A DESCRIPTION OF YOUNG ATLANTIC MENHADEN, *Brevoortia tyrannus*, IN THE WHITE OAK RIVER ESTUARY, NORTH CAROLINA

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ABSTRACT

Atlantic menhaden exhibit three different stages—larva, prejuvenile, and juvenile—during their stay in the estuary. For specimens collected from the White Oak River estuary, N.C., the length-weight relation was $\log_e \hat{Y} = -8.1104 + 3.6050 (\log_e X)$ for larvae, $\log_e \hat{Y} = -16.9638 + 6.3083 (\log_e X)$ for prejuveniles, and $\log_e \hat{Y} = -5.2298 + 3.1452 (\log_e X)$ for juveniles, where Y = weight in mg and X = length in mm. Larvae and prejuveniles concentrated in the low salinity-freshwater zone upstream. Juveniles tended to move downstream toward the higher salinity water. Condition factors of larvae and prejuveniles increased toward the higher salinity zone.

Atlantic menhaden spawn and hatch in coastal oceanic waters from Maine to Florida. The larvae enter estuaries where they transform into juveniles near the freshwater zone. The relation of young menhaden length and weight to time, salinity, and location within an estuary provides insight on the environmental requirements of menhaden during a critical phase in their life cycle. We collected young menhaden from a small estuary in North Carolina, from March to September 1969 with a tidal net (Lewis et al., 1970) to study changes in the length-weight relation.

The lower portion of the White Oak River estuary (28 sq km) is shallow with depths from 0 to 3.0 m and distances from opposing shores from 1 to 3 km. The intracoastal waterway crosses the lower estuary and is maintained at a depth of approximately 4 m. The upstream portion narrows into a river up to 4.6 m deep. During the study period we generally found that the change from brackish to fresh water occurred between 18 and 24 km upstream from Bogue Inlet. The exact location of this low salinity zone was influenced by tide, rainfall, and direction and speed of the wind. The mean tidal range at Bogue Inlet is 2.2 ft (0.67 m) (U.S. Coast and Geodetic Survey, 1970). At 21 km upstream the average river flow is 14.7 cfs (0.42 m^3/sec) (North Carolina State Board of Health, 1954). A map showing the location of the White Oak River estuary is shown in Lewis and Mann (1971).

We selected 14 stations from Bogue Inlet to 34 km upstream (Wilkens and Lewis, 1971). Stations ranged from 2 to 5 km apart and were selected to be representative of the various salinities encountered. We also sampled in fresh water to determine how far menhaden move upstream. Salinity measurements were taken within 1 m of the surface. During collections, spot checks of salinity between the surface and bottom indicated that in this shallow estuary thorough mixing generally occurred. Differences between measurements at one location were due to flooding and ebbing tides.

Our menhaden collections ranged from 15 to several thousand individuals. We measured and weighed all fish to the nearest 0.5 mm total length and 0.1 mg in collections containing less than 26 and subsampled the larger collections. Since both length and weight variances in the subsamples were small, we considered our estimates of length and weight to be reliable. Our measurements of total length were based on the greatest dimension between the most anteriorly projecting part of the head and the farthest tip

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of the caudal fin when the caudal rays are squeezed together (Hubbs and Lagler, 1949).

We separated young menhaden into three stages on the basis of body form and the length-weight relation of individuals within each stage. Length and weight ranges of all the fish used in the study are given in Table 1. An illustration of each stage (larva, prejuvenile, and juvenile) that occurs during the first year in the estuary is shown in Figure 1.

Allometric growth, with stanzas for larvae, prejuveniles, and juveniles is shown in Figure 2. The inflection points, indicating change in slope, are 30 and 38 mm for length, and 70 and 469 mg for weight. We considered specimens less than 30 mm and 70 mg as larvae; they are long and slender, and even at 30 mm total length the body depth is only 4 mm or less. In the next group,

TABLE 1.—Lengths and weights of Atlantic menhaden from the White Oak River estuary, N.C., arranged in order of increasing weight classes.

Weight	Length range	Number of menhaden	Weight	Length range	Number of menhaden
mg	*mm*		*mg*	*mm*	
0.0- 4.9	8-16	23	100.0- 199.9	29-34	38
5.0- 9.9	14-20	46	200.0- 299.9	33-37	26
10.0-14.9	17-21	43	300.0- 399.9	35-38	6
15.0-19.9	20-23	48	400.0- 499.9	37-43	5
20.0-24.9	20-24	45	500.0- 599.9	39-41	10
25.0-29.9	22-26	32	600.0- 699.9	40-44	14
30.0-34.9	23-26	30	700.0- 799.9	41-44	11
35.0-39.9	24-27	31	800.0- 899.9	44-45	6
40.0-44.9	25-28	29	900.0- 999.9	45-49	4
45.0-49.9	25-29	10	1,000.0-1,499.9	47-54	41
50.0-54.9	26-29	20	1,500.0-1,999.9	53-60	27
55.0-59.9	27-29	26	2,000.0-2,499.9	58-62	16
60.0-64.9	27-31	26	2,500.0-2,999.9	61-66	11
65.0-69.9	27-31	19	3,000.0-3,499.9	68-71	5
70.0-74.9	28-31	22	3,500.0-3,999.9	71-74	8
75.0-79.9	29-32	15	4,000.0-4,499.9	75-77	4
80.0-84.9	29-32	12	4,500.0-4,999.9	76-82	5
85.0-89.9	29-31	7	5,000.0-5,499.9	81	3
90.0-94.9	28-32	11	5,500.0-5,999.9	81-83	2
95.0-99.9	29-32	6			

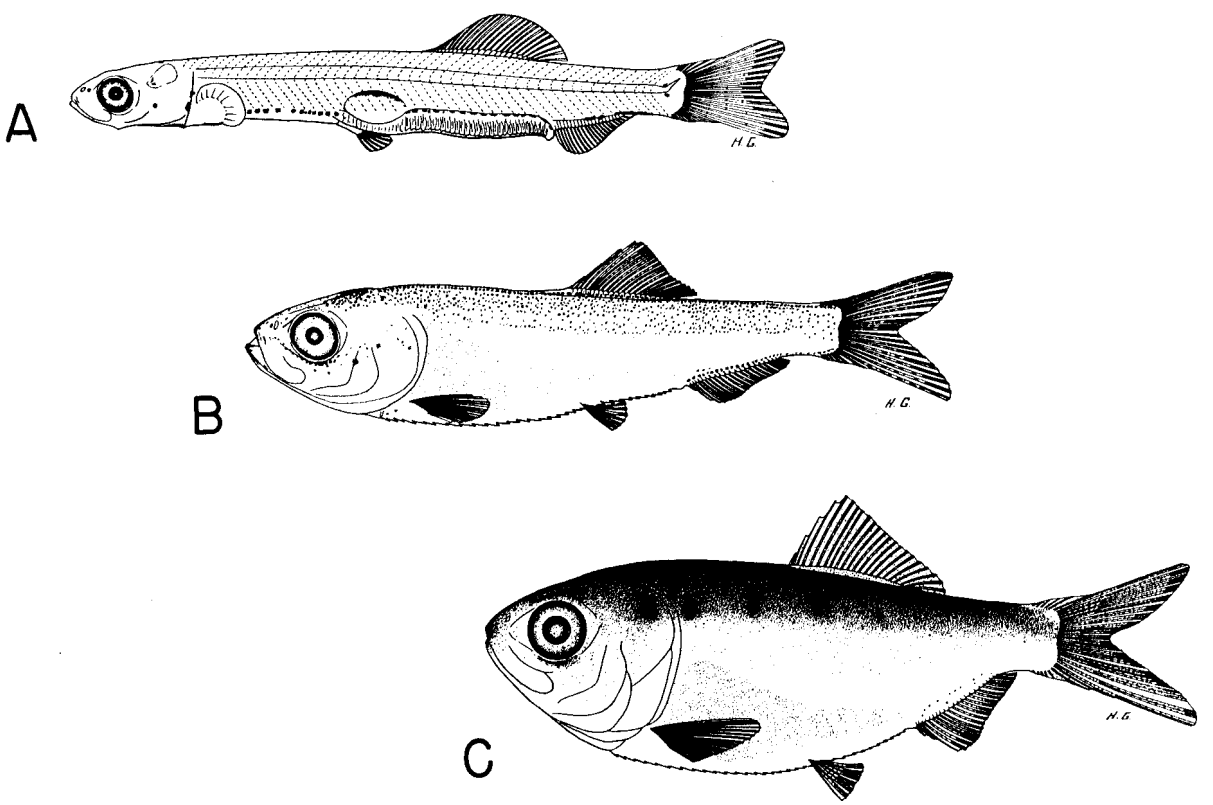

FIGURE 1.—Atlantic menhaden (a) larva 27.0 mm total length (TL); (b) prejuvenile 32.0 mm TL; and (c) juvenile, 64.0 mm TL. The alimentary tracts are shown as they were visible in the preserved specimens used in drawings.

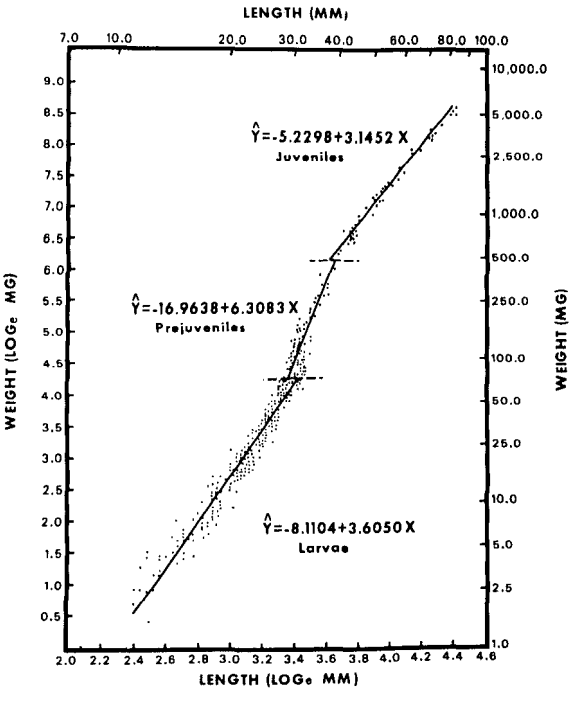

FIGURE 2.—Regression of weight on length for larval, prejuvenile, and juvenile Atlantic menhaden collected in White Oak River estuary, N.C., in 1969. (We separated the lengths and weights into three groups after visual observation of the data and fish. Lines were then fitted by least squares regression based on data in each group.)

prejuveniles, we included specimens from 30 to 38 mm and 70 to 469 mg. In this stage there is a rapid increase in body depth, but little increase in length. Fish above 38 mm and 469 mg we classed as juveniles. Huntsman[3] found that the relation between length and weight is similar for juveniles and adults. Both stages have a similar body form, only their color and size being different. We did not find any adults in our estuarine study.

Larvae enter the lower estuary and move upstream to the freshwater-low salinity zone where they go through a prejuvenile stage before completing their transformation into juveniles.

[3] Huntsman, Gene R. 1971. Growth by year class of Atlantic menhaden. (Unpublished manuscript.) NMFS Center for Estuarine and Menhaden Research, Beaufort, NC 28516.

Larval menhaden were most abundant in March, prejuveniles in late March and April, and juveniles by the beginning of May (Wilkens and Lewis, 1971). Large catches of larval and prejuvenile menhaden within the freshwater-low salinity zone (Table 2) suggest that favorable conditions for growth are present.

Condition factors (W/L^b, where W = weight in mg, L = length in mm, and b = value for the slope of weight on length for each growth stanza) of larvae and prejuveniles increased with time as the result of growth and development. The apparent lack of growth of larvae and prejuveniles in the low salinity-freshwater zone during April is probably due to large numbers entering this zone, putting on fast growth, moving out of the zone, and being replaced by new groups (Tables 2 and 3). Juveniles, which have the same body form as adults and which are scattered in schools throughout the estuary, showed no change in condition factor with time or salinity.

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TABLE 2.—The distribution and mean total length (mm) of menhaden by date collected, kilometers upstream from Bogue Inlet, and salinity (‰) in the White Oak River estuary, March-August 1969.

	Date 1969									
	Mar. 17	Mar. 27	Apr. 1	Apr. 9	Apr. 16	May 1	May 14	May 27	June 26	July 16	Aug. 27
16 kilometers:											
Salinity	--	0	1.5	4.1	8.0	5.2	13.7	15.4	1.8	10.2	15.1
Abundance index[1]	--	4.3	298.4	48.8	111.0	279.1	0.1	5.2	4.2	4.6	0.3
Mean total length	--	28.5	28.9	30.0	29.2	32.1	--	42.4	53.4	58.8	--
18 kilometers:											
Salinity	1.5	0	0.2	0.1	3.8	1.8	7.4	11.7	0.2	3.0	8.9
Abundance index	9.6	0.4	1,053.4	497.7	526.5	155.2	0.4	1.1	16.3	6.6	0
Mean total length	29.9	--	28.5	27.5	30.8	30.5	--	--	43.5	51.0	--
21 kilometers:											
Salinity	0.2	0	0	0	1.2	--	4.2	--	--	--	--
Abundance index	48.7	0	54.2	65.3	0	--	0.5	--	--	--	--
Mean total length	30.8	0	28.3	27.2	--	--	--	--	--	--	--
24 kilometers:											
Salinity	0	0	0	0	0	0	1.5	4.4	0	0	0.5
Abundance index	13.3	1.8	6.0	1.5	1,533.3	392.6	0.7	13.9	0.4	1.4	1.0
Mean total length	30.1	29.6	29.2	26.6	28.5	29.4	--	42.6	--	--	--
28 kilometers:											
Salinity	0	0	0	0	0	0	0	0.6	0	0	0
Abundance index	0	0.5	1.4	0.2	0.6	0	0.1	12.1	0.3	0.2	0
Mean total length	--	--	29.5	--	--	--	--	41.8	--	--	--
31 kilometers:											
Salinity	0	--	0	0	0	0	0	0	0	--	--
Abundance index	0	--	0.3	10.3	0	0	0	1.0	0	--	--
Mean total length	--	--	--	29.1	--	--	--	--	--	--	--

[1] Abundance index is the number of young menhaden for 100^3 of water.

TABLE 3.— Mean condition factors of young Atlantic menhaden collected in the White Oak River estuary, N.C., in 1969.

	Date	Salinity (‰)							
		0	0.1-0.9	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	>6.0
	1969								
Larvae	Mar. 17	0.292	0.303	0.253	--	--	--	--	--
	Mar. 27	0.293	--	--	--	--	--	--	--
		0.302	--	--	--	--	--	--	--
	Apr. 1	0.291	0.309	0.331	--	--	--	--	--
		0.332	--	--	--	--	--	--	--
		0.310	--	--	--	--	--	--	--
	Apr. 9	0.331	0.326	--	--	--	0.326	--	--
		0.317	--	--	--	--	--	--	--
		0.355	--	--	--	--	--	--	--
	Apr. 16	0.321	--	--	--	0.357	--	--	0.444
	May 1	0.358	--	--	--	--	--	--	--
Prejuveniles	Mar. 17	0.299	0.305	0.314	--	--	--	--	--
	Mar. 27	0.394	--	--	--	--	--	--	--
		0.376	--	--	--	--	--	--	--
	Apr. 1	0.342	0.387	0.390	--	--	--	--	--
		0.364	--	--	--	--	--	--	--
		0.381	--	--	--	--	--	--	--
	Apr. 9	0.396	0.435	--	--	--	0.420	--	--
	Apr. 16	0.402	--	--	--	0.476	--	--	0.516
	May 1	0.497	--	0.599	--	--	--	0.547	--
	May 27	--	0.555	--	--	--	--	--	0.498
Juveniles	May 27	--	0.551	--	--	--	0.517	--	0.507
	June 26	--	0.526	0.540	--	--	--	--	--
	July 16[1]	--	--	--	--	0.542	--	--	0.535

[1] Sample sizes after July 16 were too small to show trends.