermen. Ages for American shad ranged from three to seven years. Males were primarily age

Table 5 - Age and spawning frequency of blueback herring, Cape Fear River, NC, 1978-79.

Number of spawning marks	0		1		2		3		Total	
Age	M	F	M	F	M	F	M	F	M	F
III	1	0	0	0	0	0	0	0	1	0
IV	9	11	1	0	0	0	0	0	10	11
V	9	9	5	3	2	0	0	0	16	12
VI	0	4	1	2	0	2	0	1	1	9
VII	0	0	0	1	0	0	0	1	0	2
Total	19	24	7	6	2	2	0	2	28	34

Table 6 - Total number and percent of sample by age group of striped bass (sexes combined), Cape Fear River NC, 1978-79.

Age	Number	Length range	Percent of sample
II	1	- - -	2
III	4	295-462	7
IV	16	410-570	29
V	23	512-668	42
VI	3	615-700	5
VII	5	685-775	9
VIII	2	820-880	4
XI	1	- - -	2
TOTAL	55		

four while females were age five (Table 7). The sex ratio for American shad was computed for both culled and unculled samples. Unculled samples were taken from the fishermen on the river or at boat landings before they reached the fish houses. In 1979 the male:female sex ratio for unculled samples was 2.3:1. This is similar to the sex ratio of 2.8:1 from the Division nets. In 1978 the sex ratio for unculled samples was 1.1:1. In both 1978 and 1979 the culled ratio was 1:1.1 males to females.

River Herring

Only a small amount of herring fishing is done in the Cape Fear River. Most herring are caught in gill nets set in bays and tributaries off the main river. Most herring caught are used for bait or personal consumption and the excess may be sold commercially. No samples of river herring were obtained from fishermen or fish houses, so no conclusions about age or length can be made.

Striped Bass

Striped bass may be caught occasionally by net fishermen. Marine Fisheries regulations prohibit retention of striped bass caught in nets in New Hanover County. There is a small sport hook-and-line fishery for striped bass, and a local annual striped bass tournament takes place in November-December, usually in the lower Cape Fear River. Striped bass caught on hook-and-line in excess of those needed for personal consumption are often sold commercially.

Sturgeon

Sturgeon are not landed very often from the Cape Fear. Some are caught by shad fishermen in their drift gill nets. Others are caught during the year by trawl fishermen. During May 1978 a few large, headless sturgeon were observed. Fishermen often kill sturgeon in getting them out of their nets.

No adult sturgeon were caught in 1979. In 1978 two Atlantic sturgeon (540 mm, 720mm Fl) were captured in drift nets in the river below Mott Creek. In addition, an immature sturgeon (560 mm Fl) was caught in a set net. Large adult sturgeon are occasionally caught by fishermen. Since mature and immature sturgeon are occasionally caught in the Cape Fear, a small spawning population probably exists.

Table 7 - Number, percent of sample, mean fork length, and length range for each age group by sex for commercially-harvested shad, Cape Fear River, NC, 1978-79.

Sex	Age	Number	Percent of Sample	Mean fork length (mm)	Length Range (mm)
Male	III	4	2	375	360 - 388
	IV	104	64	415	380 - 430
	V	46	28	439	416 - 465
	VI	9	6	463	450 - 480
		163			
Female	IV	7	5	425	400 - 460
	V	102	66	466	440 - 500
	VI	42	27	491	465 - 510
	VII	3	2	518	515 - 520
		154			

Tagging

Out of 69 striped bass captured in both years, 23 were tagged. Most of the striped bass tagged were caught in gill nets set just above and below the city of Wilmington. Only one tag was returned; a five year old striped bass released in January 1979 at Wilmington (Horseshoe Bend) was recaptured three months later at Lane's Ferry in the Northeast Cape Fear River, a distance of over 32 river miles (Figure 19). In addition two sturgeon caught in a drift net were also tagged and released.

Spawning Area Survey

From mid-March until June, both years, samples were taken periodically with 0.5 m plankton nets at the stations shown in Figure 6. Random samples were also taken in other areas where spawning was thought to occur. During 1979, the area surveyed was extended upstream to near Lock and Dam #2.

American Shad

Little evidence of American shad spawning was discovered. In 1978, the area of the Cape Fear around Wilmington, the river just above Wilmington, and the area just below Lock and Dam #1 served as spawning areas (Table 8). In 1979 American shad eggs were found below Lock and Dam #1. No eggs or larvae were found above Lock and Dam #1, although the presence of running ripe females and juveniles below Lock and Dam #2 indicates that this area is a spawning area (Figure 20).

River Herring

River herring spawning was found to occur from mid-March to early May, 1978 although no eggs were found. In 1979, spawning occurred from late March to mid-May with eggs and larvae being found primarily in April. Table 9 lists the indications found for both years. River herring were found to spawn from Town Creek (below Wilmington) to Brown's Creek below Lock and Dam #2 (Figure 21). Spawning usually took place in creeks and sloughs off of the main river.

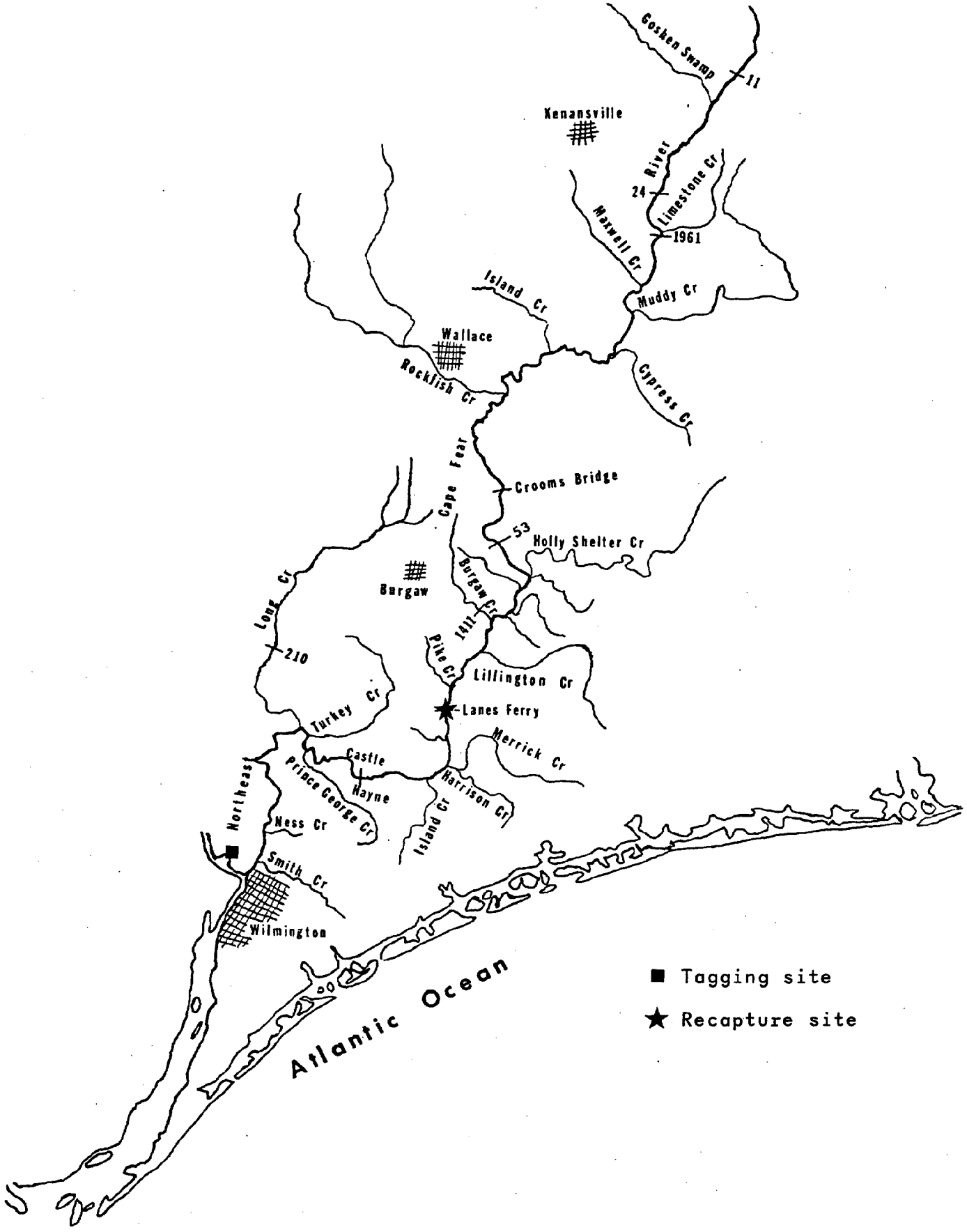

Figure 19 - Tagging site and recapture site for striped bass, Cape Fear River, NC.

Table 8 - Evidence of spawning of American shad, Cape Fear River, NC, 1978-79.

Date	Location	Mileboard	Comments
4/13/78	Lower Sturgeon Creek	1	1 running ripe female
5/5/78	Below Lock and Dam #1	35	2 running ripe females
5/16/78	Below Campbell Island	-6*	1 running ripe female
5/10/78	Above Navassa	5	1 postlarvae
5/10/78	At State Port	0	1 postlarvae
5/31/78	Below Lock and Dam #1	35	1 postlarvae
4/6/79	Below Lock and Dam #1	35	2 running ripe females
4/19/79	Neil's Eddy Cutoff	28	1 American shad egg
4/19/79	Below Lock and Dam #1	35	2 running ripe females
4/23/79	Below Lock and Dam #2	70	1 running ripe female
4/24/79	Neil's Eddy Cutoff	28	1 late stage egg
4/24/79	Below Lock and Dam #1	35	1 running ripe female
5/1/79	Below Lock and Dam #2	70	1 running ripe female
5/2/79	Below Lock and Dam #1	35	4 running ripe females
5/4/79	Below Lock and Dam #1	35	1 running ripe female
5/8/79	Below Lock and Dam #1	35	1 running ripe female
5/17/79	Below Lock and Dam #1	35	1 running ripe female

*Indicates approximate number of miles below Wilmington (River Mile 0)

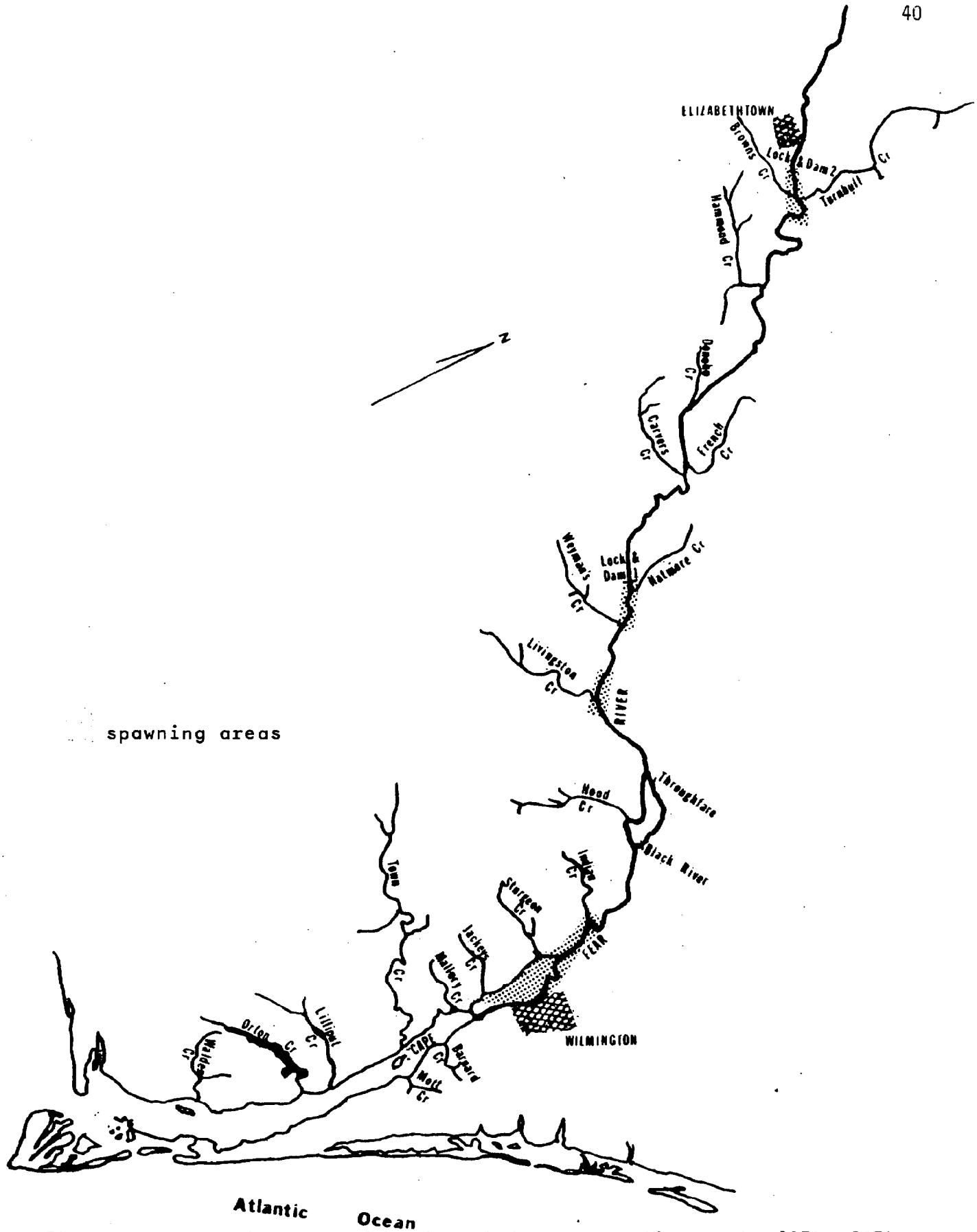

Figure 20 - Spawning areas of American shad, Cape Fear River, N.C., 1978 - 1979.

Table 9 - Evidence of spawning of river herring, Cape Fear River, 1978 - 1979

DATE	LOCATION	MILEBOARD	COMMENTS
3/23/78	Lower Livingston Creek	30	1 running ripe blueback herring female captured
3/23/78	Cape Fear River Oxbows	25-28	1 running ripe blueback herring female captured
4/6/78	Cape Fear River Oxbows	25-28	2 running ripe blueback herring females and 1 running ripe alewife female captured
4/11/78	Below Lock and Dam #1	38	1 alewife postlarvae
4/13/78	Mallory Creek Bay	-4*	1 running ripe blueback herring female captured
4/19/78	Lower Weymans Creek	35	2 alewife postlarvae
4/20/78	Lower Hood Creek	19	2 running ripe blueback herring females captured
4/21/78	Lilliput Creek (at NC Hwy. #133 Bridge)	10	1 running ripe blueback herring female captured
4/28/78	Lower Hood Creek	19	2 alewife postlarvae
5/11/78	Town Creek (above NC Hwy. #133 Bridge	-6*	6 alewife postlarvae
5/11/78	Lower Town Creek	-6*	1 alewife postlarvae
5/11/78	Cape Fear River at mouth of Town Creek	-6*	4 alewife postlarvae
4/4/79	Lower Brown Creek	70	1 running ripe female
4/4/79	Lower Hammond Creek	61	7 running ripe females
4/10/79	At Black River	17	3 alewife postlarvae
4/10/79	Upper Brunswick River	3	1 herring postlarvae
4/11/79	Cape Fear River	10	2 herring postlarvae
4/11/79	Above Navassa	5	2 alewife postlarvae
4/19/79	Below Weyman Creek, Cape Fear River	34	2 herring eggs
4/19/79	Neil's Eddy Cut Off	28	1 alewife postlarvae
4/20/79	Lower Sturgeon Creek		1 herring postlarvae
	Above Navassa	5	1 alewife postlarvae
	Alligator Creek	3	1 herring post larvae 1 blueback herring postlarvae
	Upper Brunswick River	3	2 blueback herring postlarvae
	At Black River	17	4 blueback herring postlarvae
	Lower Brunswick River	-1*	1 blueback herring postlarvae

Table 9 (continued) - Evidence of spawning of river herring, Cape Fear River, 1978 - 1979

DATE	LOCATION	MILEBOARD	COMMENTS
4/21/79	Jackey's Creek at 133 Bridge	-2*	4 early stage river herring eggs
4/24/79	At Lyon's Throughfare	22	1 river herring egg
	Below Lock & Dam #1	38	1 blueback herring postlarvae
	Town Creek at Hwy 17 Bridge	-6*	1 early stage river herring egg
4/25/79	At Steep Rum	43	1 river herring post larvae
5/2/79	Below Lock & Dam #1	38	1 river herring egg
5/11/79	HorseShoe Bend	2	1 blueback herring postlarvae

*Indicates approximate number of miles below Wilmington (River Mile 0)

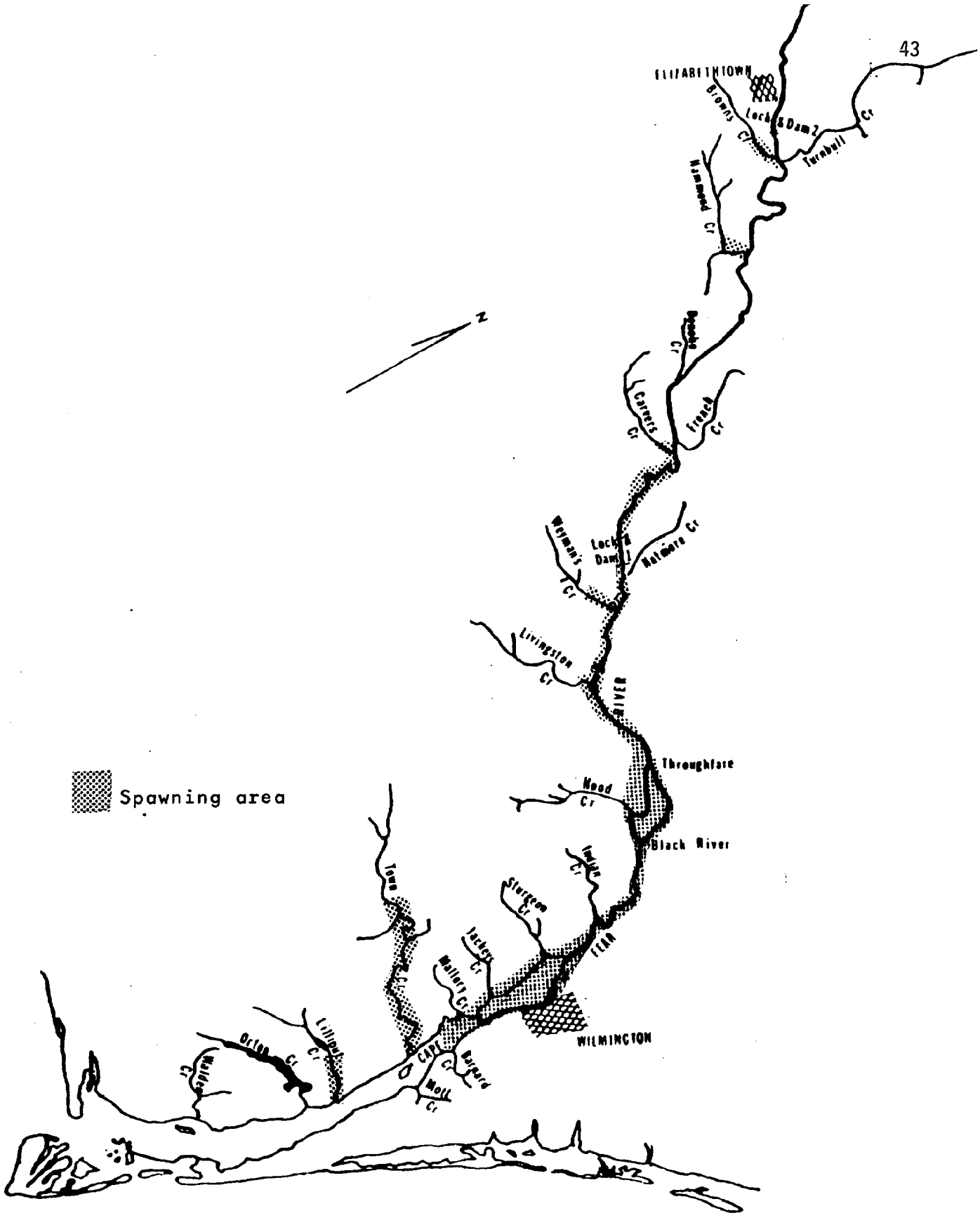

Figure 21 - Spawning areas of River herring, Cape Fear River, NC, 1978 - 1979.

Hickory Shad

Very little evidence of hickory shad spawning was found. Three post larval hickory shad were found above the North Carolina Highway #133 bridge over Town Creek in 1978 and one at Mile Board 10 in the Cape Fear River in 1979 (Figure 22).

Striped Bass

Spawning of striped bass was found to occur from mid-April until mid-May. In 1978 peak capture of eggs occurred in mid-may when the water temperature was approximately 18^{o}C. In 1979 peak capture of eggs occurred in late April when the water temperature was approximately 19^{o}C. This correlates closely with Sholar's (1977) data for 1976 - 1977. He found that peak capture of eggs in the Northeast Cape Fear River occurred when water temperatures reached 19^{o}C. Table 10 lists the indications of spawning. In both years the majority of striped bass eggs were found in the main river channel around the Throughfare, an area that has the swift currents necessary to keep striped bass eggs in suspension (Figure 23). In early May (1978 and 1979) the river had very high currents and low salinities because of heavy rainfall. The rapid water current of the river could have swept striped bass (or shad) eggs downstream from the usual spawning areas further upstream.

Northeast Cape Fear River

Juvenile Survey

During July - December 1977, June - October 1978, and July - September 1979, a program to monitor the relative abundance of juvenile anadromous fish was conducted. Approximately ten stations were sampled monthly with surface-towed wing trawls. Young of five species of anadromous fish were captured: American shad, alewife, blueback herring, hickory shad, and striped bass. The relative abundance for each species is shown in Table 11.

American Shad

Juvenile American shad were found in the river until November 1977, with seaward migration taking place during October and November. Growth rates in the Northeast Cape Fear River seem to be slightly behind those in the Cape Fear River. Figure 23 shows the mean monthly fork length for 1977-1979 for

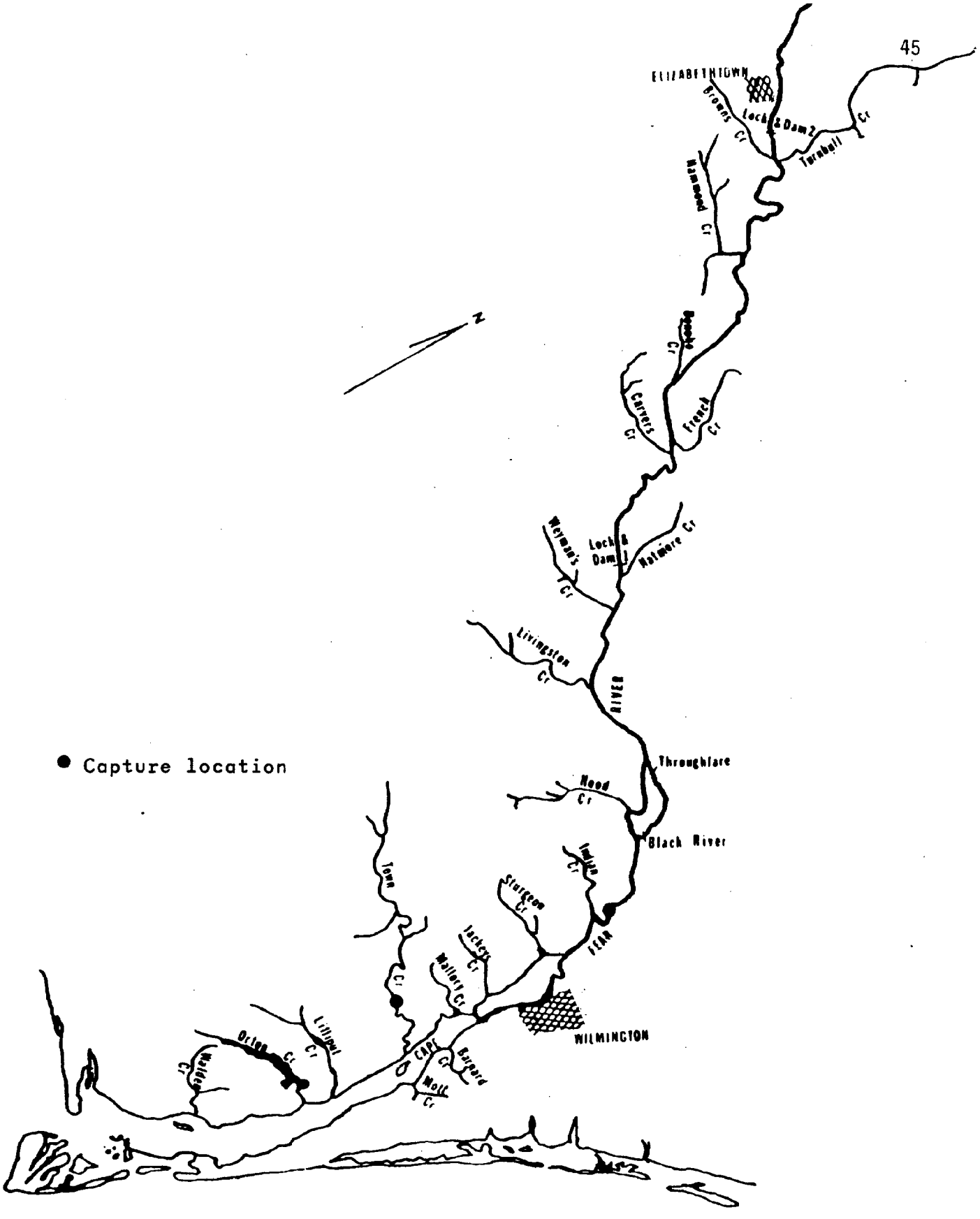

Figure 22 - Evidence of hickory shad spawning in Cape Fear River, NC, 1978 - 1979.

Table 10 - Evidence of spawning of striped bass, Cape Fear River, NC, 1978-1979

Date	Location	Mileboard	Comments
4/13/78	Mallory Bay at Cape Fear River	-4*	1 running ripe female
4/28/78	Lower Indian Creek	9	1 early stage egg
5/09/78	Lower Mallory Creek	-4*	1 running ripe female
5/19/78	Cape Fear River at Lyon's Throughfare	22	20 early stage eggs
5/19/78	Cape Fear River at Black River	17	7 early stage eggs
5/19/78	Cape Fear River at Neil Eddy Cutoff	28	1 early stage egg
4/20/79	Lower Cartwheel Branch	4	2 late stage eggs
4/30/79	Cape Fear River at Lyon's Throughfare	22	4 early stage eggs

*Indicates approximate number of miles below Wilmington (River Mile 0)

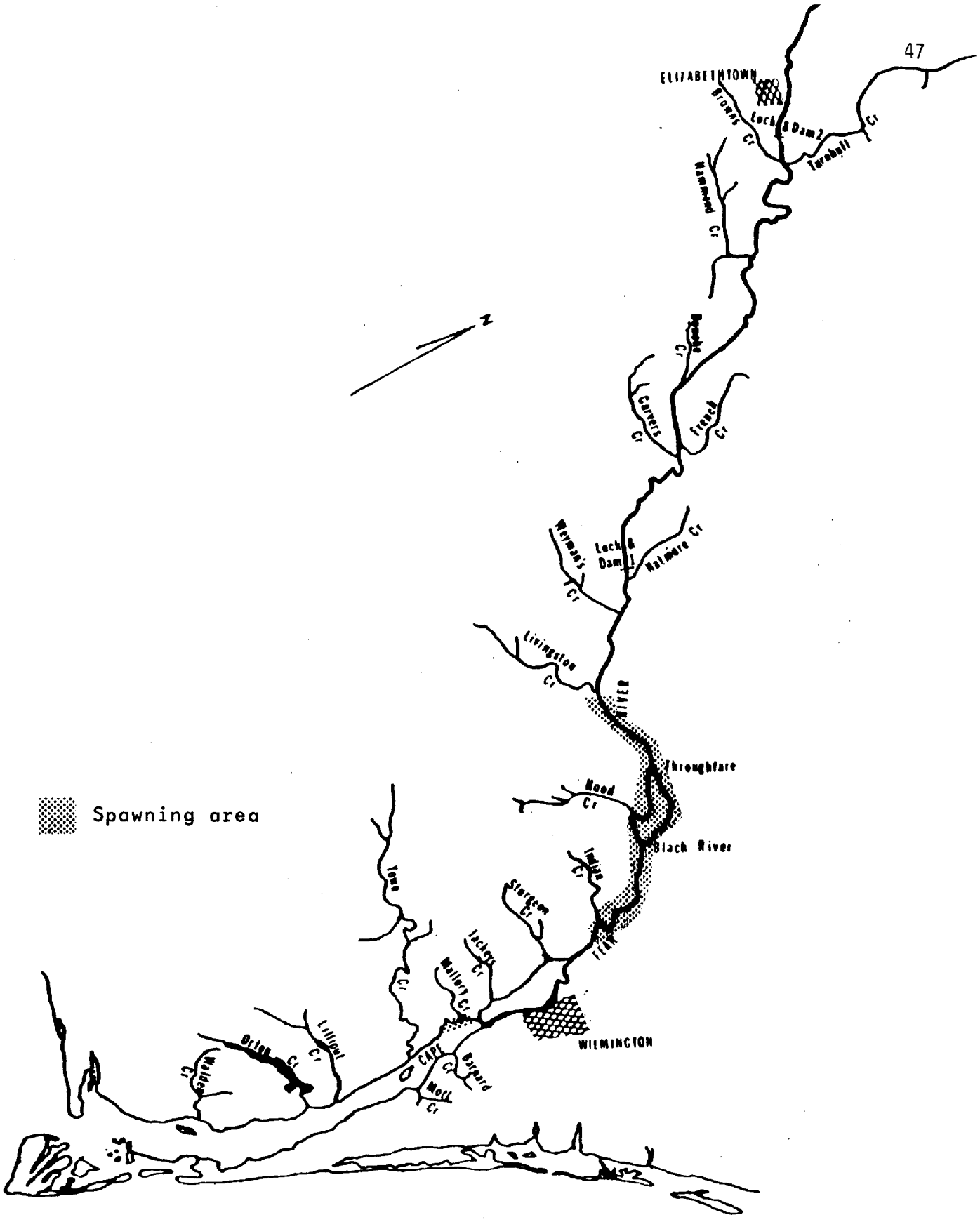

Figure 23 - Spawning areas of Striped bass, Cape Fear River, NC, 1978 - 1979.

Table 11 - Relative abundance of juvenile anadromous fish by wing trawl for the 1977 - 1979 year class.

Species	(July-Sept) 1977		(June-Oct) 1978		(July-Sept) 1979	
	Effort 60		50		30	
	Catch	C/E	Catch	C/E	Catch	C/E
American shad	99	1.65	156	3.12	44	1.46
Blueback herring	554	9.23	201	4.02	361	12.0
Alewife	9	.15	0	0	0	0
Striped bass	1	.016	0	0	0	0
Hickory shad	0	0	7	.17	0	0

juvenile American shad. Growth was slower in June-July 1978, probably due to cooler water temperatures (Figure 24). Juvenile American shad reached a mean fork length of 81 mm in November 1977.

Blueback Herring

Juvenile blueback were found in the river from July through December, 1977, June through October 1978, and July through September 1979 (project field work ended 30 September 1979). The peak occurrence is usually in the fall. This agrees with Sholar (1977:18) who thought it was due to the "increased availability of those fish moving from the upper tributaries and back waters to the lower river on their seaward migration." Catch per effort for blueback herring was substantially higher in 1979 than in 1978 or 1977 (Table 11). Juvenile blueback herring reached a mean fork length of 64 mm in December 1977 (Figure 25).

Alewife, Striped Bass, Hickory Shad

Alewife juveniles were found in the river until October 1977, when they reached a mean fork length of 70 mm. No alewife juveniles were found in 1978 or 1979.

Hickory shad juveniles were caught only in June in both 1977 and 1978. Hickory shad probably migrate out of the river system in June or early July. They had a mean fork length of 39 mm in June 1978 and 35 mm in June 1977.

Only one striped bass juvenile was caught in the river, in July 1977, its mean fork length 42mm. Because of their demersal habits, they are not generally caught in a surface trawl.

Adult Survey

For the last two weeks in March and the first three weeks in April in 1978 and 1979, adult anadromous fish were sampled one day a week by use of a haul seine (Figure 6).

American Shad

In 1979, adult American shad were caught only in April, while they were taken from the last week in March until sampling ended in mid-April in 1978. Peak catch per effort in 1979 occurred in April, as in the three preceeding years (Figure 26). Catch per effort in 1979 was greater than in 1978 but still below that of 1977 and

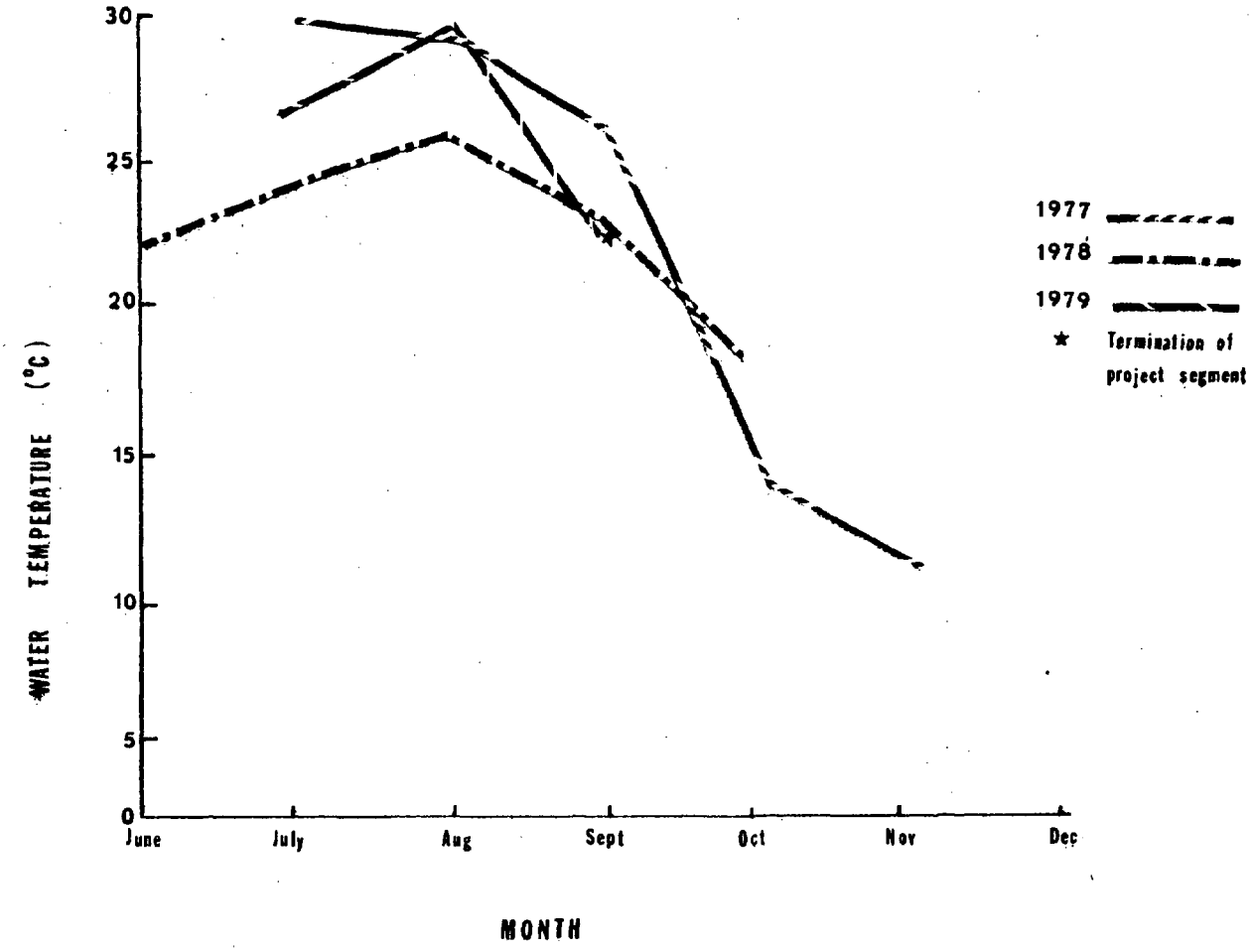

Figure 24 - Temperature graph of Northeast Cape Fear River, NC, 1977 - 1979.

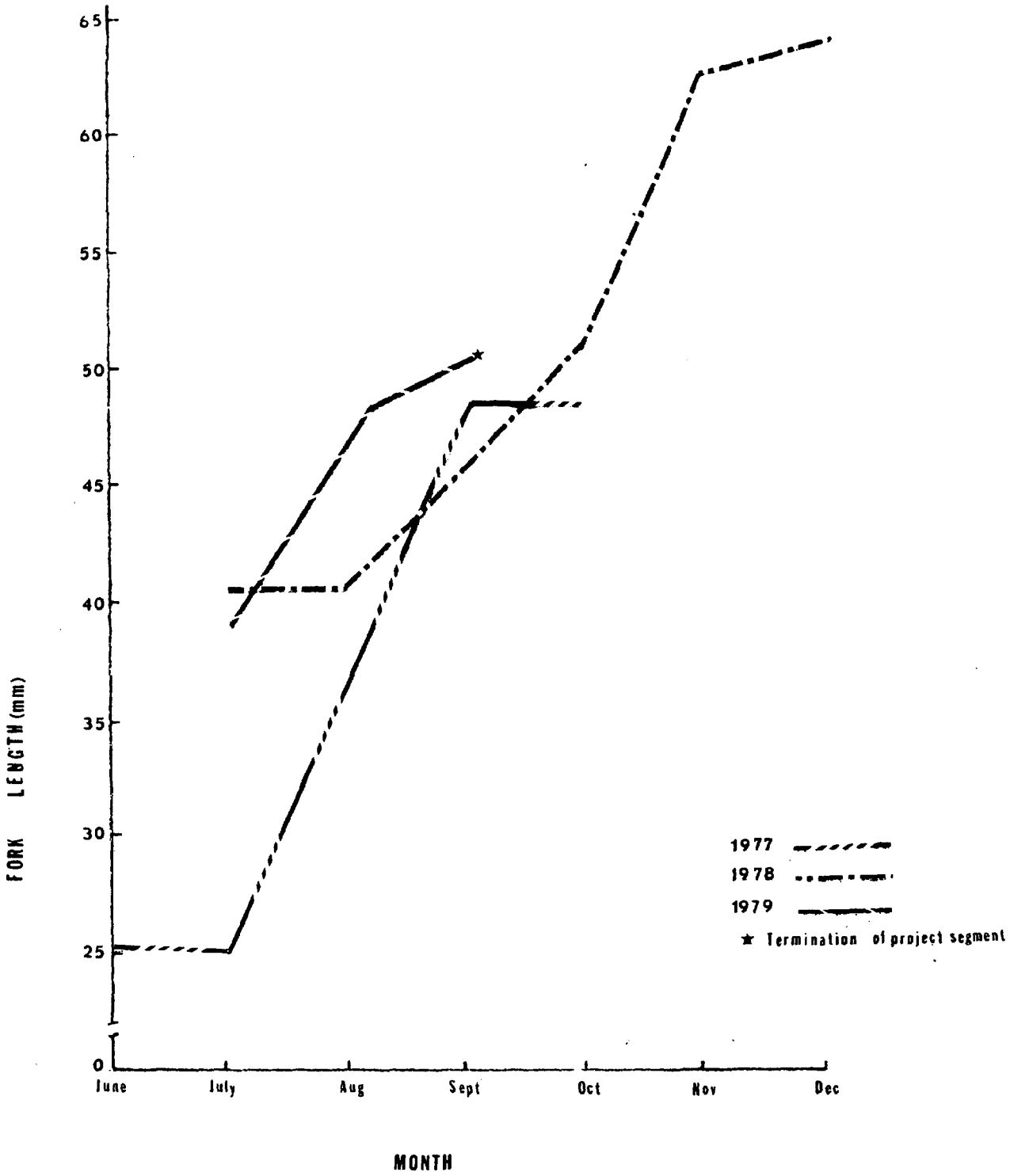

Figure 25 - Mean monthly fork length for Blueback herring, Northeast Cape Fear River, NC, 1977 - 1979.

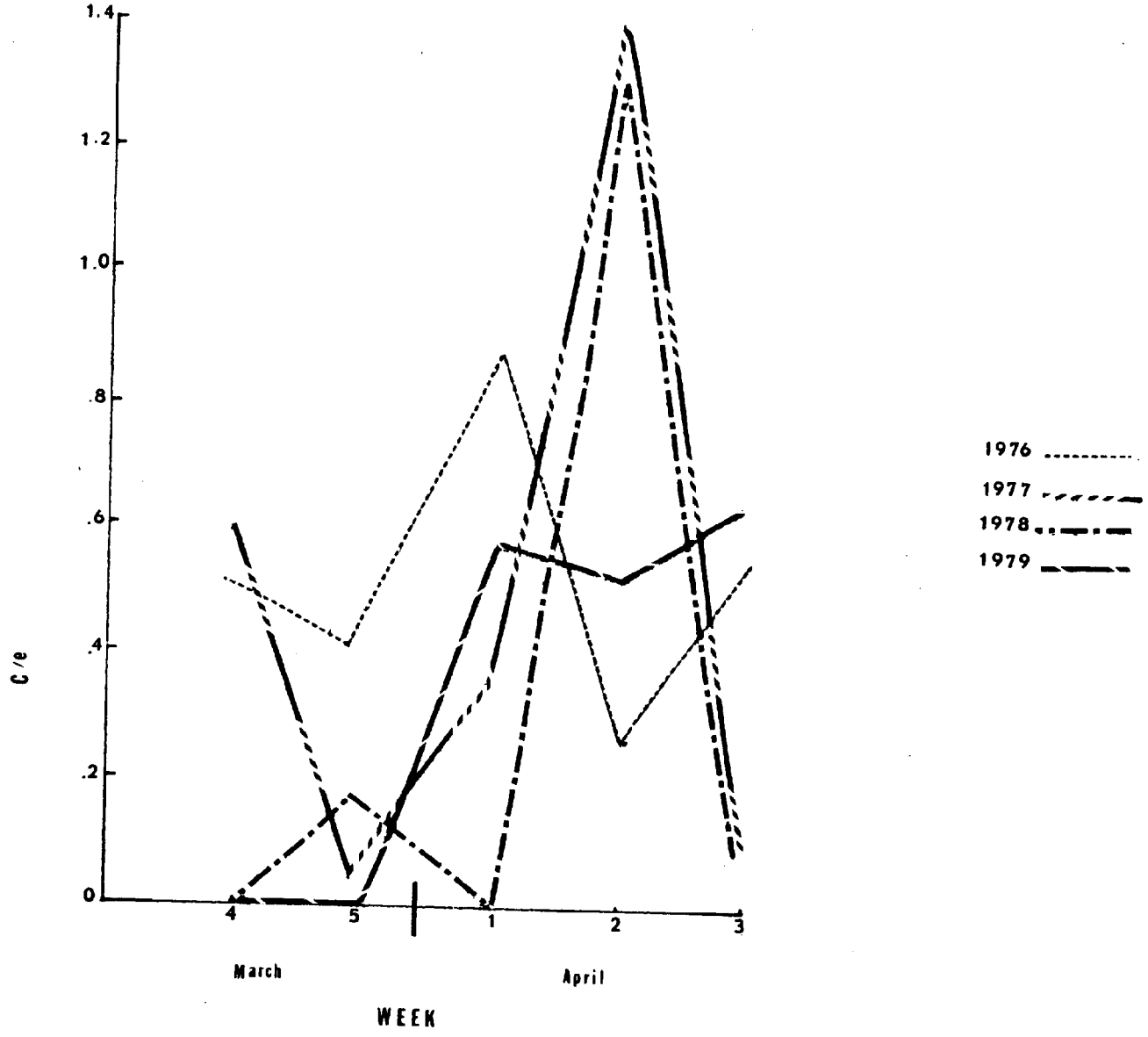

Figure 26 - Weekly haul seine catch per effort of adult American Shad, Northeast Cape Fear River, 1976 - 1979. Data for 1976 are from Sholar (1977).

1976. The seine was only sampled for a five-week period in 1978 and 1979, compared to an eight-week period in 1977 and 1976. The shorter time period could account for the lower catch (Table 12).

Blueback Herring

Adult blueback herring were the most abundant species caught in the haul seine as they were in Sholar's (1977) study. Bluebacks were caught throughout the sampling period, with the highest catch per effort in 1979 occurring during the last week in March (Figure 27). This was also true for the 1978 catches. Although effort was the lowest in 1978, catch per effort was the highest of any year studied (Table 12).

Hickory Shad, Alewife, Striped Bass

Adult hickory shad abundance was the same for 1978 and 1979. They were slightly less abundant than in either 1976 or 1977. Peak catch per effort in 1979 occurred the last week in March, while in 1978 peak catch occurred one week later (Figure 28).

Alewife were not very abundant at the haul seine, with a take of eight being caught in both 1978 and 1979. Only two striped bass and one adult alewife were caught in 1979. Sholar (1977:33) believed the haul seine "too far up river to catch many alewife."

Age and Spawning Frequency

American Shad

American shad caught in the haul seine in 1979 ranged in age from four to six. Females were predominately five years old while males were four and five (Table 13). The male:female ratio of 4:1 in 1979 was higher than the ratio of 2.6:1 in 1978. The 1979 ratio was closer to the male:female ratio of 5:1 in 1977 and 4.7:1 in 1976 (Sholar 1977). Only one repeat spawner was found in 1979, a five year old male.

Blueback Herring

Blueback herring caught in 1979 ranged in age from four to seven years (table 14). Males and females were predominately five years old. The sex ratio from the 1979 haul seine was 1:2.8 (male:female) which is similar to

Table 12 - Total catch and catch per effort for adult anadromous fish sampled by haul seine, Northeast Cape Fear River, NC, 1976 - 1979.

Species	1976*		1977*		1978		1979	
	Number hauls-113		Number hauls-114		Number hauls-98		Number hauls-100	
	Catch	C/e	Catch	C/e	Catch	C/e	Catch	C/e
American shad	56	0.50	54	0.47	25	0.25	35	.35
Hickory shad	26	0.23	30	0.26	18	0.18	18	.18
Blueback herring	85	0.75	188	1.65	194	1.97	189	1.89
Alewife	3	0.03	8	0.07	7	0.07	1	.01
Striped bass	2	0.02	3	0.03	1	0.01	2	.02

*Data for 1976 and 1977 from Sholar (1977).

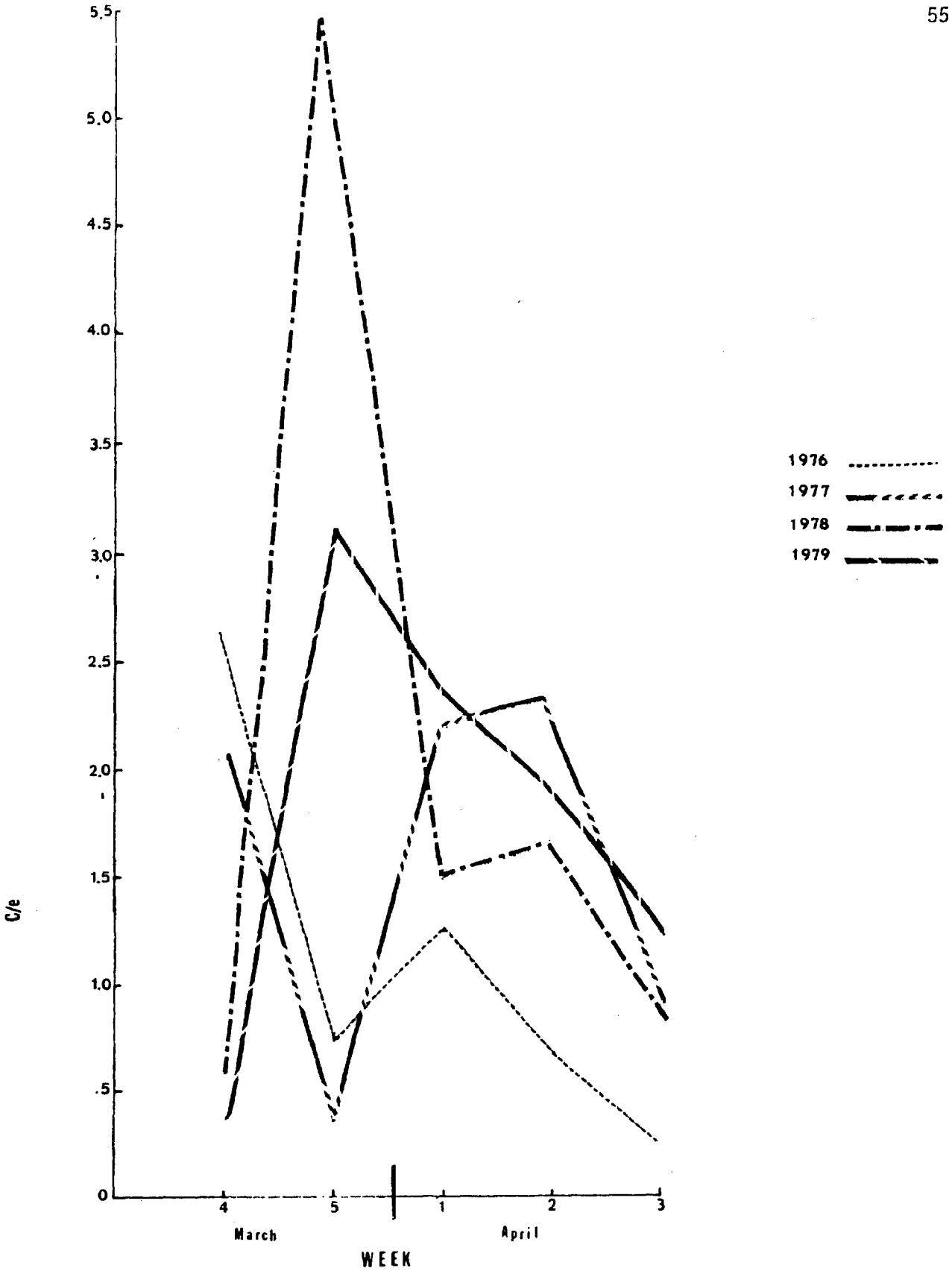

Figure 27 - Weekly haul seine catch per effort for blueback herring, Northeast Cape Fear River, NC, 1976 - 1979. Data for 1976 - 1977 are from Sholar (1977).

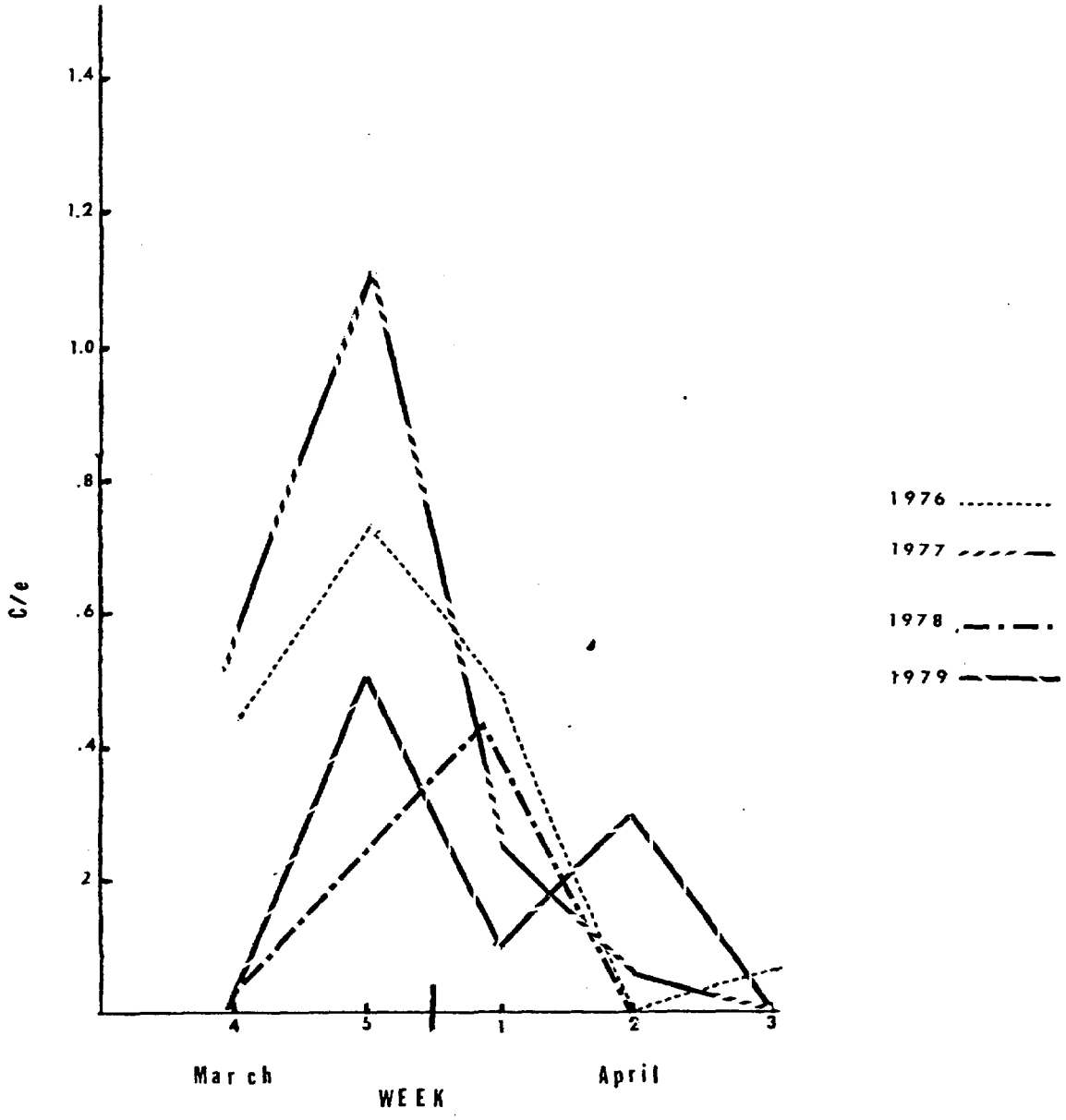

Figure 28 - Weekly haul seine catch per effort for adult hickory shad, Northeast Cape Fear River, NC, 1976 - 1979. Data for 1976 - 1977 are from Sholar (1977).

Table 13 - Number, percent of total sample, mean fork length, and fork length for each age group by sex for American shad, 1978-79, Northeast Cape Fear River, NC.

Sex	Age	Number	Percent of sample	Mean fork length (mm)	Length range (mm)
	IV	23	51	404	375 - 427
Male	V	19	42	433	422 - 465
	VI	2	5	487	485 - 490
	VII	1	2	513	- - - -
		45			
	IV	1	5	390	- - - -
Female	V	14	70	462	445 - 487
	VI	5	25	496	480 - 515
		20			

Table 14 - Number, percent of total sample, mean fork length, and fork length range for each age group by sex, for blueback herring, 1978-79, Northeast Cape Fear River, NC.

Sex	Age	Number	Percent of sample	Mean fork length (mm)	Length range (mm)
	III	1	1	240	- - - -
Male	IV	53	49	255	240 - 268
	V	48	44	265	251 - 280
	VI	6	5	278	270 - 299
		108			
	III	3	1	242	227 - 255
Female	IV	91	36	263	240 - 285
	V	125	50	275	255 - 290
	VI	29	12	286	270 - 299
	VII	3	1	295	294 - 296
		251			

1:2.3 ratio of 1976 but higher than the 1:1.96 ratio of 1978 and the 1:1.6 ratio in 1977 (Sholar 1977). It was thought by Sholar (1977) that the haul seine's large mesh might be selective against male bluebacks, which are generally smaller than females. Twenty-six percent of the adult bluebacks sampled in 1979 showed evidence of prior spawning, slightly higher than the 23% value in 1978. Virgin fish accounted for 72% of the males and 75% of the females in 1979. No blueback were found to have spawned more than twice in either 1979 or 1978 (Table 15).

Hickory Shad

Adult hickory shad ranged in age from three to five years. Females were four and five years of age while males were predominately three years old in 1979 samples (Table 16). The male:female sex ratio was 2.3:1 in 1979, as compared to 3:25:1 in 1978. There were three repeat spawners in 1979, one male and two females. Only one repeat spawner, a five year old female, was found in 1978.

Alewife and Striped bass

Only one adult alewife was caught at the haul seine in 1979, a five year old male. The male:female sex ratio was 1:3 in 1978 with only one adult repeater, a five year old female that had two spawning marks.

There were only two striped bass caught in 1979, a six year old male and a ten year old female.

SUMMARY AND CONCLUSIONS

1. The nursery area for juvenile American shad in Cape Fear River was from marker #42 (approximately six miles below Wilmington) to Gray's Creek (River Mile 99). Juvenile shad were found in the river until December; however, seaward migration took place mostly in November. The C/e (at selected stations) increased in 1979 as compared to 1977 and 1978.
2. The nursery area for juvenile blueback herring was from Town Creek (6 miles below Wilmington) to above Interstate 95 (River Mile 115), including Indian Creek, Brunswick River, Cartwheel Branch, Alligator Creek, Sturgeon Creek, and Mallory Bay. Bluebacks were found in the river until December,

Table 15 - Age and spawning frequency of blueback herring, Northeast Cape Fear River, NC, 1978-79.

Number of spawning marks	0		1		2		Total	
Age	M	F	M	F	M	F	M	F
III	1	3	0	0	0	0	1	3
IV	50	90	3	1	0	0	53	91
V	28	91	19	32	1	2	48	125
VI	2	6	1	16	3	7	6	29
VII	0	0	0	1	0	2	0	3
Total	81	190	23	50	4	11	108	251
Percent	75	76	21	20	4	4		

Table 16 - Number, percent of total sample, mean fork length, and fork length range for each age group by sex for hickory shad, 1978-79, Northeast Cape Fear River, NC.

Sex	Age	Number	Percent of total sample	Mean fork length	Length range
	III	14	52	300	280 - 320
Male	IV	9	33	316	295 - 330
	V	4	15	354	344 - 365
		27			
	III	1	10	308	- - - -
Female	IV	4	40	338	286 - 360
	V	5	50	370	360 - 380
		10			

and seaward migration took place mostly in November. Bluebacks were more abundant in 1978 than 1977 or 1979 (at selected stations).

3. The nursery area for juvenile alewife was from below Wilmington to above Interstate 95 (River Mile 115). Alewife were found in the river until August (1978) and were more abundant in 1977 than 1978 (at selected stations) or 1979.
4. Juvenile hickory shad were found during July 1977 and 1979 and June 1978 from Town Creek (below Wilmington) to above Interstate 95 (River Mile 115).
5. Juvenile striped bass were found in 1977 at only one station; none were found in 1978 or 1979.
6. Good runs of American shad, bluebacks, and striped bass were found with lesser runs of alewife. No adult hickory shad were found, although nine juveniles were taken.
7. Set and drift gill net samples in 1978 showed an American shad sex ratio of 1.2:1 (male:female) and a ratio of 2.8:1 in 1979.
8. Adult American shad ranged in age from three to seven. Only two American shad were found with a spawning mark; all other American shad were virgin.
9. Adult blueback herring ranged in age from three to seven. Approximately 31% of the bluebacks had spawned previously in 1978 and 29% in 1979.
10. Striped bass ranged in age from two to eleven.
11. Fishermen harvested primarily American shad with smaller amounts of river herring and hickory shad.
12. Striped bass and sturgeon were caught incidentally to shad fishing and trawling.
13. The majority of American shad fishing is recreational, using drift gill nets and to a less extent, anchored gill nets and hook-and-line.
14. Net fishermen fished mainly for female shad. Unculled samples from fishermen showed a sex ratio of 1:1.1 (male:female) in 1978 and 2.3:1 in 1979.
15. River herring were mainly caught for personal consumption and to bait eel and crab traps.
16. Twenty-three adult striped bass were tagged in Cape Fear River, with one return from the Northeast Cape Fear River, a distance of about 32 river miles.
17. Two Atlantic sturgeon were tagged with no returns.

18. A spawning area survey for all anadromous fish was conducted below Lock and Dam #2.
19. American shad were found to spawn from below Lock and Dam #2 (River Mile 70) to below Wilmington.
20. River herring were found to spawn from mid-March through May from Lilliput Creek (ten miles below Wilmington) to below Lock and Dam #2 (River Mile 70), mainly in the tributaries and river oxbows and bays.
21. Striped bass were found to spawn from about five miles below Wilmington to around River Mile 28 in the main river.
22. The juvenile monitoring survey in the Northeast Cape Fear River showed juvenile American shad catch per effort was significantly higher in 1978 than 1977 or 1979. Seaward migration occurred in November.
23. Juvenile blueback herring catch per effort in the Northeast Cape Fear was significantly higher in 1979 than 1978 or 1977. Seaward migration occurred in November.
24. No juvenile alewife or striped bass were found during 1978 or 1979 in the Northeast Cape Fear River.
25. Juvenile hickory shad were found during June 1978 in the Northeast Cape Fear River.
26. Haul seine samples in the Northeast Cape Fear River produced American shad and large numbers of blueback herring with smaller amounts of hickory shad, alewife, and striped bass.
27. Haul seine samples showed an American shad sex ratio of 2.6:1 (male:female) in 1978 and 4:1 in 1979. Adults ranged in age from four to six with one repeat spawner found.
28. Blueback herring from the haul seine ranged in age from four to seven with 23% showing evidence of prior spawning in 1978 and 26% in 1979. Adults were more abundant in 1978 than 1979.
29. Adult alewife caught in the haul seine were ages four and five. Only one had a spawning mark, while 88% were virgin.
30. Hickory shad from the haul seine ranged in age from three to five years. Three adults were found to have spawned previously, while 85% were virgin.

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