

**Coastal Movements of Atlantic Menhaden as Inferred  
from Changes in Age and Length Distributions**

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# Coastal Movements of Atlantic Menhaden as Inferred from Changes in Age and Length Distributions

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## ABSTRACT

Length frequency distributions of Atlantic menhaden, *Brevoortia tyrannus*, plotted by age, month, and latitude, support the hypothesis of an annual north-south movement. The majority of Atlantic menhaden, wintering in offshore waters south of Cape Hatteras, North Carolina, move northward in early spring. By about mid-June menhaden are distributed in coastal waters from Florida to Maine, their age and size increasing from south to north. A slow northward movement of fish north of False Cape, Virginia, continues throughout the summer. A southward movement, beginning in early September north of Cape Cod, Massachusetts and involving all fish north of False Cape by November, culminates in January when the majority of the population is again south of Cape Hatteras.

## INTRODUCTION

The Atlantic menhaden, *Brevoortia tyrannus*, occurs in the inshore temperate and subtropical waters of the eastern Atlantic Ocean from about latitude 27° N to 45° N (Hildebrand, 1948; Leim and Day, 1959; Reintjes, 1960) and in past years has supported an important commercial fishery from Cape Kennedy, Florida to Cape Ann, Massachusetts (Roithmayr, 1963). In 1955 the Bureau of Commercial Fisheries began sampling the commercial menhaden catches for age, length, and weight composition.

June and Reintjes (1959) noted that menhaden from the northern ports were older and larger than those from southern ports during the "summer" fishing season from June to October. June and Nicholson (1964) concluded that Atlantic menhaden make an annual north-south movement, migrating northward during the spring from waters south of Cape Hatteras, North Carolina and then returning to these waters the following autumn. Their conclusions were based primarily on comparisons of length frequencies of major year classes, range, and differences in age and length composition in different areas.

In the present study age and length data collected during the 1955-59 fishing seasons were examined to: (1) document the degree of age and length stratification of Atlantic menhaden along a north-south axis, and (2) to determine if spatial and temporal changes in age and length frequencies support the modified

and expanded hypothesis of Atlantic menhaden movements.

The following hypotheses, accounting in greater detail for the occurrence and movements of Atlantic menhaden, are proposed:

- (1) Menhaden of all ages and sizes, including juveniles from all parts of the range, concentrate in the offshore waters from about Cape Hatteras, North Carolina to northern Florida, January to March.
- (2) These menhaden commence relatively rapid inshore and northward movement in late winter, the older and larger fish leaving first and moving farther northward along the coast.
- (3) By approximately June, the menhaden population is stratified by age and size along a north-south axis; menhaden south of Cape Hatteras cease any northward movement, but those from Chesapeake Bay to the northernmost part of the range continue a slow northward drift through the summer.
- (4) Menhaden north of Cape Cod, primarily fish age 4 or older, begin to move south in late summer, join with fish from Long Island and Nantucket Sounds, and congregate in dense schools off Long Island in October. These and all other fish from Long Island to Chesapeake Bay, including juveniles, move southward during October to Decem-

ber, eventually wintering offshore from Cape Hatteras to northern Florida.

#### THE ATLANTIC MENHADEN FISHERY

Atlantic menhaden inhabit estuaries during their first summer of life, but thereafter keep to coastal waters and the larger bays and sounds. They are not known to occur beyond the Continental Shelf and are found in greatest abundance within about 15 miles of the coast-line.

Purse seines are the principal gear used, but pound nets capture substantial numbers, incidentally with other species, from April to October in Chesapeake Bay and in certain areas along the coasts of New Jersey, Long Island, and New England. Although some of the pound net catch is processed into meal, most is sold as either fresh or frozen bait.

Purse seining begins when menhaden gather in large schools and appear near the surface. This occurs in late April or May from Florida to North Carolina, in late May or early June from Chesapeake Bay to northern New Jersey, in mid-June in Long Island Sound, and in late June or early July in waters north of Cape Cod, Massachusetts.

Purse seining ends when the schools disappear from surface waters. This generally occurs in early September north of Cape Cod, in late September or early October in Long Island Sound, and in late October from the south side of Long Island to the Virginia capes. In late October or early November large schools of menhaden appear in North Carolina waters between Cape Hatteras and New River Inlet and support a sizable fishery until early January.

Menhaden purse seine catches are landed daily. Most of the catch is processed into meal and oil at reduction plants located, during 1955-59, at 13 ports from Fernandina Beach, Florida, to Portland, Maine (Figure 1). Seasonal employees at 10 ports sampled the daily landings to determine the age, length, weight, and sex composition.

June and Reintjes (1959) described the procedures in detail. Briefly, 100 fish were sampled randomly from the top of the catch of a single boat. This sample was presumed representative of the fish taken in the vessel's last

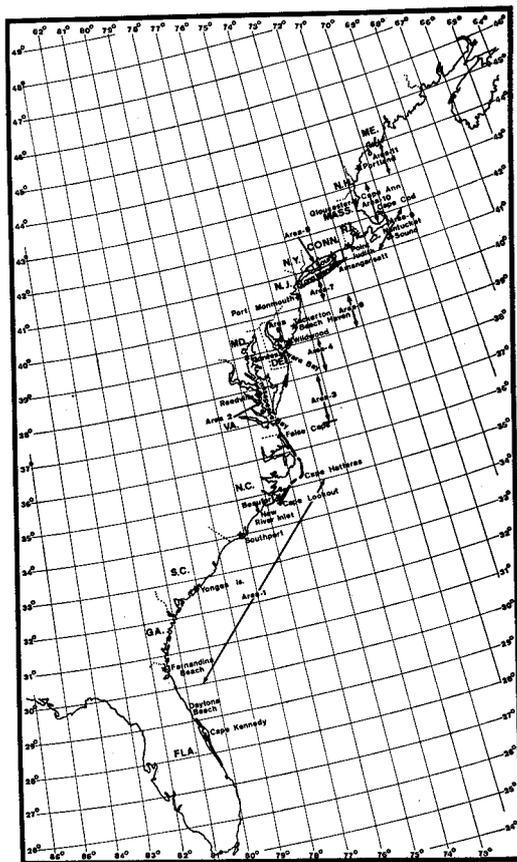


FIGURE 1.—Map showing locations of menhaden reduction plants and areas referred to in the text.

purse seine set, the location of which was recorded to the nearest 10' of latitude and longitude. The fork length (mm), weight (g), sex, and age (subsequently determined from scale samples) were recorded for every fifth fish in the 100-fish sample. When possible, two samples were taken daily at each port.

Prior to the opening of the purse seine season, pound net catches were sampled at Reedville, Virginia (1955-57), Port Monmouth, New Jersey (1955-58), Beach Haven, New Jersey (1956), and Point Judith, Rhode Island (1956). Sampling of pound net catches was discontinued when the purse seining began.

#### TREATMENT OF DATA

For each year the basic data were grouped by months and, with some exceptions, by

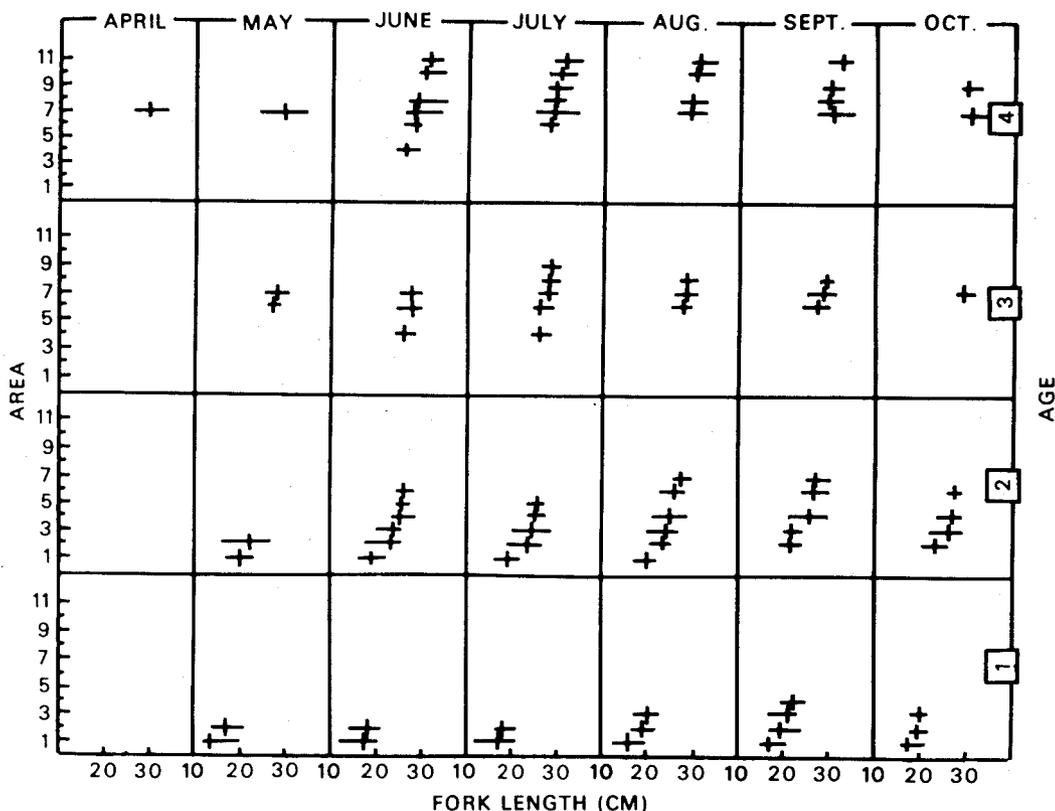


FIGURE 2.—Ranges and modes of length frequency distributions of Atlantic menhaden by month, age, and area, 1955.

degrees of latitude from  $29^{\circ}$  N to  $44^{\circ}$  N. All fish older than age 3 were combined into a single group, 4+. Chesapeake and Delaware Bays were treated as separate units, and the region from  $40^{\circ}$  N to  $44^{\circ}$  N was divided into units more geographically homogeneous than whole degrees of latitude. Latitudes  $29^{\circ}$  N to  $35^{\circ}$  N were combined after examination of the data revealed no discernible differences in the age or length distributions within these latitudes. The 11 geographical units are shown in Figure 1.

Length frequencies of each age group, computed by half-centimeter intervals, were plotted for the 11 units by months and years, and freehand curves were fitted to the points. Generally, distributions containing fewer than 25 individuals were not used. In an initial attempt to simplify the data and to reduce the amount of graphic material for publication,

only the frequency ranges and modes of the curves were plotted. Because of the similarity in the distribution of ranges and modes for each year, the 1956, 1958, and 1959 data are omitted here in order to reduce further the amount of graphic material. Two years, 1955 and 1957, are included to show the degree of variability between years (Figures 2-3).

For each geographical unit, the monthly percentages of each age group in the total sample were plotted to show changes in the contributions of individual age groups and to show the month in which an age group first appeared in the samples from a given area (Figure 4).

#### SEASONAL DISTRIBUTION BY AGE AND LENGTH

Although samples were obtained from only a few areas during April and May, they indicated that the average age and length of menhaden along the coast increased from south

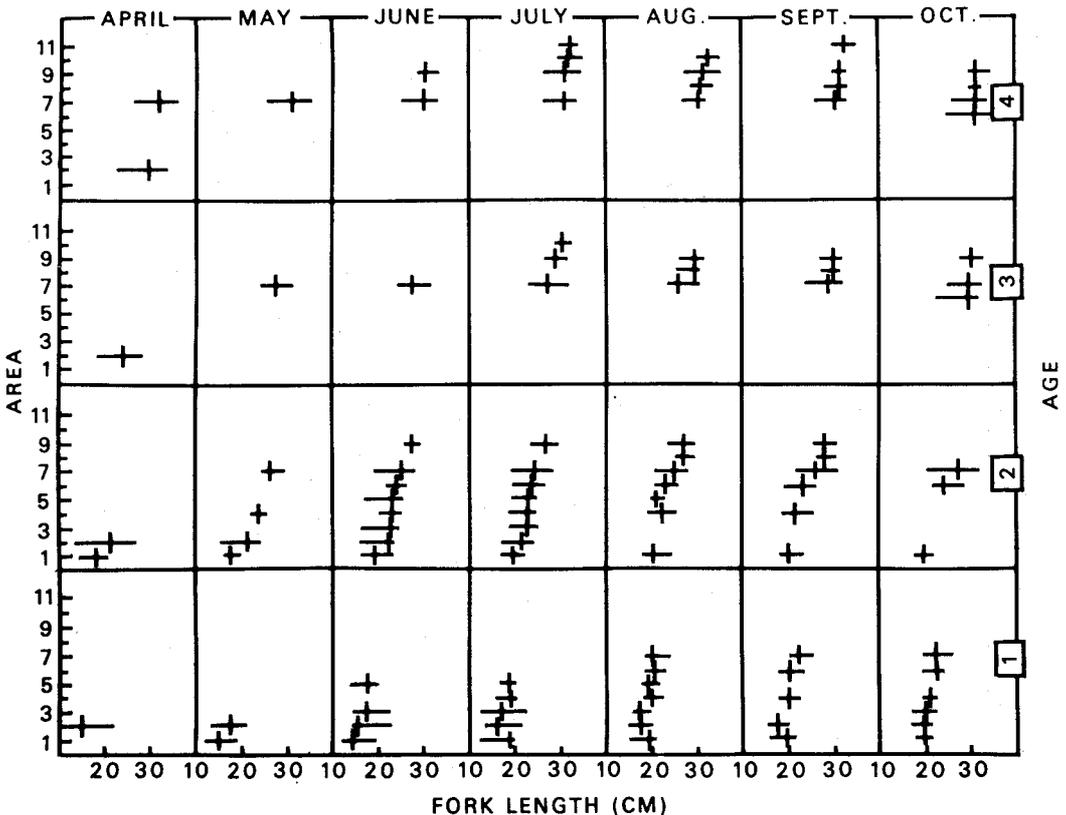


FIGURE 3.—Ranges and modes of length frequency distributions of Atlantic menhaden by month, age, and area, 1957.

to north (Figures 2-3). Age-1 and -2 fish constituted the largest percentage of the samples in Areas 1 and 2 (Chesapeake Bay southward), while age 3 and older fish constituted the largest percentage in Areas 6, 7, and 8 (latitudes 39-41° N).

From June to October, there was a stratification of the population by age and size along the entire coast (Figures 2-3). South of Chesapeake Bay, from about Daytona Beach, Florida to Cape Lookout, North Carolina, age-1 and -2 fish constituted nearly 100% of the samples, although the proportion of these age groups varied annually depending on the relative strength of individual year classes. The upper and lower limits in size and the average size of both age groups were generally less than those of fish of corresponding age north of False Cape, Virginia.

From Chesapeake Bay northward, the age

composition changed from nearly all age-1 and -2 fish in Area 2 (Chesapeake Bay) to nearly all age-4 or older fish in Area 11 (Table 1). Age-1 fish occurred from Areas 2 to 9, the percentages ranging from around 75% in Area 2 to 25% or less in Area 6. Because the 1958 year class was unusually abundant, age-1 fish were abundant in area 7 in 1959. Age-2 fish were found from Areas 2 to 10, but were most abundant in Areas 6 and 7, where they usually composed 50 to 90% of the samples. Age-3 fish constituted a significant percentage of the samples in Areas 8 and 9 only. Fish age-4 and older accounted for a small percentage of the samples below Area 7 and 90 to 100% of the samples in Areas 10 and 11.

The average size of individuals of each age also increased with the latitude. The lower and upper size limits and the modes of each age group shifted to the right at the higher lati-

TABLE 1.—Number of Atlantic menhaden in catch samples, by age and area, 1955-59

Area	Year														
	1955			1956			1957			1958			1959		
	1	2	3 4-9	1	2	3 4-9	1	2	3 4-9	1	2	3 4-9	1	2	3 4-9
11	0	0	0 538	0	0	0 165	0	0	0 1	40	—	—	—	—	—
10	0	0	10 542	0	0	20 1125	0	0	26 588	0	0	1 58	0	14 442	247
9	0	0	37 259	0	6	112 391	0	404	195 440	0	394	126 113	0	31 172	570 50
8	0	5	198 503	0	21	442 572	0	114	114 265	0	292	353 319	85	346 665	167
7	0	221	1077 2036	3	1014	1851 1349	150	3111	556 1137	2	2080	342 420	832	770 861	119
6	6	354	276 135	65	703	222 104	213	663	26 50	24	1	1	9	1239 24	1
5	0	138	29 10	3	64	2 0	318	253	1 0	4	152	1 0	4	13 44	2 0
4	48	996	164 70	335	1369	88 10	761	948	11 0	31	1505	31 0	1047	836 97	0
3	413	501	30 12	202	119	0 0	503	382	8 0	133	886	12 1	624	173 19	0
2	779	1288	32 28	2147	393	23 14	2136	699	48 42	1131	1202	10 2	2686	343 23	0
1	1919	773	89 79	3944	95	7 1	1099	1908	5 0	1395	589	48 1	2275	238 6	0

tudes (Figures 2-3). Although this shift did not occur in every area, the trend was clearly evident. It was most pronounced among ages 1 and 2.

In November, December, and occasionally in early January the only fishing was off the North Carolina coast. Fish of all ages, including age-0, were represented in the catch.

#### MOVEMENTS

The age and length frequency distributions of Atlantic menhaden and the spatial and temporal changes in these distributions support the general hypothesis of north and south seasonal movements. In certain instances where data are lacking, specific points of the hypothesis can be neither refuted nor supported. Because age-0 fish, except in rare cases, are caught only near the end of the North Carolina fall fishery, there are no spatial or temporal changes in length frequencies from which to draw inferences about their movements. From about Cape Lookout, North Carolina to northern Florida spatial or temporal changes in the length frequency distributions also are lacking. Spring, summer, and autumn movements inferred from the data are generalized in Figure 5.

#### Winter Movement

From May to October, the catch of menhaden in North Carolina waters comprises principally age-1 and -2 fish, but during November and December it comprises fish of all ages, including age-0 (Nicholson and Higham, 1964). The change in age composition and the presence of vast schools of menhaden moving southward along the North Carolina coast in autumn suggest that a major portion of the menhaden population winters in the offshore waters south of Cape Hatteras, North Carolina, the center of this population being somewhere off the North Carolina coast.

#### Spring Movement

The absence of fish older than age-2 in the May purse seine catches in Florida and North Carolina, the small size of the age-1 and -2 fish in these catches, and the appearance of fish of

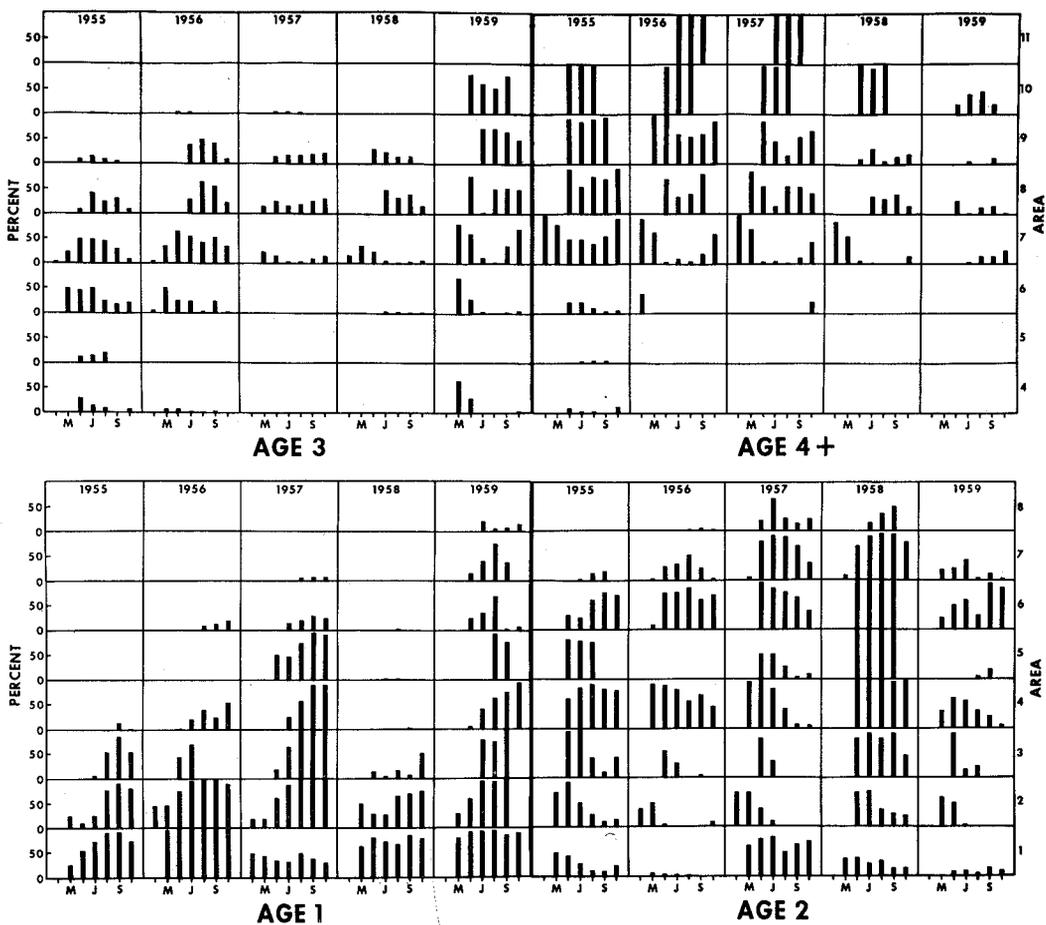


FIGURE 4.—Monthly percentages of each age group of Atlantic menhaden in samples, by age and year.

all ages in April and May catches from Chesapeake Bay to Long Island Sound, were evidence that the major portion of the population moves northward in late winter from the area south of Cape Hatteras, North Carolina. The absence of older fish in the summer purse seine catches in North Carolina, the significance of which was discussed by June and Nicholson (1964), may be noted in Table 1. The smaller size of age-1 and -2 menhaden in the summer fishery south of Cape Lookout, and the heterogeneous age composition of the catches along the northern coast may be inferred from Figures 2-3.

While age-3 or older fish composed nearly the entire sample from Areas 6 and 7 in April and May, the percentage of age-3 fish increased

in the May samples (Figure 4). This change, together with the later appearance of older fish in more northern areas and the high average age of fish in these areas during the summer, suggests that the fish are not only moving northward, but also that the older and larger fish are preceding the younger and smaller fish.

Judging from their order of appearance, menhaden in any general area arrive progressively later in the season as the latitude increases. Most of those in Area 2 (Chesapeake Bay), principally age-1 and -2 fish, probably arrive by April, while most of those north of Cape Cod, Massachusetts, principally fish age 3 or older, do not arrive until late June or early July.

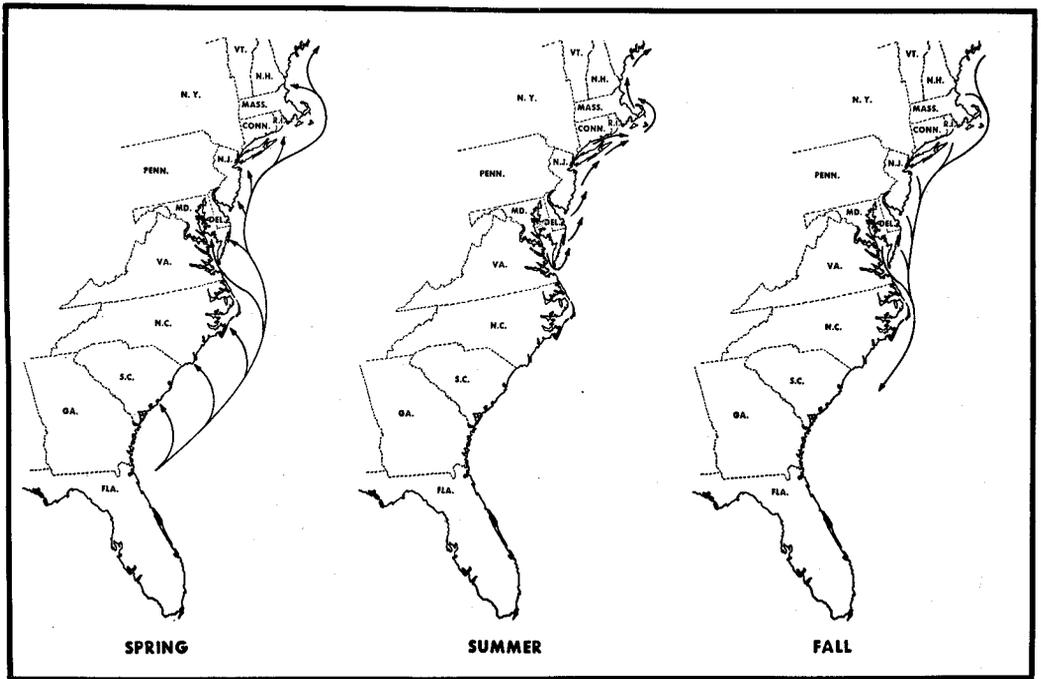


FIGURE 5.—Diagram of Atlantic menhaden movements in spring, summer, and fall.

#### *Summer Movement*

Although the area between roughly Cape Lookout, North Carolina and False Cape, Virginia is accessible to vessels and airplane spotters from North Carolina and Virginia, fish were seldom reported or caught. Consequently, few samples were available. This scarcity suggests not only a discontinuity in the distribution of the population during the summer, but also an absence of any substantial movement of fish from south of Cape Lookout to points north of False Cape.

South of Cape Lookout, fish were smaller than those of corresponding age in northern areas, but the lack of any spatial or temporal difference in the length frequency distributions between latitude  $30^{\circ}$  N and  $34^{\circ}$  N precluded drawing any inferences about movements within the area.

North of False Cape, Virginia the relatively small increases, and in some instances decreases, in monthly mean lengths of age-1 and -2 fish in samples from Areas 2 to 6 is evidence of a continuing slow northward movement (Tables 2-3). Since the average size of

the fish in each age group increased from south to north, there could have been a shift of fish only in a northward direction to have caused mean lengths to decrease or to have shown little or no change. If there had been no shift, growth would have caused substantial increases in mean lengths. If the shift had been south, length increases would have been disproportionately large. The magnitude of any changes would depend on the speed of movement and the amount of mixing. In Area 2 the small age-1 fish needed to replace the larger age-1 fish leaving the area could have been recruited from areas of Chesapeake Bay where fishing is prohibited (Maryland waters and the upper parts of Virginia rivers). It is unlikely that any substantial numbers were recruited from south of Cape Lookout, North Carolina.

As the seasons advanced, changes in the percentage age composition of samples in different areas also reflected a northern movement (Figure 4). The percentage of age-1 fish generally increased in all areas in which they were found. At the lower latitudes this prob-

TABLE 2.—Mean length in millimeters of 50 or more Atlantic menhaden by age, area, and month, 1955

Month	Area						
	2		3		4	6	7
	Age 1	Age 2	Age 1	Age 2	Age 2	Age 2	Age 2
May	173	221	—	—	253	—	—
June	180	237	—	242	254	261	—
July	185	238	—	248	254	—	—
August	194	—	199	240	257	262	275
September	199	—	210	—	267	269	275
October	204	—	205	261	—	—	—

ably reflected a loss of age-2 fish, at higher latitudes an increase in age-1 fish. Age-2 fish generally decreased in the southernmost latitudes and increased in the northernmost, reflecting their movement northward. Age-3 and older fish generally decreased in the southernmost areas and remained stable or increased in the northernmost. Since a shift in the percentage of one age group automatically caused the percentage of the other age groups to change, it is difficult to ascertain if a change resulted from one age group increasing or from another decreasing. The important consideration, however, is that the consistent pattern of change in the data examined supports the hypothesis of a northern movement.

Another indication of northern movement is that age-1 and -2 menhaden generally were not found in the most northern area of their range until mid or late summer (Figure 4). If there were no movement, one would expect to find an age group represented in samples from its northernmost range throughout the entire season, rather than for just the last part of the season. Sampling bias could account for the absence of an age group in some months, but it would be unlikely to account for the absence of an age group in the same months every year.

### Autumn Movement

From Long Island southward to Chesapeake Bay, fishing activity decreased in October and terminated when menhaden disappeared from surface waters usually by the end of the month.

The time menhaden begin a southward movement is difficult to establish. Roithmayr (1963) concluded, on the basis of a decrease in the number of purse seine sets in September and October, that menhaden north of Cape Cod decline in abundance in September and disappear by October. Since fish of the same age and size as those north of Cape Cod increase in catches from Area 7 (latitude 40°) in October, the inference is that menhaden north of Cape Cod begin moving south in September, eventually congregating off the south shore of Long Island in October along with fish from Long Island Sound.

Little is known of the behavior of menhaden after they disappear from northern surface waters in October. But the appearance off the North Carolina coast in November and December of vast schools that contain fish of the same lengths and ages as those taken from Chesapeake Bay northward in October (June and Nicholson, 1964) supports the theory that the fish move south.

TABLE 3.—Mean length in millimeters of 50 or more Atlantic menhaden by age, area, and month, 1957

Month	Area								
	2		3		4		6		7
	Age 1	Age 2	Age 2						
May	—	208	—	—	—	—	—	—	—
June	170	223	177	223	—	232	—	235	254
July	169	—	175	226	182	228	—	229	247
August	176	—	175	—	200	221	208	229	250
September	182	—	—	—	202	—	208	234	262
October	193	—	195	—	213	—	221	251	269

Juveniles (age-0) leave the estuaries in autumn and move into the ocean. Although they generally are avoided by fishermen because they yield no oil and a poor grade of meal and often gill in the purse seines, large numbers are taken each winter off North Carolina, generally in late December or early January after the larger fish disappear (June and Reintjes, 1959, 1960; June, 1961; June and Nicholson, 1964; Nicholson and Higham, 1964).

Apart from occasional midwinter trawl catches in Chesapeake Bay and in offshore waters north of Cape Hatteras, there is no evidence that any menhaden winter in northern waters. On the other hand, the disappearance of schools from northern surface waters, the visual sightings of large bodies of fish moving south along the coast, the appearance in November and December of huge schools of menhaden of all ages moving south off the North Carolina coast, and the eventual disappearance of these schools in the vicinity of Cape Fear, North Carolina, are indications that a major segment of the menhaden population winters south of Cape Hatteras.

#### SUMMARY

The major portion of the Atlantic menhaden population winters in offshore waters south of Cape Hatteras, North Carolina. These fish begin moving northward in late winter, the older and larger preceding the younger and smaller. By late June the population, excluding age-0 fish, is stratified along the coast from Florida to Maine, the age and size increasing from south to north. Menhaden south of Cape Lookout, North Carolina, generally do not continue to move northward but menhaden from Chesapeake Bay northward continue a slow northward shift throughout

most of the summer. Those north of Cape Cod, Massachusetts begin a slow southward movement in September. By November nearly all the fish northward from Chesapeake Bay are moving southward to the offshore waters south of Cape Hatteras.

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