Sport Fishery Harvest and Effort on Albemarle Sound, North Carolina

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Abstract: A creel census was conducted on Albemarle Sound and its tributaries from February 1, 1977 through January 31, 1980 to estimate the total annual sport fishing pressure and harvest of major sport fish species, particularly striped bass (*Morone saxatilis*). Total sport fishing effort was in excess of 400,000 party-hours per year, and largemouth bass (*Micropterus salmoides*), was the species for which the greatest amount of specific effort was exerted. The harvest of striped bass and most other species declined drastically during the study. The relative harvests of the sport and commercial fisheries operating on the Albemarle Sound-Roanoke River striped bass population are compared and possible causes of the decline in harvest are discussed.

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Albemarle Sound and its tributaries support a major sport fishery for both freshwater and marine fish species. However, problems associated with human population growth are creating greater pressures upon all aspects of the Albemarle Sound aquatic ecosystem. Demands for water resource usage by municipalities, industries, and agriculture increase annually, and they represent accelerating potential dangers to the fishery habitat of the Albemarle Sound area. Expected expansion of the human population in this geographical area will also result in increased recreational fishing pressure.

Many indigenous and migratory fish species are targets of both sport and commercial fisheries. The striped bass is one of the most important commercial and sport fish species in the Albemarle Sound region. Annual commercial landings of striped bass from the Albemarle Sound area averaged over 270,000 kg during the years of 1960–1979 (Hassler et al. 1981). Sport fishermen harvested an average of 54,738 additional fish annually from 1967 through 1973 (Hassler et al. 1981). The wholesale price of striped bass

never exceeded $0.46/kg prior to 1972, however, prices approached $2.20/kg in the late 1970's. Such trends toward higher commercial market values for striped bass and other fish species ultimately will lead to increased commercial fishing effort.

Intense pressures from habitat degradation and high harvests often lead to declines in populations of exploited fishes. Complaints of such a decline in the Albemarle Sound striped bass population were voiced by both commercial and sport fishermen in the mid to late 1970's. Current data on the sport harvest of striped bass and other species was needed to document any reported declines and to document the value and importance of sport fishery resources in justifying any management proposals. A creel census was conducted on Albemarle Sound to collect the needed data.

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Methods

Albemarle Sound is located in the northeastern coastal plain of North Carolina (Fig. 1). The sound and its tributaries have a surface area of approximately 253,783 ha. Most of the tributaries have large expanses of open water in their lower reaches which form expansion arms of the adjacent Albemarle Sound and were included in the study area. Albemarle Sound is not continuous with the Atlantic Ocean, and outflowing water passes through Croatan and Roanoke sounds before reaching Oregon inlet and the ocean. Croatan and Roanoke sounds were also included in the study area.

The Roanoke River, a tributary to Albemarle Sound and the primary spawning stream of striped bass in the area, was not included in the study area because sport fishery effort and harvest of striped bass were estimated in another comprehensive study of this stream by Hassler et al. (1981).

A creel census was used to collect data on sport fishing effort and harvest on Albemarle Sound during the period 1 February 1977 through 31 January 1980. The creel census was designed using guidelines established by the North Carolina State University Institute of Statistics under agreement with the Southeastern Game and Fish Statistics project. Similar procedures

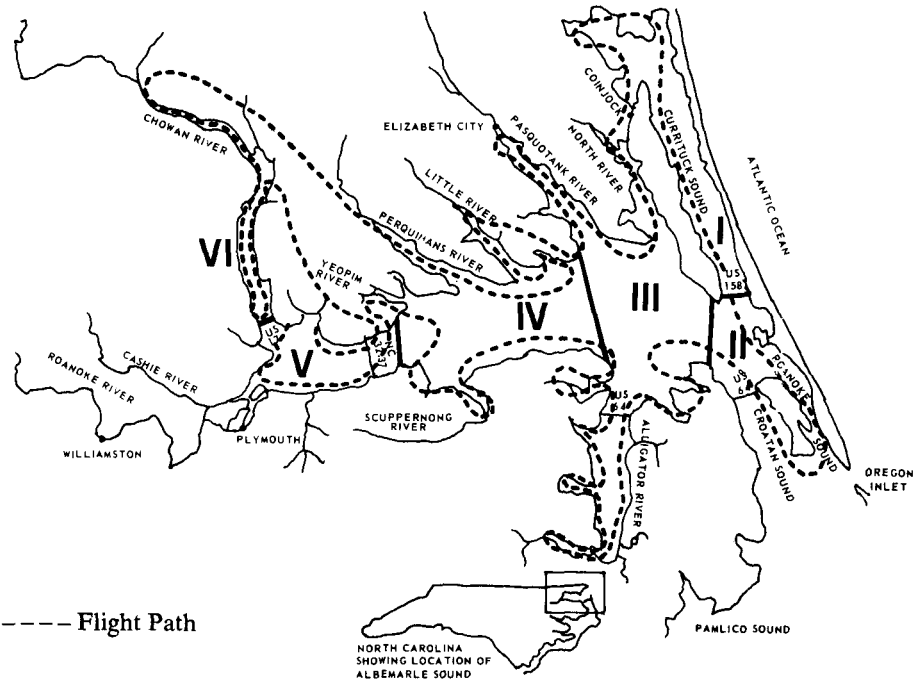

Figure 1. Map of Albemarle Sound and its major tributaries.

were used by Speir et al. (1977) to survey the Maryland portion of Chesapeake Bay sport fishery.

Striped bass was the species of primary interest during this study. Due to seasonal migration, fishing activity for this species shifts to various areas of Albemarle Sound in response to the seasonal concentrations. Therefore, Albemarle Sound and its tributaries were divided into 6 geographic zones or strata. Each year was divided into 6 (2-month) periods and within each period, days were stratified by weekend days or holidays and weekdays. Non-uniform probabilities were then assigned to each geographic zone, each access area within the respective zones and each calendar period to maximize creel clerk interviews in the anticipated areas and at the times of maximum striped bass fishing activity. Estimates of effort and harvest were made in each zone and added to provide a total estimate for the entire study area for each year of the 3-year study. Each individual year of study began on 1 February and ended on 31 January of the succeeding calendar year.

Estimates of total daytime fishing effort were based on expansion of instantaneous counts of fishing parties (boats) present during aerial surveys

(Fig. 1) of the entire study area. Four aerial surveys were made during each 2-month period (1 weekend day or holiday and 1 weekday per month). The specific dates and times of each airplane flight were chosen randomly by computer.

A relatively important night fishery for striped bass occurred in the western portion of Albemarle Sound during the warm spring, summer, and fall months. This fishery was sampled from August through November of 1977 and May through October of 1978 and 1979. Estimates of night fishing effort were based on counts of vehicles with empty boat trailers attached which were present at access ramps located around western Albemarle Sound. Trailer counts were made on 1 weekend or holiday night and 1 weekday night per month, and the dates and times were selected randomly.

Two creel clerks conducted access point interviews of returning fishing parties. Both clerks worked 5 days per week including most weekend days and holidays. Off days were randomly selected by computer. The available clerk workdays were distributed over zones in proportion to anticipated monthly fishing activity. It was assumed that the catch-per-unit-of-effort of fishermen utilizing selected access points was representative of that of all anglers fishing in the study area.

The creel clerks interviewed each fishing party which returned to the access point during their scheduled work period and recorded pertinent data on a field interview form. All fish harvested by each party were separated by species, and the total number and total weight of each of 9 major species were recorded. The combined total number and weight of all other species of fish harvested were recorded as "other species." The clerks also collected information from each party interviewed on the number of anglers in the party, total time spent fishing, species fished for, fishing method used, bait used, and residence of the fishermen.

Field interview sheets and counts of instantaneous fishing pressure were submitted to the North Carolina State University Institute of Statistics who generated harvest and effort estimates under their agreement with the Southeastern Game and Fish Statistics Project.

Results

An estimated average of 443,459 party-hours of sport fishing effort were expended per year during daylight hours on Albemarle Sound and its tributaries during the 3-year study (Table 1). Annual daytime effort decreased from 467,974 party-hours in 1977–78 to 410,274 party-hours in 1979–80. The annual mean party size ranged from 2.27 people in 1977–78 to 2.04 people in 1979–80. Annual daytime sport fishing effort averaged 964,809 angler-hours.

Zone I, Currituck Sound, and Zone VI, Chowan River, supported the greatest amount of sport fishing pressure of any of the study zones. Each supported an estimated average of 95,000 party-hours of effort per year (Table 1). All zones in the study area supported an average of at least 49,000 party-hours of recreational fishing pressure per year.

Daytime sport fishing effort peaked during June and July, however, a significant amount of effort was exerted each month from April through November.

Slightly more daytime sport fishing effort was exerted on weekends or holidays (58%) than on weekdays (42%) over the 3-year course of the study. However, the percentage of weekday effort increased from only 30% in 1977–78 to 49% in 1979–80.

An average of 3,783 (SE ± 739) party-hours per year of additional effort was exerted on Zone V by nighttime anglers. Estimated nocturnal effort dereased from 5,065 (SE ± 2,017) party-hours during the summer and fall of 1977 to only 2,684 (SE ± 607) party-hours in 1979.

Largemouth bass was the most sought after species by sport fishermen in Albemarle Sound and tributaries throughout the study (Table 2). An estimated average of 114,950 party-hours of effort per year were exerted specifically for this species. Striped bass was the second most popular species, and an average of 54,914 party-hours of effort was exerted specifically for it annually. White perch (*Morone americana*) and sunfish (*Lepomis* sp.)

Table 1. Total Estimated Annual Daytime Sport Fishing Effort (party-hours) on Albemarle Sound during the Period 1 February 1977 through 31 January 1980 by Zone

Zone	Effort			
	Feb. '77–Jan. '78	Feb. '78–Jan. '79	Feb. '79–Jan. '80	Mean
I (Currituck Sound)	100,917 (±29,583)[a]	86,039 (±29,664)	98,617 (±35,437)	95,191 (±18,291)
II (Roanoke & Croatan Sound)	86,422 (±32,337)	69,419 (±19,527)	70,320 (±19,703)	75,387 (±14,202)
III (Eastern Albemarle Sound)	70,230 (±14,268)	72,686 (±12,146)	65,237 (±14,503)	69,384 (±7,898)
IV (Central Albemarle Sound)	51,809 (±13,762)	67,087 (±18,352)	54,984 (±14,141)	57,960 (±8,982)
V (Western Albemarle Sound)	74,697 (±20,080)	44,810 (±19,909)	28,153 (±8,201)	49,220 (±9,814)
VI (Chowan River)	83,900 (±26,191)	112,090 (±22,260)	92,963 (±32,204)	96,318 (±15,701)
Total	467,974 (±125,500)	452,130 (±114,834)	410,274 (±103,217)	443,459 (±66,325)

[a] Standard errors are in parentheses.

Table 2. Estimated Annual Fished-For Effort (party-hours) on Albemarle Sound during the Period 1 February 1977 through 31 January 1980 by Species

Species	Effort[a]			
	Feb. '77–Jan. '78	Feb. '78–Jan. '79	Feb. '79–Jan. '80	Mean
Largemouth bass	95,746 (±37,412)[b]	95,863 (±19,331)	153,242 (±52,625)	114,950 (±22,467)
Striped bass	61,454 (±5,168)	61,909 (±25,544)	41,382 (±15,198)	54,914 (±70,056)
White perch	50,030 (±24,754)	46,495 (±21,569)	9,667 (±6,714)	35,397 (±11,171)
Sunfishes	42,394 (±25,217)	43,798 (±40,782)	16,153 (±7,228)	34,115 (±16,163)
Crappie	33,410 (±10,902)	14,475 (±5,265)	13,932 (±5,227)	20,606 (±4,396)
Channel catfish	21,282 (±11,286)	27,777 (±17,268)	5,656 (±2,291)	18,238 (±6,919)
Weakfish	10,483 (±9,657)	13,133 (±9,885)	4,998 (±5,475)	9,538 (±4,955)
Spotted seatrout	10,859 (±6,586)	3,537 (±2,380)	0 (±0)	4,799 (±2,334)
Other species	41,118 (±16,181)	19,924 (±10,765)	9,647 (±10,568)	23,563 (±7,374)

[a] Includes both daytime and nighttime effort.
[b] Standard errors are in parentheses.

were also highly pursued, and each had over 34,000 party-hours of pressure exerted specifically for it per year. Specific effort for largemouth bass increased each succeeding year while effort for striped bass, white perch, and sunfish declined drastically.

Zone V, western Albemarle Sound, supported the highest amount of specific fishing effort for striped bass in 1977–78, but Zone III, eastern Albemarle Sound, supported most striped bass effort during the 2 final years of the study. October and November were the peak months for striped bass fishing activity although a high amount of sport fishing activity for striped bass was also exerted during April and May in some years.

Day and night sport fishermen harvested an estimated average of 18,345 striped bass weighing 17,349 kg per year from the study area (Table 3). Harvest of striped bass declined steadily each year from a high of 33,202 fish in 1977–78 to only 5,235 fish in 1979–80. The harvest of striped bass was highest in Zone V in 1977, but the bulk of the harvest shifted to Zone IV, central Albemarle Sound, in the succeeding 2 years. The mean annual striped bass harvest was highest from Zone V with 8,390 fish weighing 7,377 kg.

Corresponding to striped bass fishing effort, the harvest of striped bass

Table 3. Estimated Annual Harvest of Striped Bass from Albemarle Sound by Sport Fishermen during the Period 1 February 1977 through 31 January 1980 by Zone

Zone	Harvest[a]						Mean	
	Feb. '77–Jan. '78		Feb. '78–Jan. '79		Feb. '79–Jan. '80			
I (Currituck Sound)	0	(0)	0	(0)	0	(0)	0	(0)
	0	(0)	0	(0)	0	(0)	0	(0)
II (Roanoke & Croatan S.)	4,434	(±4,321)[b]	246	(±270)	685	(±750)	1,788	(±1,465)
	2,820	(±2,568)	301	(±330)	489	(±536)	1,203	(±881)
III (Eastern Albemarle S.)	4,509	(±2,250)	3,054	(±3,087)	0	(0)	2,521	(±1,273)
	3,766	(±1,869)	3,085	(±2,927)	0	(0)	2,284	(±1,158)
IV (Central Albemarle S.)	1,387	(±924)	6,583	(±3,621)	3,332	(±2,945)	3,767	(±1,586)
	1,188	(±868)	9,229	(±5,156)	2,399	(±2,076)	4,272	(±1,875)
V (Western Albemarle S.)	17,497	(±9,050)	3,066	(±759)	1,567	(±709)	7,377	(±3,036)
	19,756	(±10,127)	3,203	(±872)	2,210	(±1,010)	8,390	(±3,405)
VI (Chowan River)	4,774	(±2,806)	1,073	(±1,149)	110	(±85)	1,986	(±1,011)
	5,672	(±3,186)	779	(±827)	137	(±106)	2,196	(±1,098)
Total	32,600	(±7,865)	14,023	(±6,441)	5,694	(±3,325)	17,439	(±3,565)
	33,202	(±8,753)	16,599	(±8,199)	5,235	(±2,702)	18,345	(±4,098)

[a] Includes both daytime and nighttime harvest.
[b] The top figures are kilograms and the bottom figures are number of fish in each set. Standard errors are in parentheses.

was highest during October and November. Lesser harvests of striped bass were made during August, September, December, and January.

The success rate of daytime Albemarle Sound sport fishermen for striped bass, based on total effort expended, decreased from 0.070 fish per party-hour in 1977–78 to only 0.012 fish per party-hour in 1979–80. Effort expended to catch each striped bass increased from 14.3 party-hours (32.9 angler-hours) in 1977–78 to 83.3 party-hours (170.0 angler-hours) in 1979–80. Estimate of success for those anglers who fished specifically for striped bass could be calculated only for Zone V, but in that zone the success rate declined from 0.40 striped bass per party-hour in 1977–78 to 0.30 striped bass per party-hour in 1979–80.

Sport fishermen caught an estimated average of 55,924 largemouth bass weighing 40,457 kg per year from the study area (Table 4). Largemouth bass harvest was approximately equal during the first 2 years of the study, but it increased greatly during the final year. The success rate for largemouth bass ranged from 0.037 fish per angler-hour to 0.105 fish per angler-hour. If the assumption is made that all largemouth bass were caught by anglers fishing specifically for them, the success rate ranged from 0.179 bass per angler-hour in 1977–78 to 0.284 fish per angler-hour in 1979–80. Throughout the course of the study, largemouth bass anglers required from 3.5 to 5.6 angler-hours of fishing effort for every bass caught.

Sunfish harvest did not vary dramatically throughout the study. Sport fishermen harvested an estimated average of 154,790 sunfish, excluding crappie (*Pomoxis* sp.) and largemouth bass, weighing 25,195 kg per year (Table 4).

An estimated average of 64,450 channel catfish (*Ictalurus punctatus*), weighing 38,828 kg was harvested per year (Table 4). Channel catfish harvest also did not exhibit any dramatic fluctuation, although it did decline somewhat in the final 2 years of the study from the 1977–78 level.

Crappie harvest declined by over 90,000 fish from 1977–78 to 1978–79 but increased slightly in 1979–80. The sport harvest of crappies averaged 50,456 fish and 12,968 kg per year (Table 4).

The harvest of white perch by sport anglers declined drastically throughout the 3 years from 398,693 fish in 1977–78 to only 69,837 fish in 1979–80 (Table 4). The estimated annual white perch harvest averaged 198,904 fish weighing 32,263 kg.

Sport harvest of white catfish (*Ictalurus catus*) remained relatively low throughout the study. Anglers caught an average of only 1,636 white catfish weighing 1,146 kg per year (Table 4).

The harvest of both weakfish (*Cynoscion regalis*) and spotted seatrout (*C. nebulosus*) was restricted to Zone II which included Roanoke and Croa-

Table 4. Estimated Total Harvest of 8 Major Fish Species and all Other Species from Albemarle Sound during the Period 1 February 1977 through 31 January 1980

Species	Harvest[a]							
	Feb. '77–Jan. '78		Feb. '78–Jan. '79		Feb. '79–Jan. '80		Mean	
Largemouth bass	31,286	(±7,718)	27,193	(±9,122)	62,893	(±26,286)	40,457	(±9,629)
	39,519	(±8,282)	39,547	(±18,129)	88,705	(±40,438)	55,924	(±15,028)
Sunfish	25,241	(±16,992)	35,116	(±30,664)	15,229	(±9,735)	25,195	(±12,128)
	162,023	(±112,679)	168,393	(±127,234)	133,955	(±89,482)	154,790	(±64,024)
Channel catfish	50,527	(±23,028)	34,479	(±18,580)	31,479	(±11,304)	38,828	(±10,558)
	86,653	(±53,116)	45,008	(±22,854)	61,690	(±28,450)	64,450	(±21,481)
Crappie	26,793	(±14,494)	3,891	(±1,028)	8,219	(±2,973)	12,968	(±4,944)
	109,481	(±76,323)	14,546	(±3,748)	27,340	(±7,283)	50,456	(±25,587)
White perch	70,652	(±39,745)	18,955	(±9,083)	7,182	(±2,515)	32,263	(±13,616)
	398,693	(±211,042)	128,182	(±62,315)	69,837	(±25,318)	198,904	(±73,834)
White catfish	935	(±869)	1,758	(±1,832)	746	(±377)	1,146	(±687)
	1,251	(±1,149)	1,598	(±1,590)	2,058	(±1,136)	1,636	(±756)
Weakfish	15,897	(±12,644)	3,084	(±1,657)	349	(±382)	6,443	(±4,253)
	58,379	(±57,723)	7,802	(±3,750)	1,162	(±1,273)	22,448	(±19,286)
Spotted sea trout	10,458	(±6,438)	1,653	(±908)	9	(±10)	4,040	(±2,167)
	17,055	(±9,202)	2,335	(±1,283)	30	(±33)	6,473	(±3,097)
Other species	135,177	(±84,508)	15,831	(±8,916)	10,629	(±9,244)	53,879	(±28,493)
	440,972	(±281,030)	63,172	(±31,951)	43,352	(±41,406)	182,499	(±95,285)

[a] Includes both daytime and nighttime harvest.
[b] The top figures are kilograms and the bottom figures are numbers of fish ineach set. Standard errors are in parentheses.

tan sounds. The harvest of these species was relatively high in 1977–78, but declined drastically throughout the following 2 years. Anglers caught an estimated average of 22,448 weakfish weighing 6,443 kg per year. Spotted seatrout harvest averaged 6,473 fish and 4,040 kg per year (Table 4).

The harvest of all other species by sport anglers also declined from a high of almost 441,000 fish in 1977–78 to only about 43,000 fish in 1979–80 (Table 4). The estimated harvest of other species averaged 182,499 fish weighing 53,879 kg per year. Most of those fish were caught in Zone II and were composed of marine or estuarine species, primarily croakers (*Micropogon undulatus*).

Drifting and bait casting were the 2 most popular fishing methods used by Albemarle Sound sport anglers in the daytime (Table 5). The use of natural or artificial baits was almost equal among daytime anglers (Table 5).

Over half the fishing parties interviewed during the daytime lived in 1 of the counties bordering Albemarle Sound or its tributaries (Area Resident). Approximately ⅓ of the anglers interviewed were residents of other North Carolina counties (State Resident). Only about 10% of the anglers were not North Carolina residents (Table 5).

Approximately ½ of the fishing parties interviewed at night used trolling as their primary fishing method, and most of them favored artificial bait (Table 6). As in the case of daytime fishermen, ½ of the nocturnal anglers were residents of a county bordering Albemarle Sound. However, almost all of the rest were North Carolina residents from counties that did not border on Albemarle Sound. Very few nighttime anglers were residents of states other than North Carolina.

Table 5. Angler Residence Status and Fishing Techniques Used by Daytime Sport Fishermen on Albermarle Sound and its Tributaries during the Period 1 February 1977 through 31 January 1980

	Percentage of Parties Interviewed			
	Feb. '77–Jan. '78	Feb. '78–Jan. '79	Feb. '79–Jan. '80	Mean
Method—Anchored	14	19	20	18
—Bait Casting	33	33	47	38
—Drifting	35	34	21	30
—Trolling	18	14	12	14
Bait—Natural	51	52	44	49
—Artificial	49	48	56	51
Origin—Area Resident	54	48	58	53
—State Resident	36	42	31	36
—Nonresident	10	10	11	11

Table 6. Angler Residence Status and Fishing Techniques Used by Nighttime Sport Fishermen on Albemarle Sound and its Tributaries during the period 1 February 1977 through 31 January 1980

	Percentage of Parties Interviewed			
	Aug.–Oct. 1977	May–Oct. 1978	May–Oct. 1979	Mean
Method—Anchored	0	18	32	17
—Bait Casting	0	34	29	21
—Drifting	12	17	5	11
—Trolling	88	31	34	51
Bait—Natural	9	46	37	31
—Artificial	91	54	63	69
Origin—Area Resident	74	49	39	54
—State Resident	26	46	61	44
—Nonresident	0	5	0	2

Discussion

The primary purpose of this study was to investigate the sport fishery for striped bass in Albemarle Sound and its tributaries. All stratification and assignment of access area and zone probabilities in scheduling of creel clerk work assignments were made toward achieving this purpose. Therefore, generated estimates dealing directly with striped bass harvest and effort are probably more accurate and reliable than those dealing with other species.

The mean annual 447,242 party-hours of estimated total effort (daytime and nighttime effort combined) exerted on Albemarle Sound is equivalent to 968,581 angler-hours of effort per year. Therefore, approximately 1.76 party-hours or 3.82 angler-hours of sport fishing effort were exerted per hectare per year. Currituck Sound and Chowan River, the 2 most heavily fished zones in the study area, supported averages of 1.89 party-hours per ha and 8.46 party-hours per ha of effort per year, respectively. Speir et al. (1977) estimated that a 582 sq. mi. section of Maryland's portion of Chesapeake Bay received 15.29 party-hours per ha of sport fishing pressure during the period May 12 through October 27, 1976.

The individual zone supporting the highest amount of sport fishing effort shifted from Currituck Sound in 1977–78 to Chowan River in 1978–79 and back to Currituck Sound in 1979–80. Both of these areas have a reputation for excellent largemouth bass fishing. Very heavy algal blooms were present in the Chowan River and western Albemarle Sound during the spring and summer months of 1979, and this may have influenced the shift in pressure back to Currituck Sound. Algal blooms in the western portion of the

study area may also account for the decrease in fishing pressure in the 4 most western zones and the increase of pressure in the 2 eastern zones during the last year of the study (Table 1).

Largemouth bass was the single species for which most effort was expended by Albemarle Sound and tributary sport fishermen (Table 2). Effort for this species increased throughout the study. Fish (1974) also determined that the largemouth bass was the most sought after freshwater game fish in the coastal plain of North Carolina in 1970–71. More kilograms of largemouth bass were harvested from Albemarle Sound than any other species (Table 4).

White perch was the third most popular species with sport fishermen during the initial 2 years of the study, but it dropped to fifth in specific effort exerted in 1979–80 (Table 2). This drop in specific effort was accompanied by a corresponding 82% decline in the number of white perch harvested (Table 4). The decline in white perch abundance was also reflected in a dramatic decline in the commercial harvest of this species (Scott Keefe, pers. commun.). The drastic decline in the number of white perch in the Albemarle Sound population and the harvest was possibly due to poor water quality and the resulting algae blooms and outbreaks of red sore disease that plagued the area. Epizootic red sore disease was blamed for the deaths of up to 95% of the white perch population in Albemarle Sound during the mid to late 1970's (Esch and Hazen 1980).

The importance of striped bass to Albemarle Sound anglers was demonstrated by the high amount of sport fishing effort that was specifically exerted for it, even in the face of drastically declining catches (Table 2). Striped bass was the second most sought after fish species during all 3 years of data collection.

Zone V supported the greatest sport fishing effort specifically for striped bass in 1977–78. However, it seemed that much of this effort shifted to other zones in the following year, particularly zones VI, IV, and III. In the final year of the study, 1979–80, the greatest amount of striped bass fishing pressure was exerted in Zone III. Again, dense algal blooms in the western portions of Albemarle Sound during summer and fall months are suspected as a factor in influencing the shift in specific effort for striped bass to the east, probably in response to a similar movement by the fish. Specific effort also increased in Zone VI, but most of the striped bass effort in this zone was exerted during March, April, and May when the fish were concentrated in this area before and after their spawning migration up the Roanoke River and before dense algal blooms appeared.

Sport fishermen harvested an estimated average of 18,345 striped bass from Albemarle Sound per year from 1 February 1977 through 31 January 1980 (Table 3). Estimates of the Albemarle Sound sport catch of striped

bass by Hassler et al. (1981) were never less than 49,000 fish from 1967 through 1970. However, harvest estimates in the early 1970s declined from 41,000 striped bass in 1971 to only about 31,000 fish in 1973. It was estimated the sport harvest of striped bass was 33,202 fish from 1 February 1977 through 31 January 1978, and it declined each succeeding year of the study. The 5,235 fish harvest in 1979–80 was less than 10% of the estimated annual harvest in the late 1960's.

The decline in striped bass sport harvest from that of the late 1960's has occurred in almost every zone (Fig. 2). Only in zones V and VI did the 1977–78 harvest of striped bass exceed that of the late 1960's. In addition, the 1978–79 harvest in Zone IV exceeded that of the previous year. In all other cases, striped bass harvest declined in each zone with each succeeding year of our study and from that of the late 1960's.

In the late 1960's, zones II and III supported the bulk of the striped bass harvest (Fig. 2). However, during this study, Zone II was one of the areas of lowest striped bass harvest. The striped bass catch was highest in Zone V in 1977–78, but in 1978–79 and 1979–80 catch was greatest in Zone IV.

October and November were months for peak striped bass harvest in 1967 through 1973 (Hassler et al. 1981), and this trend continued in the late 1970's.

Striped bass harvests by both sport and commercial fishermen from Roanoke River and the commercial fishery from Albemarle Sound were estimated by Dr. W. W. Hassler and the N. C. Division of Marine Fisheries, respectively (Table 7). Hassler made his estimate in numbers of fish, and the Division of Marine Fisheries estimated only the weight of the Albemarle Sound commercial harvest. Since there is no data available on the average weight per fish from either source, their estimates cannot be directly compared. However, the Albemarle Sound sport harvest was estimated in both numbers and weight, so it can be compared individually with both Hassler's and Division of Marine Fisheries' estimates.

Like the Albemarle Sound sport harvest of striped bass, the commercial harvest from the sound also declined steadily and drastically throughout the study period (Table 7). The 1979–80 harvests by each of the Albemarle Sound fisheries is only 17% of the respective 1977–78 harvests by weight. Throughout the 3 years of the study, the sport harvest of striped bass from Albemarle Sound remained a relatively constant 10 to 11% of the commercial harvest.

Harvest of striped bass by the sport and commercial fisheries from the Roanoke River remained relatively stable throughout the study (Table 7). The sport fishery in the river fluctuated by only about 15% throughout the course of the study, and the 1979–80 harvest was higher than that in

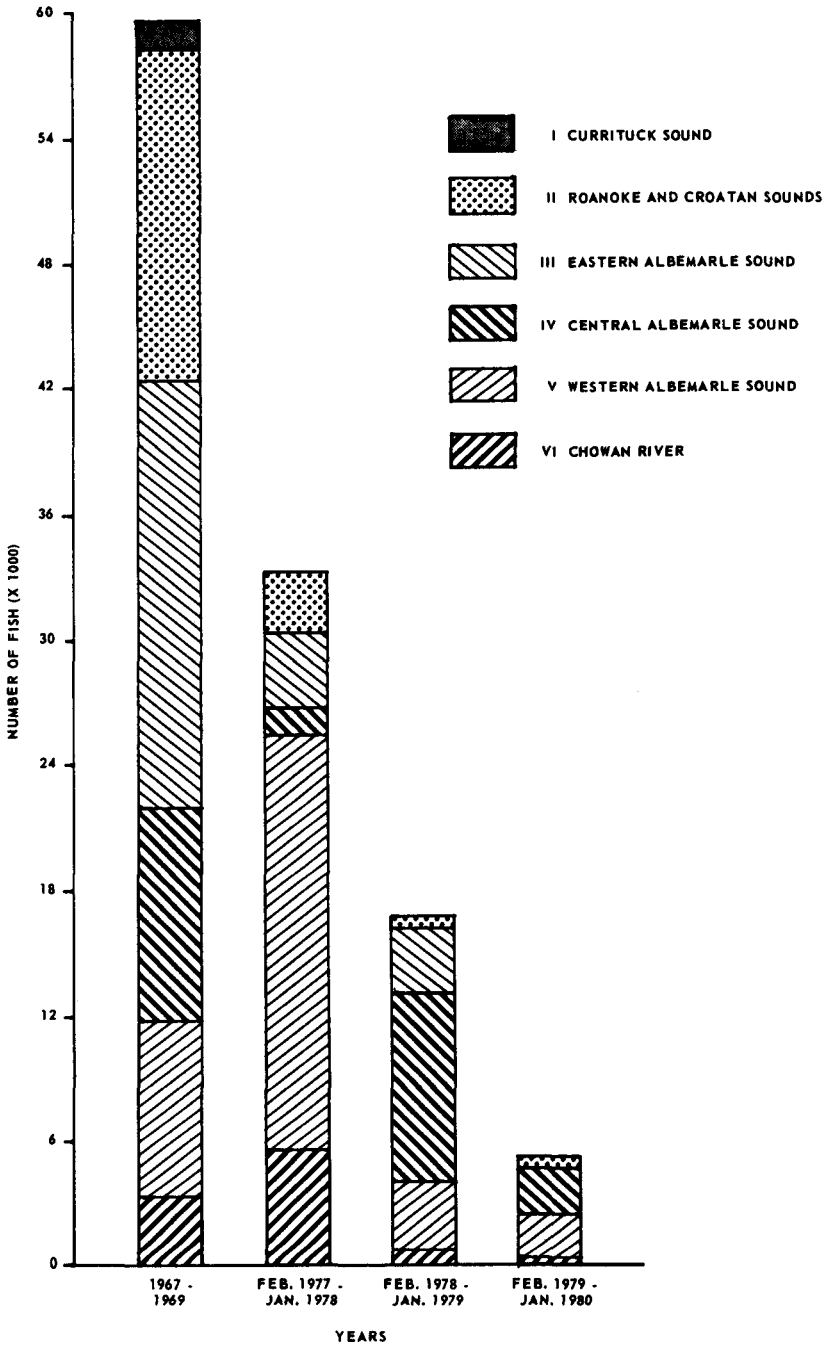

Figure 2. Total estimated number of striped bass caught by sport fishermen in Albemarle Sound and tributaries (except Roanoke River) by zone. Mean of annual catches for 1967–1969 from Hassler and Hogarth (1970).

Table 7. Total Estimated Annual Harvests of Striped Bass by Sport and Commercial Fishermen from Albemarle Sound and Roanoke River during the Period 1 February 1977 through 31 January 1980

	Harvest of Striped Bass		
	Feb. '77–Jan. '78	Feb. '78–Jan. '79	Feb. '79–Jan. '80
Roanoke River—Sport	32,983 fish[a]	28,016 fish[a]	29,419 fish[a]
Roanoke River—Commercial	10,465 fish[a]	16,253 fish[a]	9,798 fish[a]
Albemarle Sound—Sport	32,600 k	14,023 k	5,694 k
	33,201 fish	16,599 fish	5,235 fish
Albemarle Sound—Commercial	308,876 k[b]	139,210 k[b,c]	53,270 k[c,d]

[a] From Hassler et al. (1981).
[b] From Johnson et al. (1979).
[c] From Johnson and Hassler (1980).
[d] From Keefe and Hassler (1981).

1978–79. The Roanoke River commercial catch varied considerably more, but the 1979–80 harvest was only 690 fish, or 7% less than the 1977–78 harvest. The 1977–78 Albemarle Sound sport catch of striped bass was almost equal to the Roanoke River sport catch for that year, but in 1979–80, the sport harvest from Albemarle Sound was less than 18% of that from the river. In 1977–78, the Albemarle Sound sport harvest was 3 times that of the Roanoke River commercial harvest, but in the following year, catches were almost equal. By 1979–80, commercial harvest from the Roanoke River was almost double the Albemarle Sound sport catch. The Roanoke River commercial catch ranged from 32 to 58% of the sport catch in the river throughout the study period.

Harvests of striped bass by both fisheries from the Roanoke River remained relatively constant over the 3-year period. In contrast, harvests by both Albemarle Sound fisheries declined steadily during the same period and were reduced by 83%.

The difference in harvest trends between the 2 locations is indicative of the different age groups upon which the respective fisheries operate. The Albemarle Sound fisheries concentrate on younger, newly recruited striped bass that tend to move and feed in large schools. This schooling behavior serves to concentrate the fish and make them highly visible, and they are thus much more vulnerable to both sport and commercial fisheries.

The decline in Albemarle Sound harvests is probably indicative of a decline in the number of young striped bass produced in the mid to late 1970's. Hassler et al. (1981) documented decreases in egg viability on the Roanoke River spawning grounds beginning in 1975 and progressively declining in succeeding years. Egg viability ranged from 80 to 96% prior to 1975 but dropped to 56% in 1975 and reached a low of only 38% in 1978.

Viability rebounded slightly to 43% in 1979 and 1980. Preliminary studies by Guier and Mullis (1982) indicate that declining viability may be related to heavy metal and organochlorine contamination in the tissues of spawning females.

Hassler et al. (1981) also documented a decrease in the abundance index of juvenile striped bass in the western Albemarle Sound nursery area beginning in 1977. Juvenile abundance indices in the years following 1977 were among the lowest on record. In addition to the decrease in egg viability, a decline in water quality and the prolificness of blue-green algae blooms in western Albemarle Sound may be partly responsible for reproductive failures of striped bass in this area. Algae blooms may have created a shift in the populations of zooplankton from species upon which juvenile striped bass are dependent for forage to less preferred species, thereby leading to starvation of young fish. Algae species composing the blooms are known to produce enzymes which can be toxic to fish, and the blooms cause a tremendous oxygen demand which serves to further stress fish if it does not contribute directly to mortality. Numerous fish kills have been documented in association with these algae blooms. Blooms also appear to occur coincidentally with epidemics of red sore disease, a bacterial infection of fish which has been implicated in the mortality of numerous fish species in widely separated locations of the southeastern United States (Esch and Hazen 1980). Stress, induced by algae blooms and poor water quality, renders fish highly susceptible to the bacteria. Esch and Hazen (1980) found high levels of the responsible bacteria in Welch Creek. Weyerhaeuser's Plymouth Plant discharges pulp mill effluent into Welch Creek which flows into Roanoke River very near the western end of Albemarle Sound.

In contrast to the harvest of relatively young striped bass by the Albemarle Sound fisheries, both sport and commercial fisheries on the Roanoke River primarily concentrate on older, mature striped bass as they ascend the Roanoke River during their spawning migration. As male striped bass mature at approximately 2 years of age and females mature at 4 to 5 years, the spawning failures of 1977, 1978, and 1979 were not detected as reduced numbers of fish in the spawning run and the river harvests until as late as 1980. The number of striped bass in the spawning migration are expected to decline also in the near future, and thus the harvest by the river fisheries will also be reduced.

Literature Cited

Esch, G. W., and T. C. Hazen. 1980. The ecology of *Aeromonas hydrophila* in Albemarle Sound, North Carolina. Rep. 153. Water Resour. Res. Inst., Univ. of N.C., Raleigh. 116pp.

Fish, F. F. 1974. The sport fishery statistics from the inland fishing waters of North Carolina 1970–1971. Proj. F-14-R, Final Rep. N.C. Wildl. Resour. Comm., Raleigh. 31pp.

Guier, C. R., and A. W. Mullis. 1982. Investigations of egg and larval mortalities in Roanoke River striped bass. Proj. F-22-R, Study VII, Final Rep. N.C. Wildl. Resour. Comm., Raleigh. 38pp.

Hassler, W. W., and W. T. Hogarth. 1970. The status, abundance, and exploitation of striped bass *Roccus saxatilis* in the Roanoke River and Albemarle Sound, North Carolina. Completion Rep. Proj. AFC-1. Div. of Mar. Fish., N.C. Dept. of Nat. Resour. and Commun. Dev., Morehead City, N.C. 63pp.

Hassler, W. W., N. L. Hill, and J. T. Brown. 1981. The status and abundance of striped bass, *Morone saxatilis,* in the Roanoke River and Albemarle Sound, North Carolina, 1956–1980. Spec. Sci. Rep. 38. Div. of Mar. Fish., N.C. Dept. of Nat. Resour. and Commun. Dev., Morehead City, N.C. 156pp.

Johnson, H. B., H. W. Stevens, and W. W. Hassler. 1979. Cooperative management program for Albemarle Sound-Roanoke River striped bass. Annu. Prog. Rept., Proj. AFS-14, Seg. 2. Div. of Mar. Fish., N.C. Dept. of Nat. Resour. and Commun. Dev., Morehead City, N.C. 62pp.

Johnson, H. B., and W. W. Hassler. 1980. Cooperative management program for Albemarle Sound-Roanoke River striped bass. Annu. Prog. Rep., Proj. AFS-14, Seg. 3. Div. of Mar. Fish., N.C. Dept. of Nat. Resour. and Commun. Dev., Morehead City, N.C. 21pp.

Keefe, S. G., and W. W. Hassler. 1981. Cooperative management program for Albemarle Sound-Roanoke River striped bass. Annu. Prog. Rep., Proj. AFS-14, Seg. 4. Div. of Mar. Fish., N.C. Dept. of Nat. Resour. and Commun. Dev., Morehead City, N.C. 28pp.

Speir, H. J., D. R. Weinrich, and R. S. Early. 1977. 1976 Maryland Chesapeake Bay sport fishing survey. Completion Rep., Proj. F-32-R. Fish. Admin., Md. Dept. of Nat. Resour., Annapolis. 99pp.