COMPARISON OF GROWTH RATES AND ABUNDANCE OF LARGEMOUTH BASS IN SELECTED NORTH CAROLINA COASTAL RIVERS

C. R. GUIER, North Carolina Wildlife Resources Commission, Division of Inland Fisheries, 512 N. Salisbury Street, Raleigh, NC 27611

W. G. MILLER, North Carolina Wildlife Resources Commission, Division of Inland Fisheries, 512 N. Salisbury Street, Raleigh, NC 27611

A. W. MULLIS, North Carolina Wildlife Resources Commission, Division of Inland Fisheries, 512 N. Salisbury Street, Raleigh, NC 27611

L. E. NICHOLS, North Carolina Wildlife Resources Commission, Division of Inland Fisheries, 512 N. Salisbury Street, Raleigh, NC 27611

Abstract: Age-growth relationships, length-weight relationships, and relative abundance indices were determined for largemouth bass (*Micropterus salmoides*) collected from the Cape Fear, Chowan, Pasquotank and Tar-Pamlico river systems in North Carolina during 1976. Largemouth bass in the Pasquotank River had the highest mean annual growth rate during their first and second years when compared to those in the other river systems studied. Largemouth in the Tar-Pamlico River system had the highest mean annual growth rates for age groups III and older. The growth rate of the Chowan River largemouth population was intermediate between those of the Pasquotank and the Tar-Pamlico rivers, while populations in the Cape Fear River had the slowest growth. Largemouth bass in the Chowan, Pasquotank, and Tar-Pamlico rivers attain legal harvestable size and recruit into the fishery at 305 mm in total length during their fourth growing season. The Cape Fear River largemouth population did not reach this harvestable size until the fifth growing season. Largemouth bass were found in order of decreasing abundance in the Chowan, Cape Fear, Tar-Pamlico, and Pasquotank rivers.

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The northern largemouth bass (*M. s. salmoides*) is the most important freshwater game fish in the Coastal Plain region of North Carolina (Fish 1974). The coastal rivers and estuaries of this region support considerable sport fishing effort and contribute a significant portion of the total largemouth bass harvest in North Carolina. It is the responsibility of the North Carolina Wildlife Resources Commission, Division of Inland Fisheries, to manage this resource. However, little biological information has been available regarding largemouth bass populations inhabiting these coastal river systems. Elementary information about age and growth has been lacking and has prevented comparing these populations with reference to other populations. Current management recommendations applied in this area are based on information gathered from southeastern reservoirs and lakes, and the validity of their application is unknown.

Prior information about largemouth populations in coastal North Carolna waters was limited to that found in stream surveys and a research study in Currituck Sound on habitat alteration. Fishery surveys conducted in the early to mid-1960's by Bayless and Smith (1962), Louder (1963), Bayless and Shannon (1965), Davis and McCoy (1965), and Smith (1963), provided information about the distribution of the largemouth bass, but nothing about the basic biology of the species. Crowell (1966) initiated biological studies on coastal largemouth populations by conducting preliminary investigations on growth, food habits, and spawning requirements of largemouth bass in Currituck Sound. However, this study was oriented towards the effects of habitat alteration from salt water intrusion into the sound, and the basic biological information gathered has limited applicability to the coastal rivers. Age and growth information presented here has been compiled from management and research activities conducted during 1975 and 1976.

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MATERIALS AND METHODS

Largemouth bass were collected from 4 coastal North Carolina river systems. Collections were made from both the mainstream and tributaries of the Cape Fear, Chowan, and Pasquotank rivers and from 5 tributaries of the Tar-Pamlico River.

The Chowan and Pasquotank rivers are located in northeastern North Carolina. They both originate in the Coastal Plain and discharge into Albemarle Sound. The Chowan River is formed at the confluence of the Nottoway and Blackwater rivers near the North Carolina-Virginia state line, and the Pasquotank River originates in the Great Dismal Swamp. The lower sections of both rivers form tributary extensions of the Albemarle Sound. The Cape Fear and the Tar-Pamlico rivers originate in the Piedmont section of North Carolina and flow southeast across the Coatal Plain to the coast. The Tar-Pamlico River traverses the central Coastal Plain discharging into Pamlico Sound, while the Cape Fear traverses the southern Coastal Plain and discharges directly into the Atlantic Ocean (Fig. 1).

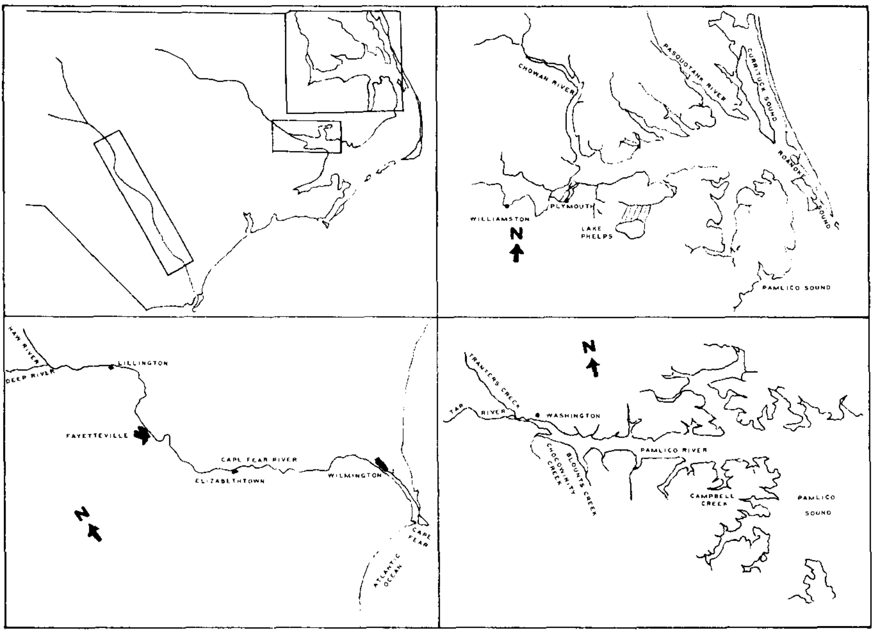

Fig. 1. Map of North Carolina Coastal Plain largemouth bass study areas.

Sampling began in November 1975 and extended through December 1976. Most largemouth were collected using electrofishing gear; however, gill nets, fyke nets, and pound nets were used as alternative methods. Electrofishing was conducted using a flat-bottomed boat designed and equipped similar to the unit described by Nototny and Priegel (1974). The unit was powered by a 3.5 kw single phase generator which produces 230 volts alternating current. A Smith-Root Mark VI Electrofisher was used as a current-modifying device. Total electrofishing effort was measured by a timer built into the Mark VI. Standard sampling runs of 900 seconds duration were completed to facilitate statistical comparisons of catch per unit of effort (CPUE) between the different rivers. Additional sampling equipment consisted of monofilament gill nets ranging in size from 35 to 76 mm bar mesh and 1.1 m diameter fyke nets with 50 mm bar webbing and attached wings, 6.1 m long. Commercial fishermen on the Chowan River also provided some of the largemouth bass captured during their pound net operations.

Total lengths of largemouth bass were recorded in millimeters. Weights were recorded in grams for all bass weighing less than 450 g. Weights of largemouth bass larger than 450 g were recorded to the nearest tenth of a kilogram and later converted to grams.

Scale samples were taken from an area immediately below the lateral line near the tip of the depressed pectoral fin. Scale impressions were made on cellulose acetate slides and examined by using an Eberbach scale projector at 43X magnification. Ages were determined by counting annuli. The distances from the focus to the annuli and the margin were measured along the midline of the anterior field.

The Lee model was fitted to scale radius-body length data using the least squares method for each of the four study streams (Lagler 1956). A fifth such relationship was also developed from a stratified random sample of 500 scale radius-body length data points drawn from a combined pool of 1300 largemouth bass collected throughout the Coastal Plain.

Differences in mean growth increments among largemouth populations in each river system were tested by analysis of variance using the Student-Newman-Keuls' test (Steele and Torrie 1960). The Student's T-test comparing the mean of CPUE data was used to indicate differences between any 2 study streams (Snedecor and Cochran 1967).

The model $W = aL^b$ was used in determining the length-weight relationship. The constants a and b were determined with logarithmic transformations of the length and weight data using the least squares method (Everhart, Eipper and Youngs 1975).

RESULTS AND DISCUSSION

The scale radius-body length relationships for largemouth bass from each river system and for the pooled data from largemouth bass samples taken throughout the Coastal Plain of North Carolina are as follows:

Cape Fear	$L = 17.52 + 1.3993\ S$ ($r = 0.9618$)	$n = 81$
Chowan	$L = 17.70 + 1.4205\ S$ ($r = 0.9664$)	$n = 226$
Tar-Pamlico	$L = 7.28 + 1.4653\ S$ ($r = 0.9055$)	$n = 176$
Pasquotank	$L = 12.90 + 1.4953\ S$ ($r = 0.9428$)	$n = 97$
Pooled data	$L = 20.35 + 1.3853\ S$ ($r = 0.9714$)	$n = 500$

L = total fish length in mm and S = the magnified anterior scale radius in mm. Only the regression developed from the pooled data was used in back-calculations of growth at each annulus.

A total of 526 largemouth bass were aged using the scale method. This included 81 from the Cape Fear River, 205 from the Chowan River, 85 from the Pasquotank River, and 155 from the Tar-Pamlico tributaries. The mean calculated total body lengths at annuli and mean growth increments between annuli of the largemouth bass collected from each of the four study areas are presented in Tables 1, 2, 3, and 4.

Table 1. Calculated total length with annual growth increments in parentheses of largemouth bass collected from the Cape Fear River during October 1976.

Age group	*No. of fish*	*Mean calculated total length and growth increments in millimeters at annulus* 1	2	3	4	5	6	7
I	14	(88) 88						
II	18	(103) 103	(96) 199					
III	18	(103) 103	(88) 191	(69) 260				
IV	8	(95) 95	(70) 166	(66) 231	(53) 284			
V	10	(93) 93	(68) 213	(59) 271	(42) 313			
VI	5	(110) 110	(71) 180	(65) 245	(63) 308	(29) 338	(27) 366	
VII	1	(131) 131	(64) 195	(42) 236	(47) 284	(38) 322	(72) 394	(28) 422
Mean calculated total length (unweighted)		98	182	241	284	322	369	422
Mean calculated annual growth increment (unweighted)		98	80	67	57	38	34	28
Range of calculated lengths at annulus		60-152	101-246	173-339	230-345	276-376	357-394	422
Number of fish		74	60	42	24	16	6	1

Table 2. Calculated total lengths with annual growth increments in parentheses of largemouth bass collected from the Chowan River from February 1976 through November 1976.

Age group	*No. of fish*	*Mean calculated total length and growth increments in millimeters at annulus* 1	2	3	4	5	6	7	8	9
I	24	(116) 116								
II	19	(127) 127	(91) 218							
III	36	(114) 114	(93) 210	(70) 279						
IV	34	(121) 121	(91) 212	(58) 269	(40) 309					
V	26	(137) 137	(81) 218	(62) 280	(48) 328	(39) 367				
VI	3	(110) 110	(87) 197	(42) 239	(59) 298	(41) 339	(18) 356			
VII	4	(147) 147	(107) 254	(76) 330	(56) 386	(42) 428	(30) 458	(16) 474		
VIII	4	(136) 136	(101) 237	(39) 276	(26) 302	(34) 336	(27) 363	(31) 393	(19) 413	
IX	2	(168) 168	(53) 220	(70) 290	(46) 336	(50) 386	(31) 417	(24) 441	(17) 458	(20) 478
Mean calculated total length (unweighted)		123	215	277	320	369	399	435	428	478
Mean calculated annual growth increment (unweighted)		123	90	63	44	39	26	26	24	18
Range of calculated lengths at annulus		55-198	120-346	198-387	249-422	277-457	311-484	353-494	378-494	450-505
Number of fish		152	128	109	73	39	13	16	6	2

During data analysis, it became evident that there were different scale radius-body length relationships from each study stream. The least square regression lines established for the Cape Fear River and Chowan River exhibit strong linear relationships (=0.97) and positive Y intercepts of 17.5 and 17.7 mm, respectively. Other investigators fitting the straight line to largemouth bass scale radius-body length relationships have reported intercepts ranging from 18.6 to 37.7 mm (Hubert 1975; Pasch 1975; Pasch 1976; Range 1972). However, in analyzing data from the Tar-Pamlico and Pasquotank river samples, negative intercepts, -7.28 mm and -12.9 mm, respectively, were discovered. While these negative intercepts do not automatically preclude their consideration for use, it is felt these scale radius-body length relationships are misleading. In both cases, the samples are characterized by a preponderance of larger fish in the sample with very few fish in the smaller size ranges. It is interpreted that this clustering of data is the cause of the negative intercept rather than any substantial biological differences in the population. It has previously been pointed out by Lagler (1956) that the age and length distribution of the samples does influence the estimation of the intercept constant.

Table 3. Calculated total lengths with annual growth increments in parentheses of largemouth bass collected from the Pasquotank River from February 1976 through November 1976.

Age group	*No. of fish*	*Mean calculated total length and growth increments in millimeters at annulus*								
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
I	3	(143) 143								
II	11	(128) 128	(74) 202							
III	19	(134) 134	(83) 217	(65) 283						
IV	22	(137) 137	(87) 226	(62) 288	(56) 344					
V	14	(143) 143	(83) 240	(78) 318	(43) 361	(31) 392				
VI	9	(140) 140	(90) 231	(84) 314	(46) 360	(33) 393	(26) 419			
VII	2	(144) 144	(77) 221	(94) 315	(54) 368	(51) 419	(53) 471	(26) 497		
VIII	1	(138) 138	(56) 194	(16) 210	(44) 254	(36) 290	(25) 315	(24) 339	(39) 378	
IX	1	(115) 115	(102) 217	(71) 288	(93) 381	(54) 435	(15) 450	(34) 484	(21) 505	(28) 533
Mean calculated total length (unweighted)		136	223	296	352	392	422	454	442	533
Mean calculated annual growth increment (unweighted)		136	85	70	51	34	29	28	30	28
Range of calculated lengths at annulus		83-200	149-318	205-376	254-455	290-487	315-500	339-504	378-505	---
Number of fish		82	79	68	49	27	13	4	2	1

Table 4. Calculated total lengths with annual growth increments in parentheses of largemouth bass collected from five Tar-Pamlico River tributaries from November 1975 through December 1976.

Age group	*No. of fish*	*Mean calculated total length and growth increments in millimeters at annulus*					
		1	*2*	*3*	*4*	*5*	*6*
I	9	(154) 154					
II	30	(123) 123	(119) 230				
III	58	(114) 114	(94) 208	(89) 297			
IV	21	(119) 119	(91) 210	(92) 302	(63) 361		
V	7	(122) 122	(102) 223	(61) 285	(53) 338	(32) 370	
VI	3	(139) 139	(147) 286	(74) 327	(46) 416	(46) 463	(29) 492
Mean calculated total length (unweighted)		121	217	298	362	398	492
Mean calculated annual growth increment (unweighted)		121	102	87	59	36	29
Range of calculated lengths at annulus		77-214	103-325	191-400	245-456	346-501	464-522
Number of fish		128	119	89	31	10	3

Other authors have reported problems in developing satisfactory scale radius-body length relationships. Manooch and Huntsman (1977) reported that relationships developed from porgy scale samples collected in three study areas had different relationships. They attributed the problem to poor field techniques in collecting data and chose to solve the problem by using the relationship developed from the study area in which suitable field techniques were used. This relationship was then used throughout all study areas. Hubert (1975) reported low intercepts for largemouth bass when he included samples from all size classes and chose to use a relationship derived only from young-of-year fish. Range (1972) reported developing undesirable intercept values for crappie, walleye, and smallmouth bss and chose to use values obtained from the literature in back-calculations for these species.

As a means of comparing growth, the data were pooled from over 1300 largemouth bass collected throughout the Coastal Plain with samples from both inside and outside the study areas. This was done because it is felt that the scale radius-body length relationship is primarily a genetic function of the species rather than a function of habitat. From the 1300 fish sampled, 500 fish were utilized in developing this relationship. To assure complete representation of all age and length groups, the 1300 fish sample was stratified into five 75 mm groups. A 100 fish sample was then randomly drawn from each group and the resulting relationship used in all back-calculations to provide directly comparable growth information.

The growth rates of largemouth bss in the 4 river systems were analyzed to determine if there was any difference among the populations. The Pasquotank River population exhibited the greatest growth during the first and second year of all samples analyzed. Largemouth from the Tar-Pamlico tributaries showed the greatest growth for the age groups III and older. Chowan River largemouth exhibited intermediate growth between the Pasquotank and Tar-Pamlico populations for all age groups encountered (I through VI). Largemouth bass in the Cape Fear River had the slowest growth rate of all population samples evaluated. On the average, largemouth bass in the Chowan, Pasquotank and Tar-Pamlico rivers attained legal harvestable size and recruited into the fishery at 305 mm in total length during their fourth growing season. Largemouth in the Cape Fear did not reach this recruitable size until their fifth growing season (Fig. 2).

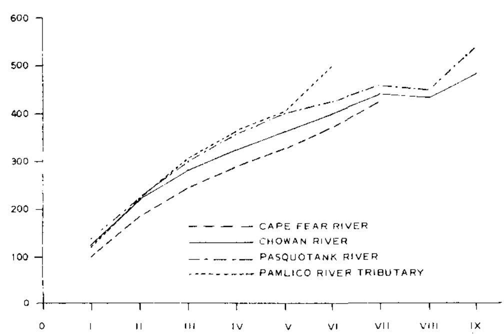

Fig. 2. Comparative calculated total lengths at annulus formation of largemouth bass from the Cape Fear River, Chowan River, Pasquotank River and five Tar-Pamlico River tributaries.

The mean growth increments for largemouth in the four river systems studied are presented in Table 5. Analysis of variance showed significant differences in mean growth increments among the various populations at the 5% level (5 = 2.9883 with 3 d.f.). However, the Chowan River sample was not significantly different from the Pasquotank River sample.

Table 5. Comparison of the mean growth increments for all years combined between river systems.

		CF(1)	*(Ch (2)*	*(Pq (3)*	*TP (4)*
Mean growth increment (m)		*77.1*	*82.1*	*83.0*	*98.9*
Number of increments		*222*	*513*	*318*	*380*
Comparison	*Difference*	*SE*	*q*	*q0.05*	*Conclusion*
CF vs TP	21.8	1.71	12.75	3.65	Reject H_o:$M_1 = M_4$
CF vs Pq	5.9	1.77	3.33	3.33	Reject H_o:$M_1 = M_3$
Ch vs TP	16.8	1.37	12.26	3.33	Reject H_o:$M_2 = M_4$
CF vs Ch	5.0	1.63	3.07	2.78	Reject H_o:$M_1 = M_2$
Ch vs Pq	0.9	1.44	0.62	2.78	Fail to reject H_o:$M_2 = M_3$
Pq vs TP	15.9	1.54	10.33	2.78	Reject H_o:$M_3 = M_4$

CF = Cape Fear
Ch = Chowan River
Pq = Pasquotank River
TP = Tar-Pamlico River Tributaries

Largemouth bass from the tributaries of the Tar-Pamlico River exhibited the greatest mean growth increment of all populations studied, followed in order by the Pasquotank, Chowan, and Cape Fear river populations. Largemouth from the Cape Fear River grew significantly slower when compared to populations from the other three river systems.

The factors which contributed to comparatively faster growth rates of largemouth bass in the Pasquotank and Tar-Pamlico rivers are not known. Salinity concentrations ranged up to 1.3 ppt in the Pasquotank River and up to 5.0 ppt in the Tar-Pamlico River during the period of sampling, but no measurable concentrations of salinity were recorded during sampling in the Chowan and Cape Fear river study areas. Salinity may directly influence growth rates, or forage may be provided through the annual immigration of marine fishes.

Largemouth bass growth rates in North Carolina coastal rivers were comparatively slow considering growth rates of the species from other regions of the United States (Table 6). Pasch (1976) reported that largemouth in Lake Sinclair (Georgia) attained legal harvestable size, 305 mm, during their second year, and Lake Blackshear (Georgia) largemouth attained legal harvestable size during their third year. The attainment of these sizes in relationship to age was apparently directly related to the existing forage base.

Length-weight relationships were determined for 564 largemouth bass collected from the 4 study streams (Table 7). Fish samples from the Cape Fear River were collected only during the fall months of September and October. Monthly electrofishing samples were collected throughout the year from the Pasquotank and Chowan river systems. Therefore, fall samples were comparable with those from the Cape Fear River. Adequate fall samples were not available from the Tar-Pamlico tributaries so comparisons with the Cape Fear River samples were not made. Adequate samples were available for comparisons of populations from the Tar-Pamlico tributaries with those from the Pasquotank and Chowan rivers on an annual basis.

Table 6. Calculated total lengths of largemouth bass from various waters, ranked by length at the first annulus.

	Age group						
Body of water	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*
Louisiana (Bennett 1937)	193	287	368	478	531	597	630
Lake Sinclair, Ga. (Pasch 1976)	191	312	412	507	555	560	528
Norris Lake, Tn. (Stroud 1948)	175	310	371	412	445	490	
Clear Lake, Ca. (Tharratt 1966)	170	310	376	424	503	544	557
Unweighted mean: Al., Ga., La., Tx. (Carlander 1972)	160	256	315	391	437	518	
Sutherland Res., Ca. (Tharratt 1966)	165	290	363	414	460		
Silver Lake, Ga. (Padfield 1951)	157	281	355	417	500	559	599
Folsom Lake, Ca. (Tharratt 1966)	142	264	425	368	401	432	
Oklahoma Res. Avg. (Houser and Bross 1963)	140	246	318	378	434	472	505
Lake Wappapello, Mo. (Carlander 1972)	137	277	338	409	460	498	
Pasquotank River (present study 1977)	136	223	296	352	392	422	454
Chowan River (present study 1977)	123	215	277	320	369	399	435
Tar-Pamlico River Trib. (present study 1977)	121	217	298	362	398	492	
Lake Havasu, Ca. (Tharratt 1966)	117	246	343	412			
Lake Blackshear, Ga. (Pasch 1975)	106	253	352	418	473		
Cape Fear River (present study 1977)	98	182	241	284	322	369	422
Wisconsin Lakes, Avg. (Bennett 1973)	84	188	267	316	356	384	

Table 7. Length-weight relationships for largemouth bass collected from the Cape Fear River, Chowan River, Pasquotank River, and the Tar-Pamlico River system in 1976[a].

River system	*n*	*Intercept*	*Slope*	*Correlation coefficient*
Cape Fear (fall)	92	-5.213	3.150	0.980
Chowan (fall)	153	-5.527	3.271	0.997
Chowan (all seasons)	242	-5.489	3.262	0.997
Pasquotank (fall)	57	-5.420	3.229	0.996
Pasquotank (all seasons)	102	-5.349	3.196	0.997
Tar-Pamlico (all seasons)	128	-5.350	3.200	0.991

[a]log W = log a + b (log L)
Where W = total weight
L = total length
log a = intercept
b = slope

Table 8 shows the calculated total weight of largemouth bass at each annulus formation. During the first 2 years of life, the Pasquotank population displayed the highest calculated total weight followed by those from the Tar-Pamlico tributaries, the Chowan River and the Cape Fear River. Populations from the Tar-Pamlico tributaries exhibit the greatest calculated total weight after the second year followed by the Pasquotank, Chowan and Cape Fear rivers, respectively, through age VI.

Table 8. Calculated total weight at annulus formation for largemouth bass from Cape Fear River, Chowan River, Pasquotank River, and Tar-Pamlico River tributaries.

Age	*Cape Fear* (fall)	*Chowan* (fall)	*Chowan* (all)	*Pasquotank* (fall)	*Pasquotank* (all)	*Tar-Pamlico* (all)
1	11.5	20.4	20.3	29.4	29.4	20.6
2	80.6	126.6	124.8	145.5	143.3	133.9
3	195.1	290.0	284.4	362.9	354.2	369.4
4	327.3	464.9	454.7	635.0	616.2	688.4
5	486.1	740.9	722.7	898.9	869.2	932.4
6	746.7	956.7	931.9	1140.6	1100.3	1837.8
7	1139.6	1269.1	1234.1	1444.2	1390.0	---
8	---	1203.5	1243.9	1324.5	1275.8	
9	---	1727.4	1783.6	2424.4	2320.7	---

The mean CPUE in numbers of largemouth bass collected with standardized electrofishing samples was higher in the Chowan River ($Y = 4.10$ largemouth bass per 900 second sample) than in the Cape Fear River ($Y = 2.74$), Tar-Pamlico River tributaries ($Y = 2.64$), or the Pasquotank River ($Y = 0.90$).

Using this CPUE information as an index to relative abundance, the Chowan River was found to be the most heavily populated of the study streams. The Cape Fear River and Tar-Pamlico tributaries have similar population densities with both being noticeably lower than those found in the Chowan. The lowest fish population densities were found in the Pasquotank River. The specific causes of the population differences were not determined in this study.

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