# THE RELATION BETWEEN SPAWNING SEASON AND THE RECRUITMENT OF YOUNG-OF-THE-YEAR BLUEFISH, *POMATOMUS SALTATRIX*, TO NEW YORK[1]

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## ABSTRACT

The association between oceanic spawning season and the recruitment of young-of-the-year (YOY) bluefish, *Pomatomus saltatrix*, to the inshore waters of New York was studied by estimating the spawn dates of recruited fish collected in the shore zone from the number of growth increments in their otoliths. Field collections on the south shore of Long Island showed that recruitment of 3–6 cm fork length fish occurred as a distinct pulse during the last week of May in 1985 and the second week of June in 1986. Length-frequency distributions were generally unimodal and most fish collected later could be attributed to this one recruitment episode. The frequency of otolith ring deposition in YOY bluefish was determined by marking the otoliths of field-caged fish with an injection of tetracycline, and then periodically subsampling these over the ensuing 61-day period. Regression analysis indicated a 1:1 relation between the number of days since marking and the number of rings beyond the mark. Back-calculation to the time of first ring deposition revealed that field-collected YOY bluefish from Long Island were spawned primarily in the March–April spawning season reported to occur south of Cape Hatteras. Relatively few fish were collected from the summer spawning season that reportedly occurs in the Middle Atlantic Bight. Almost all of these summer-spawned fish were collected from the Hudson River.

The bluefish, *Pomatomus saltatrix*, supports a major recreational fishery along the Atlantic coast of the United States. In 1985, more bluefish by weight were caught than any other marine fish, accounting for over 24% of the total marine recreational catch (U.S. Department of Commerce 1986). Despite the importance of bluefish to the recreational fishery, very little is known of its early life history.

Bluefish are found over different portions of the continental shelf from Florida to Nova Scotia at various times of the year (Bigelow and Schroeder 1953; Wilk 1977; Gilmore 1985). Based on descriptions of the temporal and spatial abundance of larvae, Kendall and Walford (1979) suggested that there are primarily two distinct spawning periods and regions: a spring spawning in the South Atlantic Bight at the edge of the Florida Current (see also Collins and Stender 1987), and a summer spawning in the Middle Atlantic Bight midway over the continental shelf (see also Morse et al. 1987). They further proposed that the spring-spawned larvae are transported northward in the slope waters and then move inshore, spending their first summer in the bays and estuaries of the Middle Atlantic Bight. Summer-spawned larvae, according to Kendall and Walford, spend their first summer at sea or enter the estuaries of the Middle Atlantic Bight only briefly before migrating southward with the onset of winter. A minor spawning season extending from September to November off the coast of Georgia and Florida (Collins and Stender 1987) involves fish resident to the South Atlantic Bight (Kendall and Walford 1979).

The purpose of this study is to evaluate Kendall and Walford's hypothesis by back-calculating the spawn dates of young-of-the-year (YOY) bluefish that have recruited to inshore waters, from the number of growth increments in their otoliths. First, we describe the timing and pattern of recruitment of YOY bluefish to one segment of the mid-Atlantic coastline: Long Island, NY. If spawning is episodic, and if YOY bluefish from each spawning period enter New York waters, then length-frequency distributions of field collections should be multimodal. Next, we verify that otolith increment deposition has a daily peri-

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odicity in *P. saltatrix*. Finally, the spawning season(s) of YOY bluefish recruiting to New York is determined by ageing and back-calculating to the date of first ring deposition.

## METHODS

### Seine Collections

The temporal abundance and length-frequency distribution of YOY bluefish was estimated by seining 2–4 times per month from April to October at several sites on Long Island and in the Hudson River (Fig. 1). In 1985 and 1986, three sites in Great South Bay on the south shore of Long Island were sampled: Smith Point County Park, Fireplace Neck, and the Carmans River. Seining was conducted with a 0.6 cm mesh, 30 m net set from shore, either on foot or from a small boat. Water temperature was recorded at each site and date. In 1986, a site on the north shore of Long Island, Setauket Harbor, was also sampled. A few samples were taken in the fall by angling with rod and reel. All specimens were frozen for later measurement of fork length (FL) and weight, and extraction of otoliths.

Additional specimens captured in 1986 from Jamaica Bay and the Hudson River were provided by the New York Department of Environmental Conservation (NYDEC). Their sampling was conducted with a 60 m seine (1.2 cm mesh) set from a boat.

### Otolith Preparation and Analysis

The sagittae were mounted concave side down on a glass microscope slide with cyanoacrylate (instant glue). Two layers of masking tape were applied on either side of the otolith. The slide was then turned upside-down and sanded on a strip of wet 1200 grit wet-dry sandpaper. The masking tape ensured that the otolith was sectioned on a consistent plane and helped prevent grinding past the nucleus. Once the nucleus was reached, the otolith was polished on wet felt, using levigated alumina polishing compound. Three replicate counts of each otolith were made under a Zeiss[4] compound microscope with transmitted polarized light at 125–312×. If the three counts differed by more than 10% (which occurred in about 1 out of every 10 otoliths), an additional count was made and the outlier discarded. The three final counts were then averaged. The total length of each otolith was measured (nearest 0.1 mm) with a dissecting microscope using an ocular micrometer.

[4]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

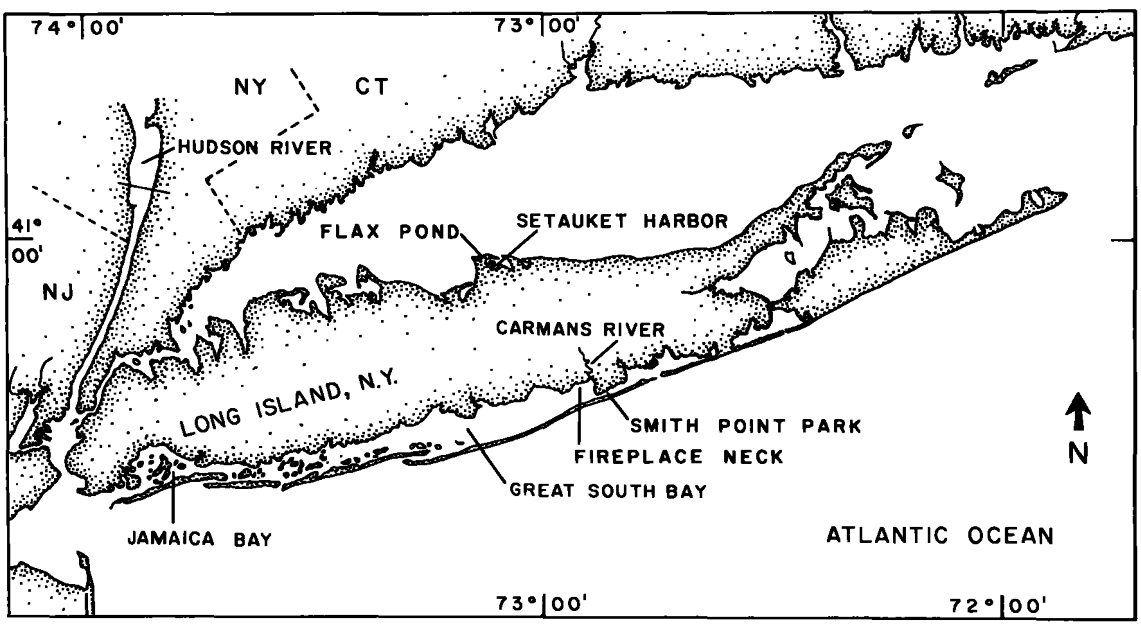


FIGURE 1.—Map of the study area with sampling locations as indicated.

## Frequency of Ring Deposition

The frequency of growth ring deposition was determined by marking the otoliths of fish with tetracycline and then subsampling the marked fish at various periods of time thereafter (Campana and Neilson 1982). Sixty YOY bluefish (7–10 cm FL) were captured by seine in Flax Pond, Old Field, NY (Fig. 1) and were transported to the Flax Pond Laboratory of SUNY Stony Brook. The fish were anesthetized in a solution of MS-222 (30 mg/L) and given an intraperitoneal injection of tetracycline (100 mg/kg of fish). After injection, all fish were placed in a 1.3 × 1.3 m cylindrical floating cage constructed out of 5 mm plastic mesh and anchored in Flax Pond. The fish were fed chopped *Menidia menidia* twice a day, and dead bluefish were removed daily. Samples of 5–10 healthy fish were periodically taken from the cage using a dip net and frozen until the otoliths could be excised. The experiment was terminated 61 days after the injections.

After preparation as described above, the tetracycline-treated otoliths were viewed on a Zeiss compound microscope using reflected ultraviolet (UV) light at 160–400×. Tetracycline fluoresces upon exposure to UV light, thus enabling the location of the marked ring to be determined. The UV light was then turned off, and the number of rings from the mark to the edge of the otolith was counted under transmitted white light. Each otolith preparation was coded so that the reader did not know the true age. Three replicate counts were conducted on each otolith.

# RESULTS

## Temporal Abundance and Length Frequency

### Great South Bay

The appearance of YOY bluefish in the shore zone was abrupt in both years of the study. In 1985, no YOY bluefish were caught in weekly samples until 28 May when a catch per unit effort (CPUE = no. fish per seine haul) of 14.0 was recorded (Fig. 2a). Corresponding water temperature was about 20°C. CPUE declined steadily thereafter through October with two exceptions: the large collections on 10 and 28 July were each due to an unusually large number of fish in single seine hauls in the Carmans River. In 1986, YOY bluefish were first caught on 10 June when the water temperature was 24°C. The maximum CPUE (45.3) was obtained on 16 June and was followed by a decrease in CPUE in subsequent collections (Fig. 2b).

Length-frequency distributions in 1985 showed the progression of a single mode through mid-August (Fig. 3a). Newly recruited fish in late May were 3–6 cm FL. Subsequent samples showed an increase in the mean and range of fish lengths, probably due to somatic growth of the initial recruits. There was no evidence of new 3–6 cm recruits entering the shore zone later in the year (Fig. 3a). Although seining continued until November, very few YOY bluefish were caught after August. An additional sample ($n$ = 8) taken on 16 September by angling from a pier on Great South Bay had a mean fork length of 17.8 cm and a range of 14.6–19.5 cm. Length-frequency data from 1986 (Fig. 3b) show a very similar pattern to that in 1985: a single length mode appears in June and these fish increase in size through the summer. Few YOY bluefish were caught in August, September, or October.

Size at recruitment to the shore zone was similar in both years of our study: mean length of the 1985 and 1986 year classes at first appearance in the shore zone was 4.6 and 4.5 cm respectively (Fig. 4). However, because the 1986 year class first appeared in the shore zone two weeks later than did the 1985 year class (Fig. 2), the mean lengths of 1986 year class were less than those of 1985 on comparable dates in June and early July. By mid-July, however, this difference in mean length of the two year classes was no longer apparent. Both year classes reached a size of about 13–14 cm by late August when they rarely appeared in our seine collections.

### Setauket Harbor

In 1986, the YOY bluefish did not appear on the north shore of Long Island at Setauket Harbor until 3–6 weeks after they first appeared in Great South Bay. Collections at Setauket Harbor were small at first with only one individual being caught on 1 July and three on 8 July. It was not until 22 July that catches similar in number to those in Great South Bay were being obtained. These fish had similar mean lengths (10.2 cm, $n$ = 87, on 22 July; 11.9 cm, $n$ = 22, on 5 August; 13.9 cm, $n$ = 17, on 20 August) to those on comparable dates from Great South Bay (cf. Fig. 4). Length-frequency distributions by date were unimodal.

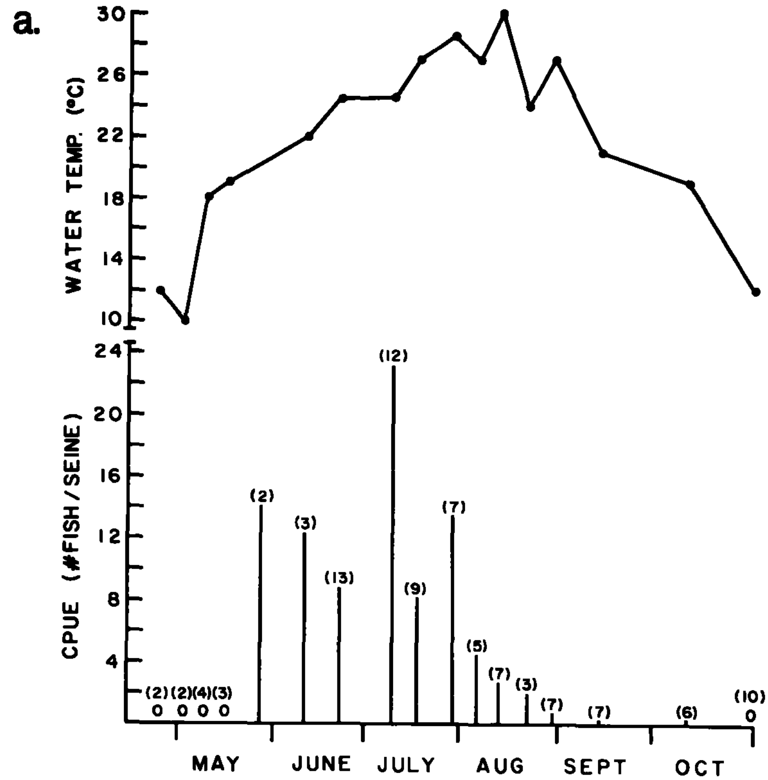


FIGURE 2.—Catch per unit effort (CPUE) of YOY bluefish from Great South Bay, NY, plotted with the mean water temperature

### Jamaica Bay and the Hudson River

The length-frequency distributions of YOY bluefish from Jamaica Bay in June, July, and August were similar to those from Great South Bay (Fig. 5). Fish lengths in June were unimodal. Subsequent collections contained progressively larger fish that were also unimodal in length distribution.

Sampling in the Hudson River began on 16 July 1986 and continued through 8 October. The size ranges of YOY bluefish in the July and August samples were similar to those from Great South Bay, although the length distribution on 30 July appears bimodal (Fig. 6). The length distributions from the 10 and 23 September collections were especially broad. In particular, the 23 September sample contained a group of fish that were much smaller (10–14 cm FL) than the mean size at this time in Great South Bay (Fig. 4), together with a second group of larger fish that correspond more closely in size with those collected elsewhere (18–24 cm).

## Frequency of Ring Deposition

In tetracycline-injected YOY bluefish, the number of rings beyond the tetracycline mark ($Y$) and the number of days after injection ($X$) had a 1:1 correspondence (Fig. 7). The relationship was described by the equation $Y = 0.971X - 0.287$ ($n = 27, r = 0.996$). The slope did not differ significantly from 1.0 ($t$-test, $P > 0.1$).

Growth rate of the caged fish was slightly greater than that of field fish and survival was high (80%) with mortalities occurring only in the first few days of the 61-d experiment. The increase in mean fork length was 1.7 mm/day among the caged fish, as compared with about 1.3 mm/day for fish from field collections during the same time period (Fig. 4). Hence, the caged fish did not appear to be adversely affected by confinement.

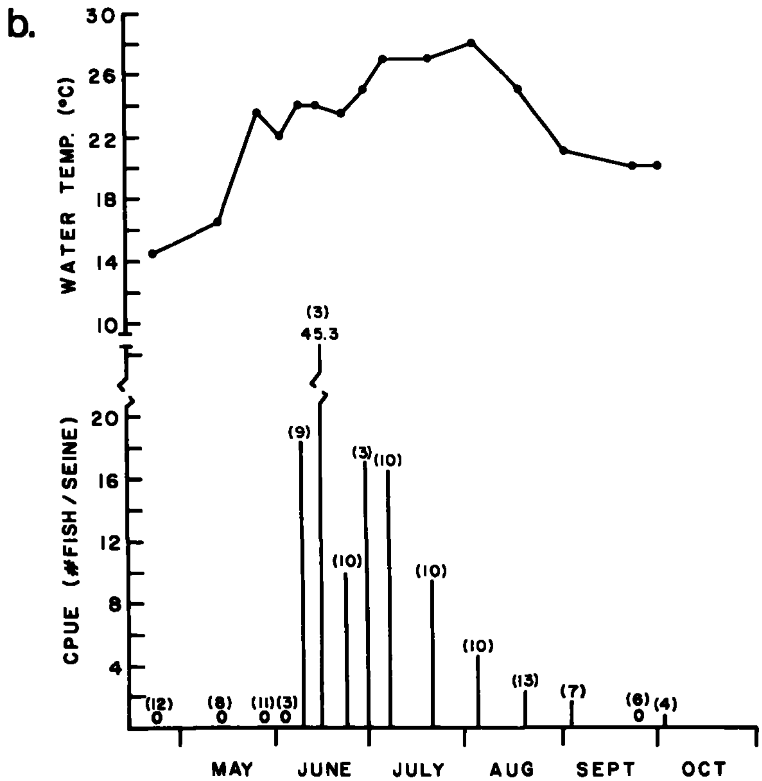


FIGURE 2.—*Continued*—on each sampling date. (a) 1985; (b) 1986. Number of seine hauls is in ().

## Back-Calculated Date of First Ring Deposition

A representative sample of 169 YOY bluefish ($n$ = 88 from 1985, $n$ = 81 from 1986) captured in Great South Bay were aged by counting the total number of otolith rings. The date of first ring deposition for each aged fish was then calculated based on the date of capture. In both 1985 and 1986, the dates of first ring deposition for YOY bluefish were predominantly in March and April (Fig. 8a, b).

Four fish from each of the two apparent length modes in the 30 July collection from the Hudson River (Fig. 6) were aged to determine if these represented a difference in spawning season. The fish examined were 7.8–13.8 cm in size, and back-calculated dates of first ring deposition extended from 7 to 30 April. Hence, these fish could all be attributed to the same spring spawning period as those from the south shore of Long Island.

However, YOY bluefish from the smaller (10–14 cm) size class caught on 23 September in the Hudson River (Fig. 6) were also aged and their back-calculated dates of first ring deposition were found to be predominantly in June and July, and to a lesser extent in May (Fig. 8c). These dates differed greatly from those of fish captured earlier in the year in the Hudson River, and along the south shore of Long Island.

The relationship of ring number and fork length for each year was best described by the following equations: $Y = 132.308X - 29.890$ in 1985 and $Y = 95.532X + 1.186$ in 1986, where $X$ is log fork length and $Y$ is the number of rings (Fig. 9). The slopes of these regressions differed significantly (ANCOVA, $P < 0.001$). Total otolith length and fork length were highly correlated ($r > 0.99$) and increased isometrically. Total otolith length and ring number also had a high correlation ($r = 0.91$).

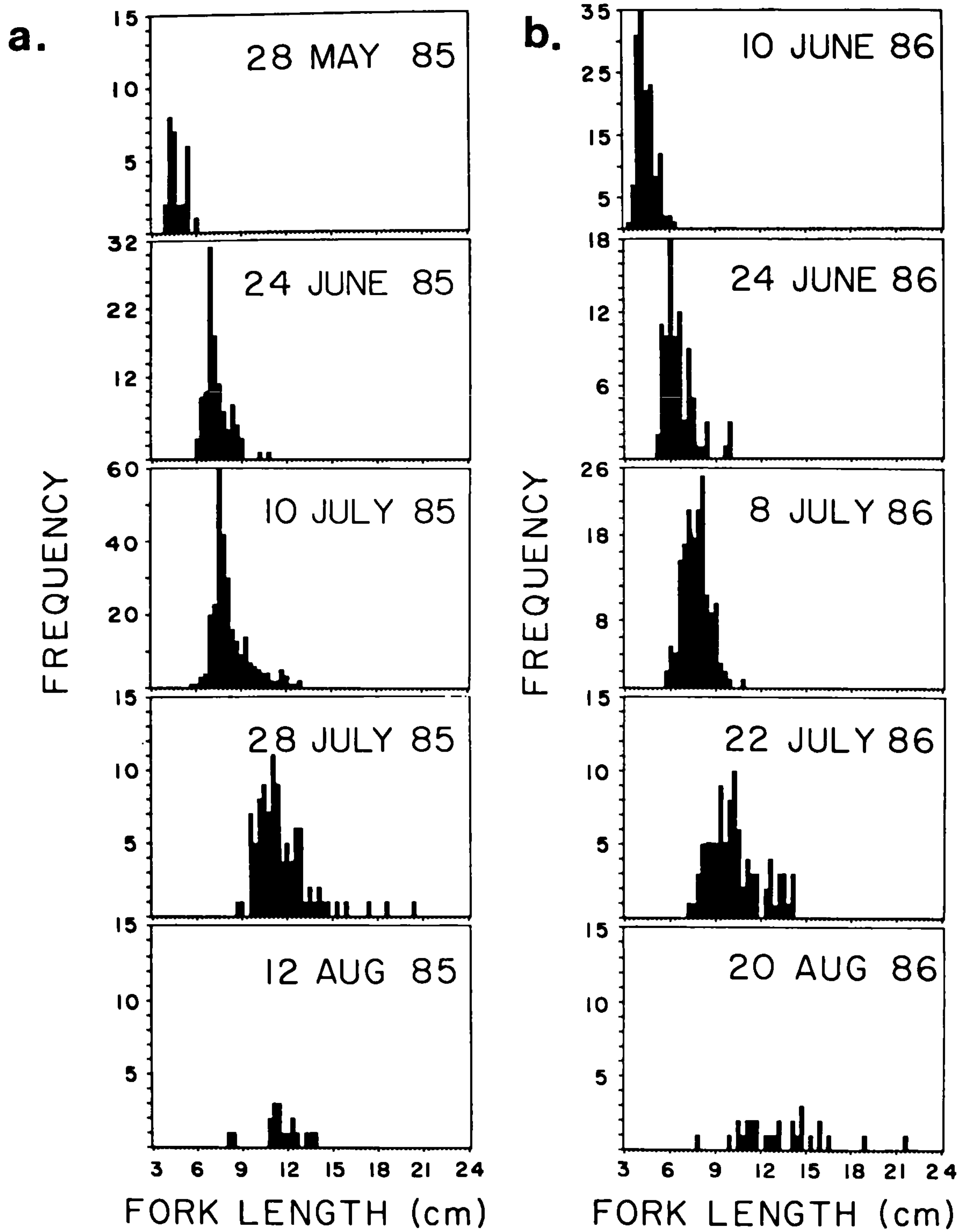


FIGURE 3.—Length-frequency histograms for YOY bluefish (no.) from Great South Bay, NY. (a) 1985; (b) 1986.

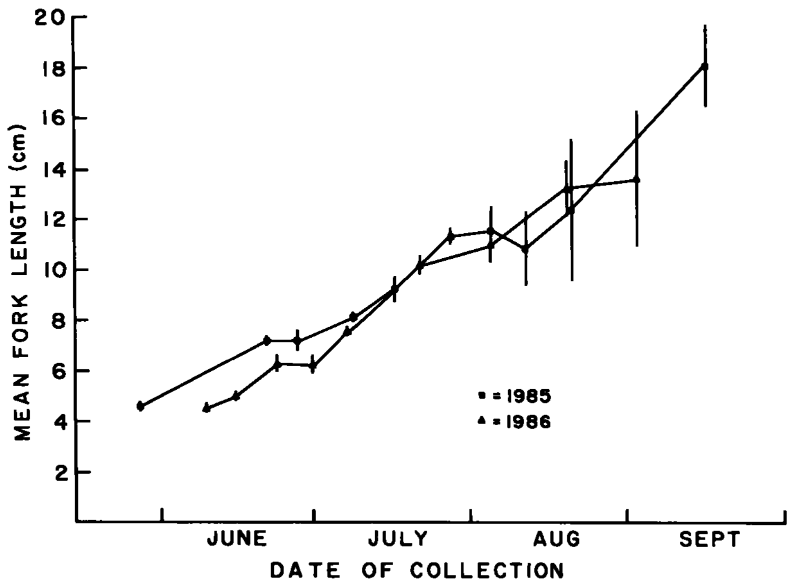


FIGURE 4.—Mean fork length (cm) of YOY bluefish (no.) captured with a beach seine in Great South Bay in 1985 and 1986. Vertical bars are 95% confidence intervals. The last sample in 1986 was caught by angling.

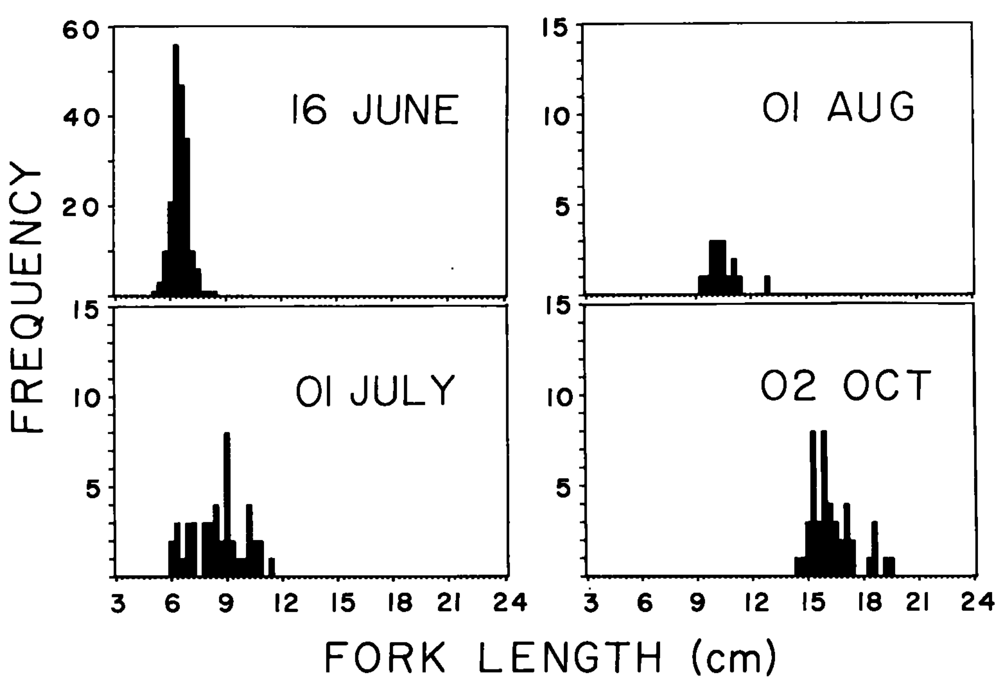


FIGURE 5.—Length-frequency distributions for YOY bluefish (no.) from Jamaica Bay, NY, 1986.

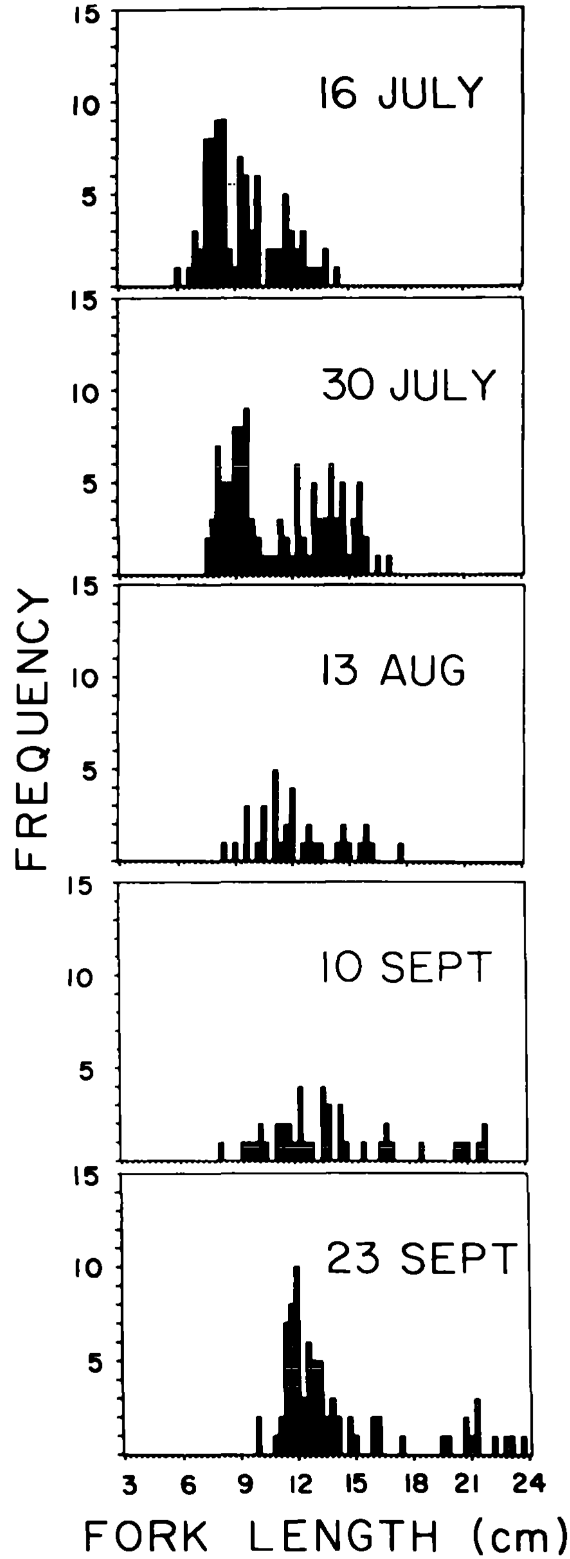


FIGURE 6.—Length-frequency distributions for YOY bluefish (no.) from the Hudson River, NY, 1986.

The analysis was then expanded to the remaining samples of YOY bluefish from Great South Bay that had not been aged. The above length-age equations were used to estimate date of first ring deposition from the dates of capture for all YOY captured in each year of sampling from Great South Bay. This exercise revealed that the vast majority of YOY bluefish in our collections from Long Island had dates of first ring deposition in late March, April, and early May (Fig. 10). The weighted mean date of first ring deposition was 8 April 1985 and 14 April 1986.

The age-length equations for YOY bluefish from Great South Bay were not applied to collections from Jamaica Bay or the Hudson River. Preliminary analyses suggested that the age-length equation for fish from the Hudson River differs substantially from those in Great South Bay, probably owing to a difference in growth rate. Geographic variation in the pattern of recruitment and in the age-length relationships of YOY bluefish are being further investigated.

## DISCUSSION

### Recruitment of YOY Bluefish to New York

In both 1985 and 1986, the arrival of YOY bluefish on the south shore of Long Island was abrupt. Within about a 1-wk period, CPUE went from 0.0 to 14–18 fish/seine haul. CPUE then remained high for the next two months until declining in August and September when the fish probably became too large to be efficiently sampled by our techniques. These data suggest that the YOY bluefish recruit to the shore zone as a sudden pulse. The timing of this recruitment event is apparently variable, differing by about two weeks among the two years of our study. The appearance of fish 3–6 weeks earlier on the south shore (Great South Bay) than on the north shore (Setauket Harbor) of Long Island suggested that these fish arrive from offshore waters to the south.

Temperature probably influenced the time of arrival of YOY bluefish in the shore zone. In both years of our study, YOY bluefish appeared as temperatures reached about 20°–24°C. In October, after temperatures dropped to the middle

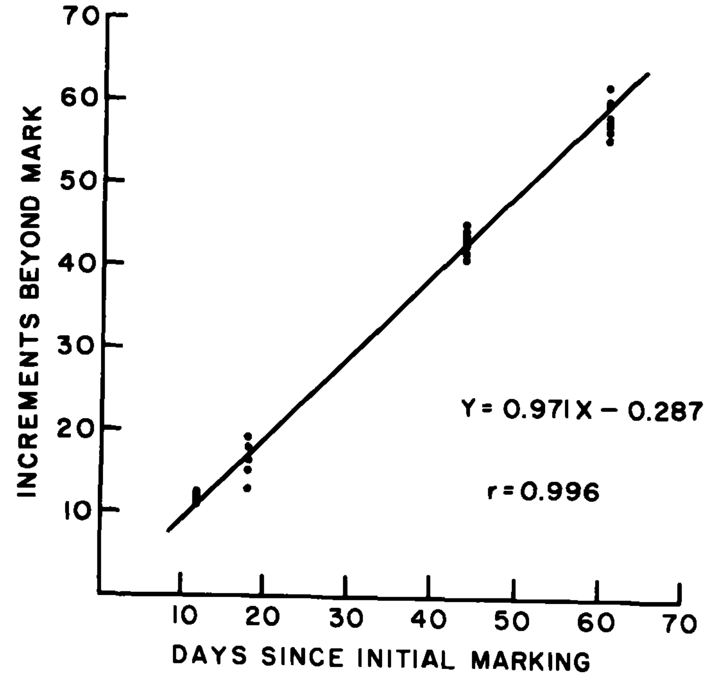


FIGURE 7.—Relation between number of days since marking with tetracycline and the number of growth increments beyond the mark in YOY bluefish maintained in a field cage.

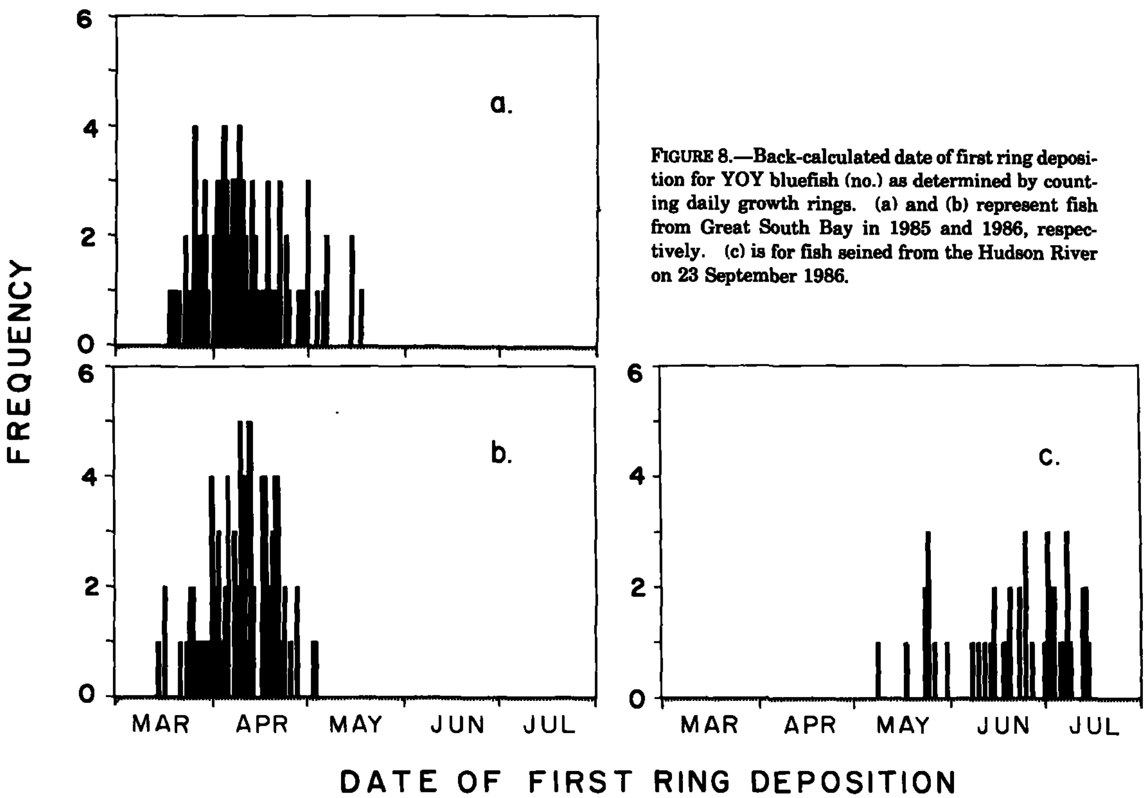


FIGURE 8.—Back-calculated date of first ring deposition for YOY bluefish (no.) as determined by counting daily growth rings. (a) and (b) represent fish from Great South Bay in 1985 and 1986, respectively. (c) is for fish seined from the Hudson River on 23 September 1986.

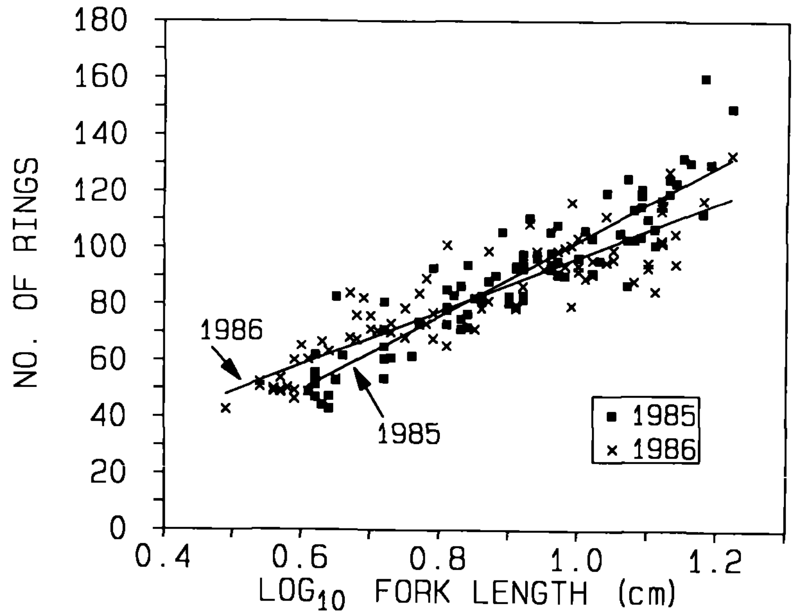


FIGURE 9.—Relation between log fork length ($X$) and number of otolith rings ($Y$) for YOY bluefish from Great South Bay, NY. The regression equations are $Y = 132.308X - 29.890$ ($n = 88$) for 1985 and $Y = 95.532X + 1.186$ ($n = 81$) in 1986.

teens, we no longer captured YOY bluefish. Oben (1957) noted that in the Black Sea, YOY bluefish appeared in the shore zone at temperatures of 18°–24.5°C, and left the shore zone in October and November when temperatures dropped to 13°–15°C.

Length-frequency distributions of YOY bluefish from the south shore samples showed only a single mode that attained progressively larger size through the summer and fall, and corresponded to the initial recruitment of fish. If multiple spawning and recruitment events contributed YOY bluefish to Long Island, multimodal length-frequency distributions should have been observed. The unimodal distributions suggested that only one spawning period contributed the majority of YOY bluefish to Long Island.

Interannual variation in the length-age relationship of YOY bluefish was observed. Although recruitment occurred two weeks earlier in 1985 than in 1986, the empirical mean lengths at recruitment were similar (Fig. 4). Postrecruitment growth, however, was slower in 1985 than 1986 so that empirical mean lengths became similar by mid-July. Correspondingly, the slope of the length-age regressions differed significantly among years: YOY bluefish at an age of about 50–70 days had greater fork lengths in 1985 than in 1986 (Fig. 9), but the reverse was true among older, larger fish. Apparently, the growth rate of YOY bluefish prior to recruitment was higher in 1985 than 1986, but this pattern among the two years was reversed during the period of postrecruitment growth.

## Validation of Daily Otolith Rings

Our experimental results demonstrate that otolith ring deposition is daily in YOY bluefish. A regression slope of 0.971 indicates a one-to-one correspondence between number of days after injection and the number of rings beyond the tetracycline mark. This outcome is not particularly surprising because numerous studies have shown that increment production is daily, particularly in the early life history when somatic growth is rapid (Brothers et al. 1976; Campana and Neilson 1985; Jones 1985). Cases where ring periodicity is reportedly less-than-daily have involved suboptimal growing conditions (Geffen 1982, 1987; Rice et al. 1985). In our study, the confinement of YOY bluefish in a field cage apparently had little effect on growth rate, or the production of daily growth increments. The field cage allowed for natural light, temperature, and salinity variations that the fish would normally have experienced in na-

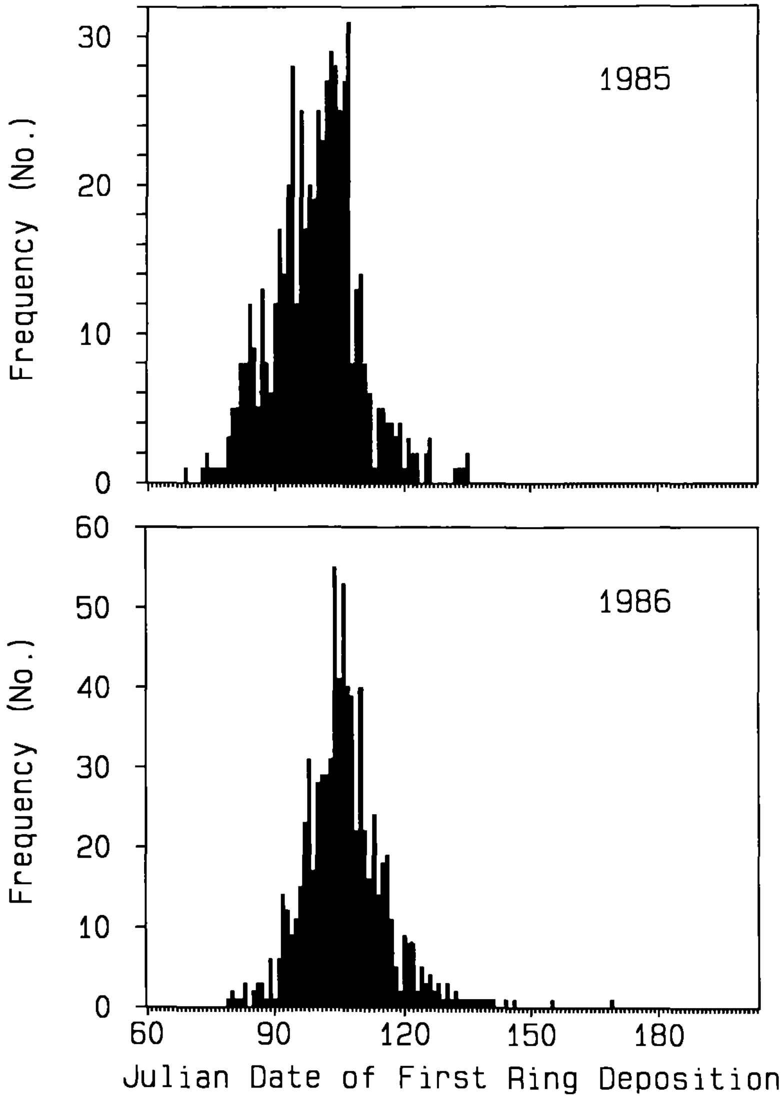


FIGURE 10.—Estimated date of first ring deposition for all YOY bluefish caught in Great South Bay in 1985 ($n$ = 561) and in 1986 ($n$ = 868) using the respective age-length equations in Fig. 9.

ture. Feeding periodicity was probably the primary artifact of confinement that could have affected the rate of ring production in caged fish. However, Marshall and Parker (1982) showed that feeding periodicity did not significantly affect ring production in sockeye salmon, *Oncorhynchus nerka*.

We were unable to determine directly the number of days between spawning and first ring deposition because numerous attempts to capture running-ripe females for initiating experiments on eggs and larvae were unsuccessful. However, most species of fish deposit the first daily growth increment within a few days of hatching (Brothers et al. 1976; Radtke and Dean 1982; McGurk 1984; Radtke 1984; Davis et al. 1985). Recent evidence suggests this is also true in bluefish. Larvae captured off Long Island in 1987 had about seven otolith increments at a total body length of 4–5 mm (R. K. Cowen and D. O. Conover, unpubl. data). Based on the rate of development at 20°C in the laboratory observed by Deuel et al. (1966), larvae would reach this size in about 5–7 days posthatch. If so, first ring deposition would roughly coincide with hatching. Bluefish hatch in 48 hours at 20°C (Deuel et al. 1966), so the day of first ring deposition probably follows the date of spawning by about 2–4 days.

## Spawning Seasons Along the Atlantic Coast

Published studies of larval bluefish distributions along the Atlantic coast suggest the existence of three temporally and spatially distinct spawning seasons: spring and fall spawning seasons in the South Atlantic Bight and a midsummer spawning in the Middle Atlantic Bight. In the only synoptic study covering most of the U.S. east coast, Kendall and Walford (1979) described two periods of high larval abundance: One peak occurred in March and April on the outer shelf of the South Atlantic Bight, and the other peak was in July and August midway over the continental shelf of the Middle Atlantic Bight. Subsequently, Powles (1981) and Collins and Stender (1987) also found the highest abundance of bluefish larvae in the South Atlantic Bight (Cape Canaveral to Cape Fear) to be in April and May. Collins and Stender, however, noted the existence of a lesser peak in larval abundance during September–November. This fall spawning season in the South Atlantic Bight was further confirmed by Finucane and Collins (in press) based on the gonad condition of bluefish from Georgia and the Carolinas. In the Middle Atlantic Bight off Virginia, Norcross et al. (1974) found that eggs and larvae of bluefish first appeared in June, peaked in abundance in July, and persisted into August. Similar observations on the timing of the summer spawning season in the Middle Atlantic Bight were presented by Sherman et al. (1984) and Morse et al. (1987).

Lassiter (1962) provided additional evidence of the existence of relatively discrete spawning seasons in bluefish. He showed that the distribution of back-calculated lengths at age one has a distinctly bimodal pattern among adult fish from North Carolina. Size at age 1 tended to be either about 14 cm or 28 cm. Lassiter showed that the bimodal pattern could not be explained as a difference in growth rate, and suggested that there must be two distinct spawning seasons such that one group of fish had a first growing season about twice as long as the other.

## Spawn Dates of YOY Bluefish from New York

Back-calculation to the day of first ring deposition for YOY bluefish recruiting to Great South Bay in 1985 and 1986 demonstrated that these fish were spawned primarily in March and April (Figs. 8, 10). Fish that were spawned in July–August were rarely captured by us on Long Island in 1985 or 1986, despite continued sampling into October.

Recruitment to Jamaica Bay and the Hudson River in July and August 1986 involved YOY bluefish of about the same size as those from Great South Bay. Though the size range of fish from the Hudson was slightly greater than those from Long Island, fish aged from each of the two modes appearing in the July Hudson River samples (Fig. 6) were all spawned during April within about three weeks of each other. The apparent bimodality in July is probably a sampling artifact. Hence, Jamaica Bay and Hudson River fish collected in July and August can be attributed to the same spawning season as those from Great South Bay.

Length-frequency distributions from the Hudson River in September, however, contained a group of unusually small bluefish, and back-calculation showed that they were spawned predominately in June and July (Fig. 8c). These fish probably resulted from the summer spawning season in the Middle Atlantic Bight. Examination of gonads from adult fish captured during 1986 suggested that the running-ripe males and mature females were most abundant during late June and July off Long Island (L. Chiarella and D. O. Conover, unpubl. data). Hence, at least, some summer-spawned YOY bluefish do recruit to the shore zone of the Middle Atlantic Bight. They were, however, much less abundant than spring-spawned YOY bluefish in our 1985 or 1986 samples.

Spawning by bluefish in the spring is known to occur only in the South Atlantic Bight (Kendall and Walford 1979; Collins and Stender 1987). Water temperatures over the shelf north of Cape Hatteras are probably too low for bluefish to spawn in March and April: average shelf water temperatures in the Middle Atlantic Bight range from 5° to 14°C in March and April (Ingham 1986). Virtually no eggs and larvae (Morse et al. 1987) and comparatively few adult bluefish (Gilmore 1985) are captured in plankton or trawl surveys north of Cape Hatteras in March and

April. Moreover, the time of arrival of YOY bluefish on Long Island actually precedes the summer spawning season in the Middle Atlantic Bight. We therefore conclude that YOY bluefish recruiting to the Middle Atlantic Bight in late spring come from spawnings in the South Atlantic Bight.

## Larval Transport

The physical mechanisms that account for the transport of bluefish larvae from the South Atlantic Bight to New York are not clear. Spawning in the South Atlantic Bight occurs primarily over the outer half of the continental shelf (Powles 1981; Collins and Stender 1987), and some larvae may be entrained by the Gulf Stream and carried northward into the slope waters of the Middle Atlantic Bight (Kendall and Walford 1979). Neuston net collections in April have shown that bluefish larvae are periodically abundant on both sides of the Gulf Stream-shelf water interface off Cape Hatteras (Kendall and Walford 1979). Collins and Stender (1987) found a negative correlation between larval size and latitude in the South Atlantic, but their sampling may not have extended far enough north (i.e., they did not sample above Cape Fear).

If the Gulf Stream is responsible for the northward transport, a mechanism by which larvae avoid being advected too far offshore would appear to be necessary. According to our results, the interval between spawning and recruitment to Long Island is about 45–60 days, whereas the surface flow of the Gulf Stream at lat. 36°N is about 104 km/day (Iselin 1936). Hence, larvae remaining in the Gulf Stream for an extended period would be transported far off the shelf. Retention near the shelf could be achieved by entering the slope waters at an appropriate time.

The abrupt appearance of YOY bluefish in the shore zone suggests that the onshore migration is a temporally distinct event, perhaps triggered by vernal warming of the shelf. Because the circulation of the slope and shelf waters of the Middle Atlantic Bight is toward the southwest (Sherman et al. 1984), the cross-shelf migration must to some extent involve active swimming.

Very few summer-spawned YOY bluefish were captured in our study. This may not be surprising, however, because the prevailing currents over the midshelf off Long Island would carry larvae to the southwest. If so, summer-spawned fish would be found along the coast from approximately New Jersey to Cape Hatteras. We caution, however, against any general conclusion concerning the lack of summer-spawned fish in New York. There could, for example, be substantial year-to-year variation in the recruitment level of spring- and summer-spawned fish along any particular segment of the U.S. coast. These issues are now being examined by extending our sampling to southern latitudes.

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