Fisheries Session

Movements and Impingements of Juvenile Spot

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Abstract: Spot (*Leiostomus xanthurus*) comprised 35.9% of the 92,823 trawl-caught fish at 8 stations in the vicinity of a power plant on the Cape Fear River estuary, North Carolina. Monthly length frequency determinations of trawl-caught spot showed the major size mode progressed from about 4 to 10 cm from April 1975 to December 1975. The highest catches per unit of effort during the 2-year study were in the intake canal of the power plant. Of 982 spot tagged in the intake canal, 161 were returned and 9.4% of these were impinged on intake screens. The rate of impingement was highest for those released nearest to the intake structure and least for those released at greater distances.

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Spot (*Leiostomus xanthurus*) are abundant and important as a commercial and recreational species. They occur in estuaries and nearshore areas from Cape Cod to Texas and are often the most frequent species captured in trawl samples. It is postulated that spot spawn offshore or in sounds and inlets (Smith 1907, Dawson 1958) and that the larvae are transported to estuaries by tide and wind currents. The presence of high concentrations of postlarvae in bays, estuaries, and lagoons indicate that primary spawning, which may vary with location, occurs in December through February. However, some postlarvae are present from November through April (Welsh and Breder 1923, Pearson 1929, Hildebrand and Cable 1930, Gunter 1945). Dawson (1958) believed that spot remained in nursery grounds until the end of their second summer before beginning a gradual movement to the sea for spawning. Movement rates of juvenile spot between adjacent tidal creeks in a 40-day period was reported to be relatively insignificant (Weinstein and O'Neil 1986). The juveniles which occur in waters with wide salinity ranges are largely benthic feeders and eat a variety of organisms but particularly harpacticord copepods (Stickney et al. 1975, Hodson et al. 1981).

Conclusions regarding the distribution and growth of juvenile spot have been based largely on fish caught in trawls. Length frequency determinations indicated

that first-year modal peak was approximately 120 mm fork length (Pacheco 1962a) and 93 to 109 mm total length (Parker 1971). McCambridge and Alden (1984) reported first year growth in a James River estuary to be 148 mm standard length, and they concluded, based upon the weight-length relationship, that the Chesapeake Bay system provides an optimum environment for growth of 0–year class fish. Otolith examinations by Beckman and Dean (1984) of spot captured in North Inlet Estuary, South Carolina, showed hatching dates were between late November 1980 to mid-February 1981. They also reported 3 separate cohorts were recruited at approximately monthly intervals into Town Creek and recruitment took place approximately 2 months after their estimated date of hatch. Growth of individuals did not vary with their location in Town Creek and adjacent intertidal areas. Since fish populations may be influenced by withdrawals of water through power plants, we attempted to determine how spot populations might be affected by operation of a steam electric plant in the estuary of the Cape Fear River, North Carolina.

Field collections were conducted by Christopher Benedict, Richard Barmore, Todd Johnson, and David Ruple. Funds were provided by a contract between North Carolina State University and Carolina Power and Light Company, B. J. Copeland, Project Leader. The work was supervised by the North Carolina Cooperative Fishery Research Unit, which is jointly supported by North Carolina State University, North Carolina Wildlife Resources Commission and the U.S. Fish and Wildlife Service.

Methods

Study Area

The Cape Fear River estuary is about 20 km long, 1.6 to 3.6 km wide, and has extensive marshes and tidal flats; the substrates are soft mud, hard sand, and shell. The sampled area was 11 km north of Southport, North Carolina, near Snows Marsh and Walden Creek (Fig. 1).

The intake canal of the power plant is about 4.8 km long, 5.5 m deep, and 100 m wide and moves water to a once-through cooling system. The channel is perpendicular to the ship canal near the center of the river; it crosses Snows Marsh near the mouth of Walden Creek and crosses marshes and highlands adjacent to the plant. When the 2 821-megawatt generating units are operated, water is pumped through the plant at the rate of about 63 m^3/second.

Surface salinities in the mixed estuary ranged from 11.1 to 35.0% and were lowest in August and highest in September and December (Carpenter 1971). Surface water temperatures were highest in July (30.0°C) and lowest in January (4.5°C) (N. Marshall. Unpubl. rep., Univ. of N.C., Chapel Hill 1951). Mean tidal currents were 1.5 knots and the average tidal amplitude about 1.4 m (Wilder 1967). Occurrences and relative abundances of spot and other species in this area have been reported by Copeland et al. (1979), Hodson and Birkhead (1979), and Geaghan (1980).

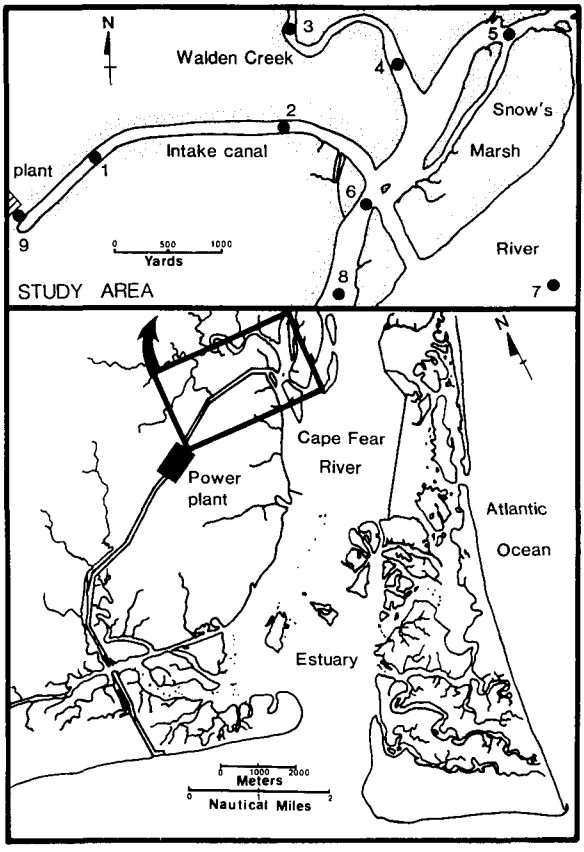

Figure 1. Cape Fear River estuary and locations of sample stations and power plant.

Sampling Procedure

Trawl and gill net data were collected at 8 stations during 2 years of study (January 1975 to December 1976). The gill nets were 91 m long, 1.8 m deep, graded-mesh (experimental) consisting of equal lengths of 4 meshes (2.54, 3.81, 5.08, and 6.35 cm bar measure) and constructed of No. 104 monofilament nylon. The nets were set on the bottom parallel with the current. Each 24-hour set was considered a unit of effort. Trawls were 0.76 m deep with mouths 3 m wide. The bar mesh size was 1.9 cm in the body and 0.63 cm in the cod end. They were towed at a constant speed with the current by a boat equipped with an 85-horsepower outboard motor for 10 minutes (each such tow constituted a unit of effort).

Eight stations (Fig. 1) were each sampled 6 times monthly on a rotating day basis except that the schedule was occasionally interrupted by unfavorable weather. Salinity, water temperature, tide stage, and weather conditions were determined at the time of sampling. Fish were measured (standard length), and those tagged were released at the capture site. Serially numbered Floy tags were used in January and

February 1975, and Petersen tags thereafter. A reward of $2 was paid for return of the tags. Impinged fish were examined weekly at the rotating intake screens of the power plant.

Results and Discussion

Of 92,823 fish caught in trawls, 35.9% were spot and 6.4% of 66,296 caught in gill nets were spot. The monthly catches per unit effort (CPUE) in trawls and gill nets at all stations were highest in April through July 1975, January through May 1976, and November and December 1976. The lowest trawl catch rates were in September and October 1975. The lowest CPUE's in the gill nets were July through September 1975 and April through August 1976.

There were major year, season, and station differences of trawl CPUE during the 2 years. However, the highest mean CPUE for the entire period occurred at stations 1 (63.9) and 2 (59.6) in the intake canal. The lowest CPUE's were at station 7 (7.2) and stations 3 and 4 (16.7 and 2.0) in Walden Creek. In 1976 highest CPUE's were at stations 2 and 5 and at stations 1 and 2 in 1976. Highest total catch was in 1976. The data showed that spot, although more abundant at some stations and less so at others, were not necessarily limited to restricted areas in the estuary. However, the stations which exhibited the lowest catches (7, 3, 4) were characterized by sand, sand-shell, and hard mud substrates. The nature of these substrates suggest that currents at those stations were strong relative to stations with silt substrates and with higher CPUE's (1, 2, 5) of spot (Table 1).

The monthly modal peaks of spot measurements (Fig. 2) indicated progressive increases of the modal classes occurred. The major length mode in January 1975 was composed of juveniles about 10 cm long. By April the catch of smaller fish greatly increased and the proportions of the larger fish declined, perhaps due to their escape from the trawls or to emigration. The major length group in April 1985 was approximately 4 cm. In subsequent months this mode progressively increased to about 7 cm in July and to 10 cm in December 1975. The length mode pattern of the 1975 year class was nearly repeated by the 1976 year class although the numbers caught in January to March 1976 far exceeded those of 1975 suggesting stronger recruitment in 1976.

The smallest length mode detected in the gill net catches was 16 cm. This mode did not progressively increase probably because the gill nets were size selective. The next larger length mode in gill nets was about 21 cm and it progressively increased from July 1975 through April 1976. Due to unknown escape rates of larger fish from trawls and lack of small fish in gill nets, the data are not considered useful for assigning year classes to the larger fish.

Monthly CPUE of spot 18 cm long or longer in gill nets and CPUE of spot <18 cm long in trawls both increased and decreased in approximately the same months, suggesting that their presence or absence was due to factors other than size and age.

We tagged 2,111 spot at the eight stations of which 226 (10.7%) were returned

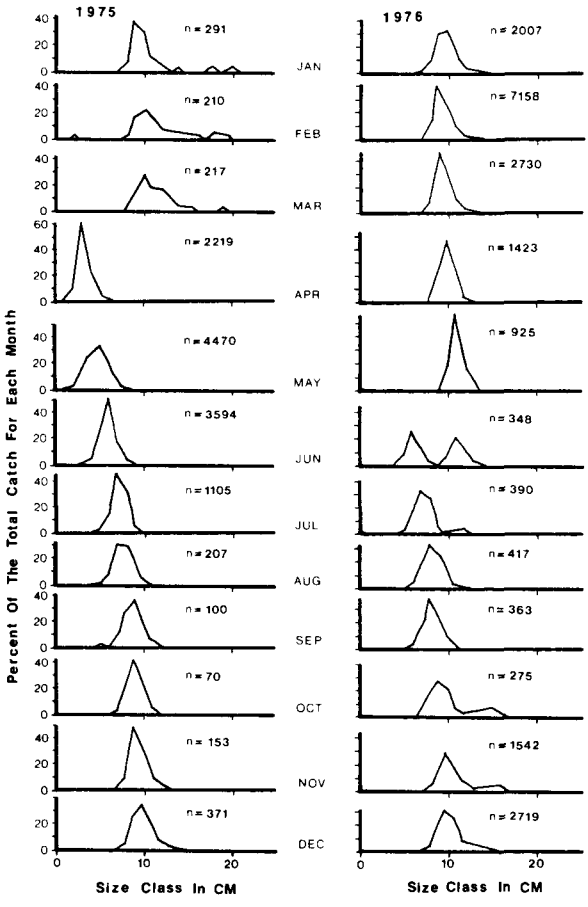

Figure 2. Length frequency of spot captured by trawls in 1975 and 1976, Cape Fear River Estuary.

Table 1. Catch of spot per unit of trawl and gill net effort at each station in 1975 and 1976, Cape Fear River Estuary, North Carolina.

	Trawl			Gill Net		
Station	1975	1976	Units of effort	1975	1976	Units of effort
1	16.5	110.6	145	9.2	5.6	144
2	48.2	69.9	152	5.2	6.1	144
3	16.9	16.4	144	0.2	0.4	144
4	2.5	1.5	144	0.5	0.7	143
5	23.8	24.7	144	1.2	1.5	145
6	19.5	21.6	143	1.4	4.0	143
7	4.6	9.8	142	3.6	13.1	143
8	.0	16.2	154	0.9	5.2	144
All stations	22.6	34.2	1,168	2.8	4.6	1,150

Table 2. Numbers of tagged spot released in four areas and percentages returned from the areas and the intake screens.

Area of release and stations	Number tagged	Area of recovery Station numbers: Intake canal (1, 2)	Snows Marsh (5, 6, 8)	Walden Creek (3, 4)	East Side (7)	Intake screens	Other	Total
Intake canal (1, 2)	982	5.0	0.4	0.1	0.0	9.4	1.5	16.4
Snows Marsh (5, 6, 8)	612	1.8	3.1	0.0	0.0	1.6	1.5	8.0
Walden Creek (3, 4)	106	0.9	0.9	0.0	0.0	0.2	4.7	8.5
East Side (7)	411	0.0	0.5	0.0	1.0	0.0	0.2	1.7
All areas	2,111	2.9	1.2	0.05	0.2	4.9	1.4	10.7

(Table 2 and Fig. 3). Of 982 released in the intake canal, 161 tags were recovered. Of the 161, 49 were recaptured by us in the canal and 5 at other stations. None were returned from the east side of the river. Fifteen (1.5%) were returned by commercial fishermen, other researchers, or sport fishermen from sites other than our stations. The remainder (9.4%) were recovered from the intake screens. Fewer returns occurred as the distances increased from the place of release.

The greatest numbers of tagged spot recovered were impinged on the intake screens and the rate of recovery of these was highest for those released nearest to the intake structure and progressively lower for those released at greater distances. Recovery from the screens for fish released in the canal was 9.4%, 1.6% for those released at Snows Marsh, 0.2% for Walden Creek and none for fish released at the East Side station (Table 2). Since impingement data were obtained by examining the intake screens 1 day per week a 7X projection may approximate the extent of impingement. Based on such a projection, 65% of the spot released in the intake canal may have been impinged, 11% of those from Snows Marsh, 1.5% of those from Walden's Creek, and none from the East Side. The total impingement estimates at this site were similarly projected in 1974 and 1975 (MacPherson 1977).

The coefficient of correlation (r) values for CPUE of spot in the trawls at stations 1 and 2 and all stations combined and the numbers impinged per month were highly significant (<0.01). A comparison of the lengths of spot tagged at stations 1 and 2 with the lengths of those recovered from the intake screens showed that they were similar.

Over 50% of the tagged spot were recaptured within 10 days after their release and, summed by 10-day intervals, fewer and fewer were returned. By the 60th day, nearly all recaptures had been made. The fact that most fish recaptured were taken near their point of release suggests that they generally do not range over large areas in short periods. However, the rapid decline of recaptures suggests that over longer periods appreciable movements or mortalities occur. Pacheco (1962*b*) indicated that summer movements of spot were limited in the tributaries of Chesapeake Bay, al-

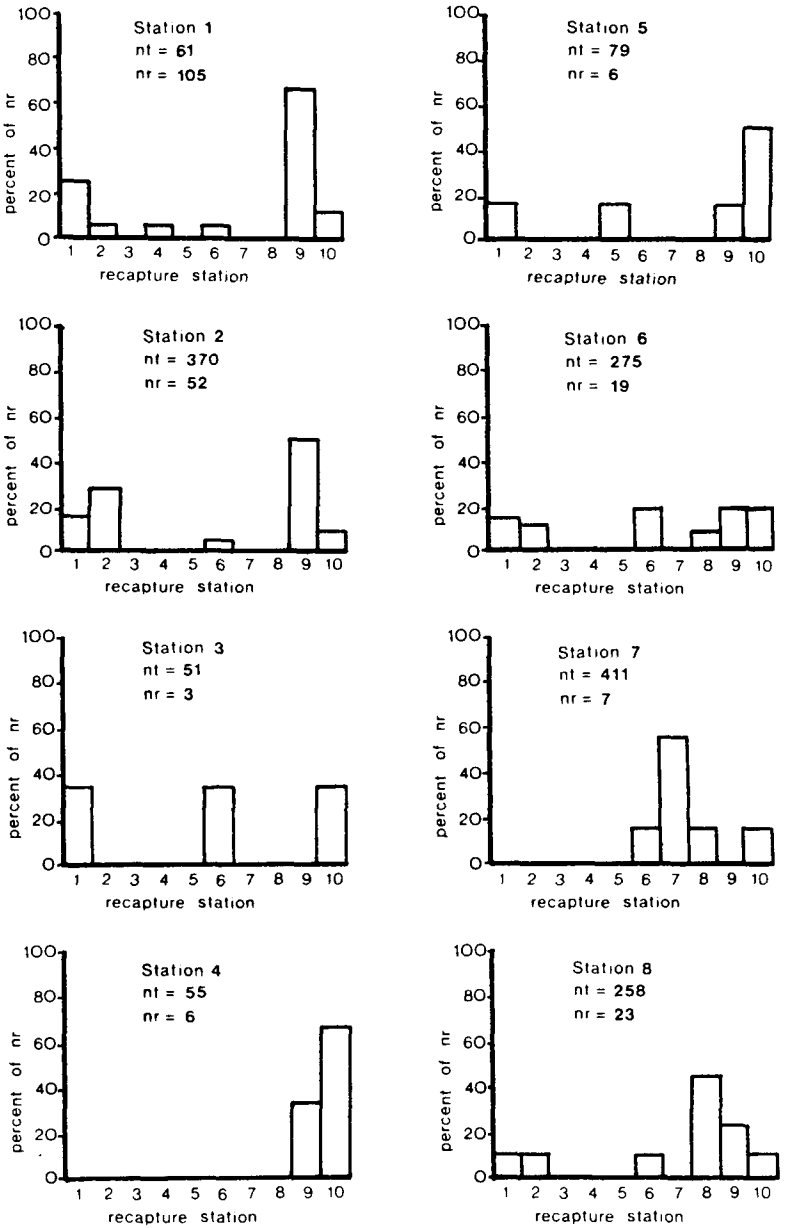

Figure 3. Numbers and locations of spot tagged and percent recaptured from each station (St.), Number returned (nr), number tagged (nt), intake screen (9), other areas (10).

though 2 of his fish were captured by trawlers near Cape Hatteras, North Carolina, in winter.

The relative high catch of spot in the intake canal during winter months suggested that they moved to the deeper water in the intake canal as well as to oceanic areas during cold weather. The habitat afforded by the intake canal appeared to encourage higher densities of spot, and they thus may have been subject to impingement due to their proximity to the intake structure. Impingement would probably be reduced by altering the canal habitat to one less attractive to spot or by preventing the fish from entering the canal.

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