Abstract.—This study focuses on composite field collections and in situ observations from the mid-Atlantic Bight continental shelf and a New Jersey estuary in order to elucidate aspects of the early life history of age 0+ black sea bass, *Centropristis striata*. Spawning in the mid-Atlantic Bight is prolonged (April through November, with a peak between June and September) and is most intense in the southern portion of this range. Between 1977 and 1987, larvae were collected between Cape Hatteras, North Carolina, and Long Island, New York. In New Jersey coastal waters larvae first appear in July but can occur into November. Recently settled individuals (15–24 mm total length [TL]) were collected at an inner continental shelf site and an adjacent estuary from July through October. By fall, fishes from these areas were 18–91 mm TL, and many had moved offshore from New Jersey estuarine waters and other estuaries to inner continental shelf waters between southern Massachusetts and Cape Hatteras. Subsequently, they continued to move offshore and during their first winter, they were concentrated near the shelf or slope break in the southern portion of the mid-Atlantic Bight. Some age 0+ individuals moved back into New Jersey estuaries in early spring, at sizes approximating those of the previous fall (50–96 mm TL). Thus, black sea bass reach relatively small sizes after 12 months of growth partly because little or no growth occurs during their first winter. This year class reached sizes of 78–175 mm TL by midsummer and 134–225 mm TL by the following fall.

During summer, benthic juveniles were collected or observed primarily in a variety of structured habitats. On the inner continental shelf they were found among accumulations of surfclam *Spisula solidissima* valves or among smaller pieces of shell, and occasionally in burrows in exposed clay. While in the estuary, they were collected from areas with a variety of structured habitats, such as shell accumulations in marsh creeks and peat banks. The data suggest that during their first summer, black sea bass have similar densities and growth rates in estuarine and inner continental shelf habitats, and thus both areas serve as nurseries.

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Early life history of black sea bass, *Centropristis striata*, in the mid-Atlantic Bight and a New Jersey estuary*

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The black sea bass, *Centropristis striata*, is an important component of recreational and commercial fisheries along much of the east coast of the United States (U.S. Dep. Commerce, 1993). Despite its importance we know relatively little of the early life history of this species (Kendall, 1972). The best efforts to date are studies on larval distribution (Cowen et al., 1993), with comments on presumed estuarine nursery areas (Kendall, 1972), and studies on seasonal distribution and size attained at different seasons (Musick and Mercer, 1977) as well as at the end of the first year (Briggs, 1978). Faunal surveys in the mid-Atlantic Bight from Massachusetts (Lux and Nichy, 1971), New York (Perlmutter, 1939), New Jersey (Bean, 1888; Nichols and Breder, 1927), Maryland (Schwartz, 1961, 1964a), and Virginia (Hildebrand and Schroeder, 1928) have also contributed to our understanding of the seasonal distribution of juveniles. A general summary of the biology, population size, and fisheries is provided by Kendall and Mercer (1982).

In this study we limit our observations to black sea bass in the mid-Atlantic Bight, the area between Cape Cod and Cape Hatteras, because this population is considered a separate stock from those south of Cape Hatteras, North Carolina (Mercer, 1978; but see Bowen and Avise, 1990). This interpretation appears to be supported by studies that show movements inshore and north in spring and offshore and south in the fall within the mid-Atlantic Bight (Pearson, 1932; Nesbitt and Neville, 1935; Lavenda, 1949; June and Reintjes, 1957; Frame and Pearce, 1973) but only localized movements in the South Atlantic Bight (Parker, 1990; Low and Waltz, 1991). Recently, variations in meristic and morphometric characteristics have led to the suggestion that stock structure may not be homogenous within the mid-Atlantic Bight (Shepherd, 1991).

The objectives of this study are to elucidate aspects of the reproduc-

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tive periodicity, seasonal distribution, growth, and nursery habitats during the first year (age 0+) of black sea bass. We used composite data from a variety of field collections for larvae and juveniles, in situ observations on the mid-Atlantic Bight continental shelf, and intensive collections from a New Jersey estuary.

Materials and methods

Data sources for planktonic larvae and benthic juveniles (age 0+) from the mid-Atlantic Bight (Fig. 1) and southern New Jersey (Fig. 2) are summarized in Table 1. Larval sampling was conducted as part of the National Marine Fisheries Service (NMFS) Marine Resources Monitoring, Assessment, and Prediction (MARMAP) surveys (Sherman, 1980, 1986). Further details of the sampling methodology are provided by Sibunka and Silverman (1984, 1989) and Morse et al. (1987). Larval distribution and abundance are displayed as average number of larvae per 10 m^2 of sea surface calculated by month for the mid-Atlantic Bight study area for 1977–87. Larvae were also collected as part of a characterization of the Long-term Ecosystem Observatory (LEO-15) around Beach Haven Ridge off southern New Jersey (von Alt and Grassle, 1992) (Fig. 2). Samples were collected with an opening and closing Tucker trawl (1-m^2, 505-μ mesh) with multiple codends that were fished in a step-oblique manner from the surface to near bottom for 7.5–15 minutes. The mouth of the net was equipped with a flowmeter to determine the volume of water sampled.

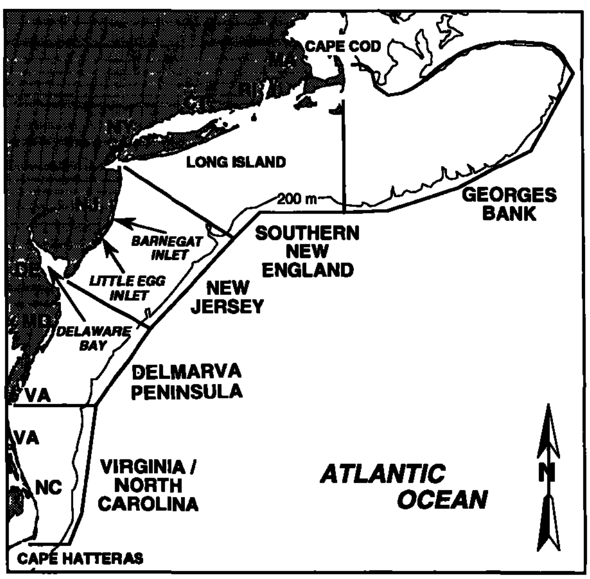

Figure 1
Collection sites for larval and juvenile black sea bass, *Centropristis striata*, in the mid-Atlantic Bight.

Age 0+ juveniles, as determined from length frequencies, were collected from the mid-Atlantic Bight continental shelf during the NMFS-Northeast Fisheries Science Center (NEFSC) bottom trawl surveys. Samples were collected at stratified random stations between Cape Hatteras, North Carolina, and Nova Scotia on the continental shelf. Details of the sample distribution and technique are provided by Azarovitz (1981). Seasonal sampling occurred during fall (September–October), winter (January–February) and spring (March–April). After additional depths were stratified, random sampling occurred seasonally with otter trawls in inshore continental shelf waters off Massachusetts by the Massachusetts Division of Marine Fisheries (MADMF) (Howe, 1989) and off New Jersey by the New Jersey Department of Environmental Protection (NJDEP) (Byrne[1]; Byrne et

[1] Byrne, D. M. 1988. Inventory of New Jersey's coastal waters. New Jersey Division of Fish, Game, and Wildl., Trenton, NJ, 3 p.

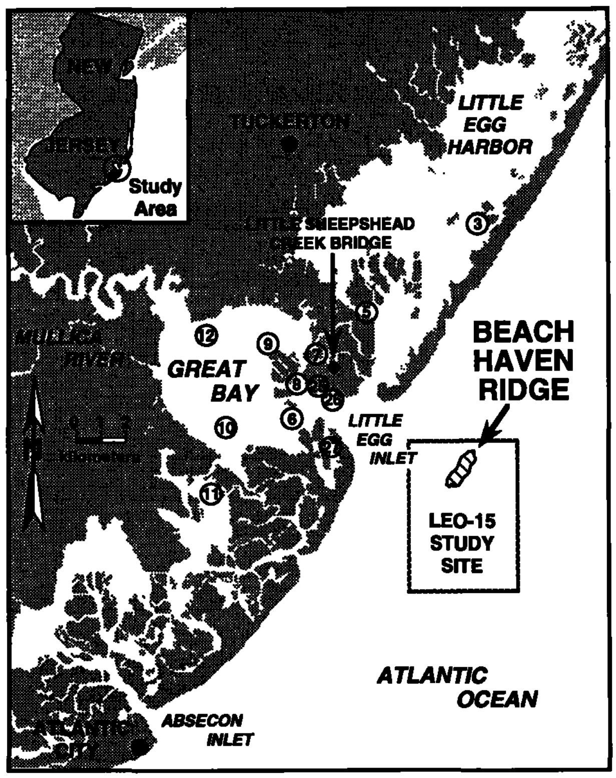

Figure 2
Collection sites for larval and juvenile black sea bass, *Centropristis striata*, from inner continental shelf and estuarine study areas off southern New Jersey. Circled numbers indicate otter trawl sampling sites; number 25, however, is the location of trapping sites at Rutgers University Marine Field Station. Little Sheepshead Creek is the location of the plankton sampling site. LEO-15 = Long-term Ecosystem Observatory.

Table 1

Summary of data sources for larval and juvenile (age 0+) black sea bass, *Centropristis striata,* examined during this study. See Figures 1 and 2 for study areas.

Study area	Sampling method	Sampling period	Sampling depths	Frequency of sampling	Sources
Great Bay–Little Egg Harbor, New Jersey	Plankton net (1 m, 3-mm mesh)	1989–91	0–4 m,	Weekly	Witting, Able, and Fahay, unpubl. data
	Otter trawl (4.9 m, 6-mm mesh codend)	1989–91	1–8 m	Monthly	Szedlmayer and Able[1]
	Traps (6-mm mesh)	1991–92	1-3 m	Daily-weekly	This study
Vicinity of Beach Haven Ridge, off southern New Jersey	Tucker trawl (1 m, 1-mm mesh)	1991–92	0–15.5 m	Bimonthly-monthly	This study
	Beam trawl (2 m, 6-mm mesh)	1991–92	6–23.5 m	Bimonthly-monthly	This study
	Otter trawls (7.6 m, 13-mm mesh codend)	1974	2–19 m	Monthly	Milstein and Thomas, 1977
	In situ observations with SCUBA	1992	10–20 m	Variable during summer	This study
Mid-Atlantic Bight	Otter trawl (10.4 m, 12.5-mm mesh)	1982–90	9–365 m	Seasonal	Azarovitz, 1981
	Bongo plankton nets (61 cm, 505-μ mesh)	1977–87	8–1,500 m	Monthly-bimonthly	Sibunka and Silverman, 1984
Nearshore off Massachusetts	Otter trawl (15 m, 12-mm mesh codend)	1982–90	7–147 m	Seasonal	Howe, 1989
Nearshore off New Jersey	Otter trawl (30 m, 6-mm mesh codend)	1988–91	5–27 m	Seasonal	Byrne (Footnotes 1 and 2 in the text)

[1] Szedlmayer, S. T., and K. W. Able. Patterns of seasonal availability and habitat use by fishes and decapod crustaceans in a southern New Jersey estuary. In review.

al.[2]). More temporally intensive sampling with beam trawls (2-m, 6-mm mesh) was conducted outside Little Egg Inlet in southern New Jersey in the vicinity of Beach Haven Ridge at the LEO-15 site (Fig. 2). Additional length-frequency information was adapted from an environmental impact study in 1974 at this site (Table 1). In the Great Bay-Little Egg Harbor estuarine system (Fig. 2), juveniles were collected with otter and beam trawls and traps over several years in a variety of habitats and depths (Table 1). For all samples, larval size was recorded as notochord length (NL) or standard length (SL), and juveniles as total length (TL).

Visual observations and video records of juveniles and available habitat at several locations in the study area in inner continental shelf waters were made during 1991 and 1992 (Table 1). Near Beach Haven Ridge, 30-m transects were made across a variety of habitat types during 1992.

[2] Byrne, D. M., A. W. Burnett, and D. J. Vareha. 1990. Inventory of New Jersey coastal waters. New Jersey Div. Fish, Game, and Wildl., Trenton, NJ, 39 p.

Results

Temporal and spatial distribution of larvae

Black sea bass reproduction throughout the mid-Atlantic Bight occurs over a fairly prolonged period on the basis of occurrence of larvae from April through November (Fig. 3; Table 2). It appears that reproduction progresses seasonally from south to north on the basis of collections off Virginia and North Carolina as early as April, and off New Jersey and Long Island beginning in July (Fig. 3). The smallest larvae (2–3 mm NL) occurred off New Jersey from July through October (Table 3). At Beach Haven Ridge off southern New Jersey, larvae (4–12 mm TL) were collected in late July and early August.

Larvae occurred in samples from April through November and into January in the mid-Atlantic Bight, although their occurrence varied with geographic location (Table 2; Fig. 3). For all regions, the peak in abundance was from July through September or October (Table 2). The largest larvae collected

Table 2

Abundance of black sea bass, *Centropristis striata,* larvae in the mid-Atlantic Bight expressed as no./10 m^2 of sea surface by month and area during 1977–87. Areas are indicated in Figure 1.

Area	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Georges Bank									6		
Southern New England				4	22	88	42				
New Jersey			7		110	370	150	216	5		
Delmarva				79	376	1672	670	15	8		
Virginia/North Carolina		126	76	100	534	1561	502	53	16		20

Table 3

Monthly totals of black sea bass, *Centropristis striata,* larvae by length collected over the continental shelf off New Jersey during 1977–87. Total number of stations refers to collections containing black sea bass larvae.

Month	Total number of stations	Length (mm NL) 2	3	4	5	6	7	8	9	10	Total number of larvae
April	—										
May	1								1		1
June	—										
July	12		3	5	7	3		1			19
August	31	15	66	36	18	13	3	1			152
September	18	2	22	13	6	5	3			1	52
October	13	3	23	12	11	10	2				61
November	2						1	1			2
Totals	77	20	114	66	42	31	9	3	1	1	287

were 8–10 mm NL but most were <8 mm NL. The larvae were distributed across much of the mid-Atlantic Bight continental shelf; the greatest abundance occurred between Cape Hatteras and Delaware Bay (Fig. 3). At the northern limit of occurrence, off New Jersey and Long Island, larvae were most abundant on the inner half of the continental shelf. Only a few larvae were found north and east of the eastern end of Long Island (July, Fig. 3). A single 6.4-mm larva was collected on Georges Bank in November 1982. During weekly night-time sampling in the Great Bay estuary at a site just inside Little Egg Inlet, New Jersey (Table 1; Fig. 2), larvae were never collected during the period from 1989 to 1991 (Witting et al.[3]).

[3] Witting, D. A., K. W. Able, and M. P. Fahay. Marine Field Station, Institute of Marine and Coastal Science, Rutgers Univ., Tuckerton, NJ 08087. Unpubl. data.

Temporal and spatial distribution of benthic juveniles

Benthic age 0+ individuals smaller than 25 mm TL were collected from both inner continental shelf (Beach Haven Ridge) and estuarine (Great Bay) habitats from July through October (Figs. 4–6). Collections from these areas indicate that two length modes occurred during the summer and fall of 1992. The first mode appeared in late July and could be followed through the fall when the fish have reached lengths >50 mm TL. The second mode appeared at the inner shelf site in late September at sizes >10 mm TL. This group reached an apparent minimum size of 30 mm TL by the fall (Fig. 4).

Movement out of the estuary in the fall is indicated by the reduction in the number of age 0+ individuals by November-December (Figs. 4–6). This same pattern of movement out of the estuary also was reflected in the catch per unit of effort (CPUE)

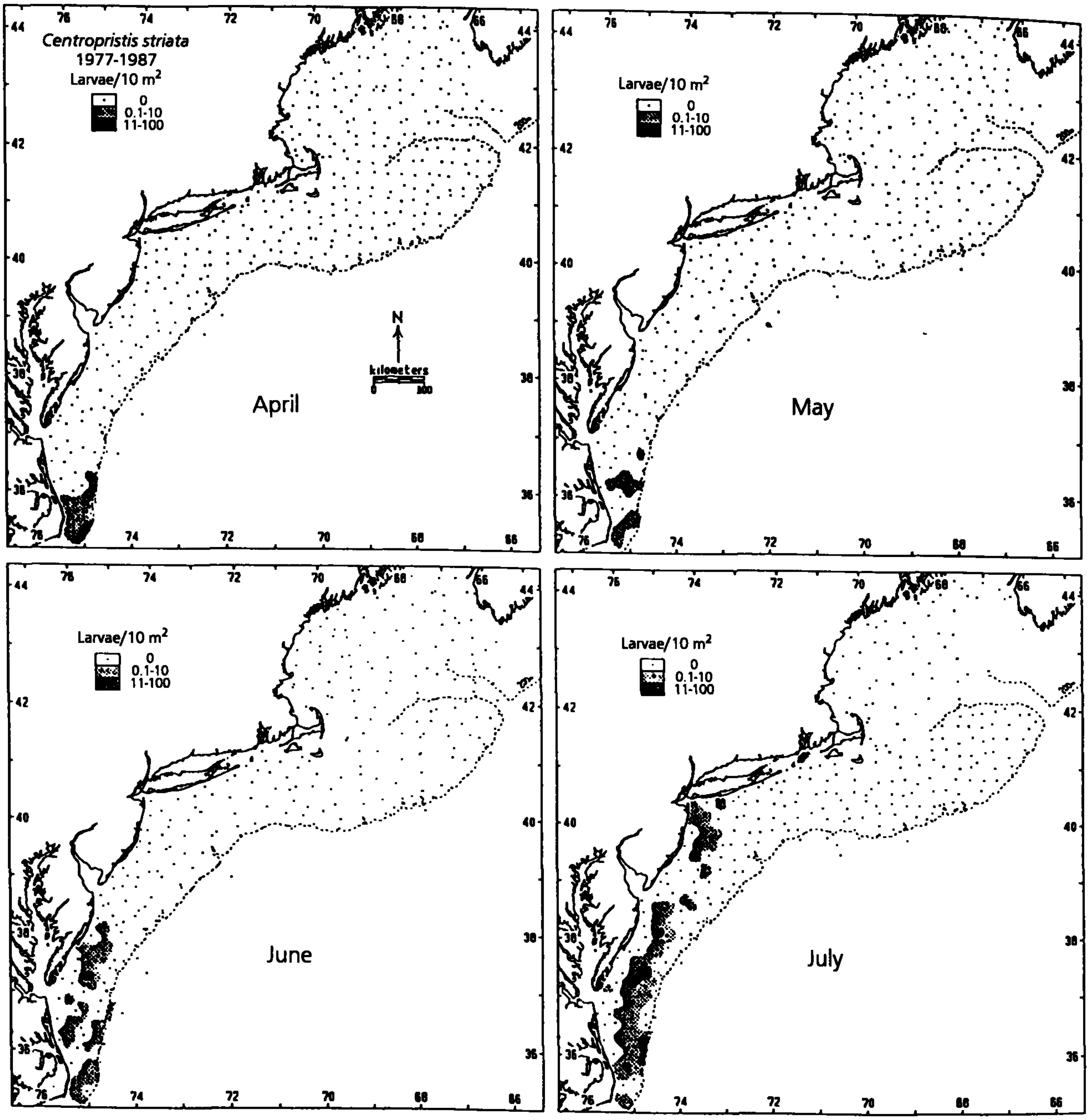

Figure 3
Monthly distribution and abundance of black sea bass, *Centropristis striata*, larvae in the mid-Atlantic Bight based on NMFS-MARMAP surveys during 1977–87.

from trap collections in the Rutgers University Marine Field Station (RUMFS) boat basin in 1992 (Fig. 7). At the same time, catch rates increased dramatically, compared with those for summer, on the inner continental shelf off New Jersey (Fig. 8), owing, presumably, to the addition of individuals moving from the estuary as well as to recently settled fishes. Age 0+ individuals were absent in the winter. Catches at Beach Haven Ridge were zero from December through February and few individuals were caught in March (Fig. 7) in 1991 and 1992. Catches increased in April or May, or during both months, depending on the year, and then decreased through the spring and early summer. This same general seasonal pat-

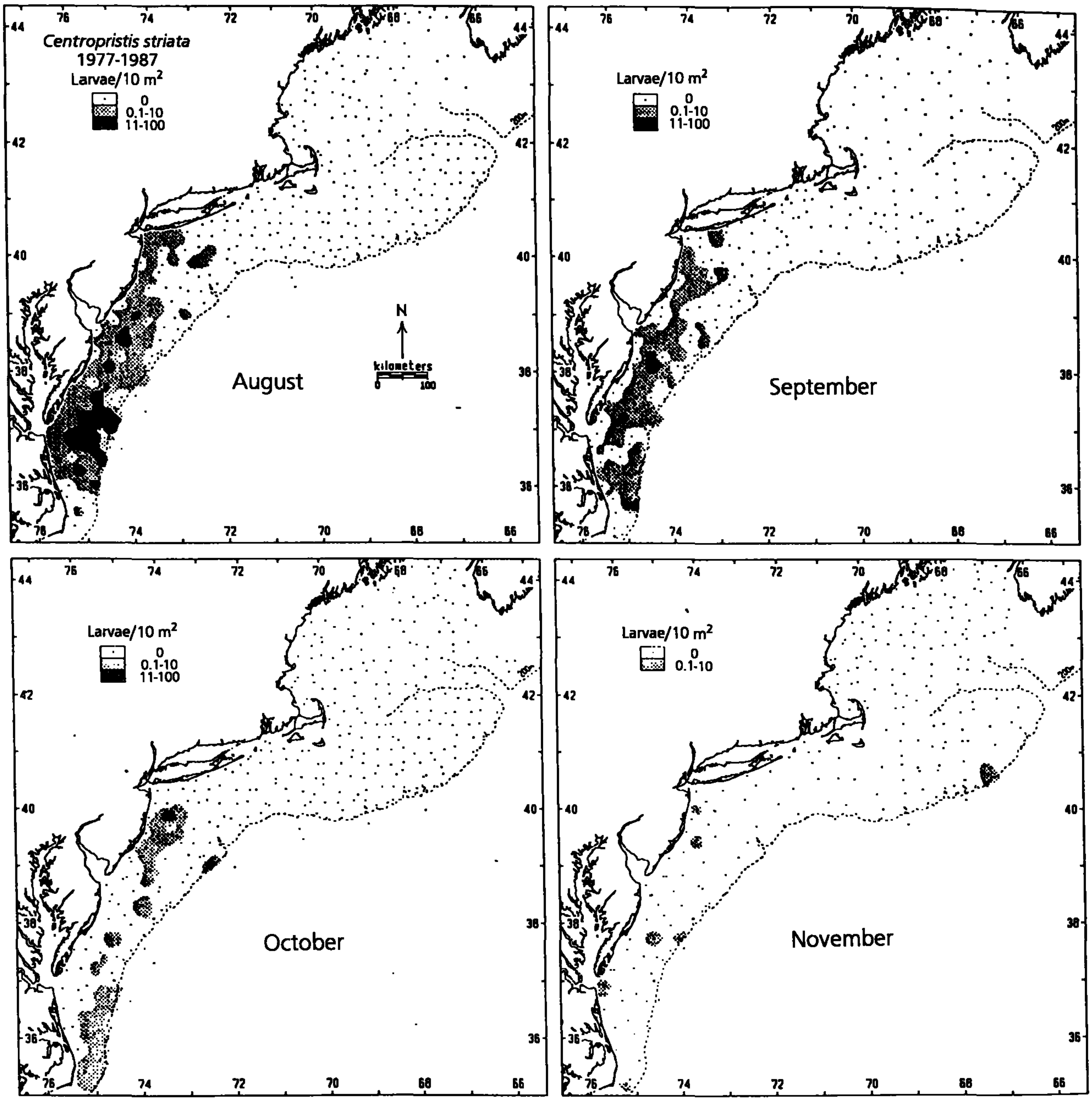

Figure 3 (continued)

tern occurred in the Great Bay estuary between 1988 and 1992 (Fig. 5) and during 1974 (Fig. 6) when most individuals were present from March through May and from August through November and were absent during the winter.

Fall otter trawl sampling from the continental shelf off New Jersey (Fig. 8) and from elsewhere in the mid-Atlantic Bight (Fig. 9) collected age 0+ individuals of the same lengths (3–9 cm TL) as those in the fall estuarine sampling (September and October, Figs. 4–6). These individuals were distributed throughout the inshore portions of the mid-Atlantic Bight (Figs. 8 and 10). Interestingly, the largest collections of age 0+ individuals were taken off eastern Long Island, Rhode Island, and off Massachusetts, both north and south of Cape Cod (Fig. 10). These are areas where larvae were virtually absent in extensive collections between 1977 and 1987 (Fig. 3).

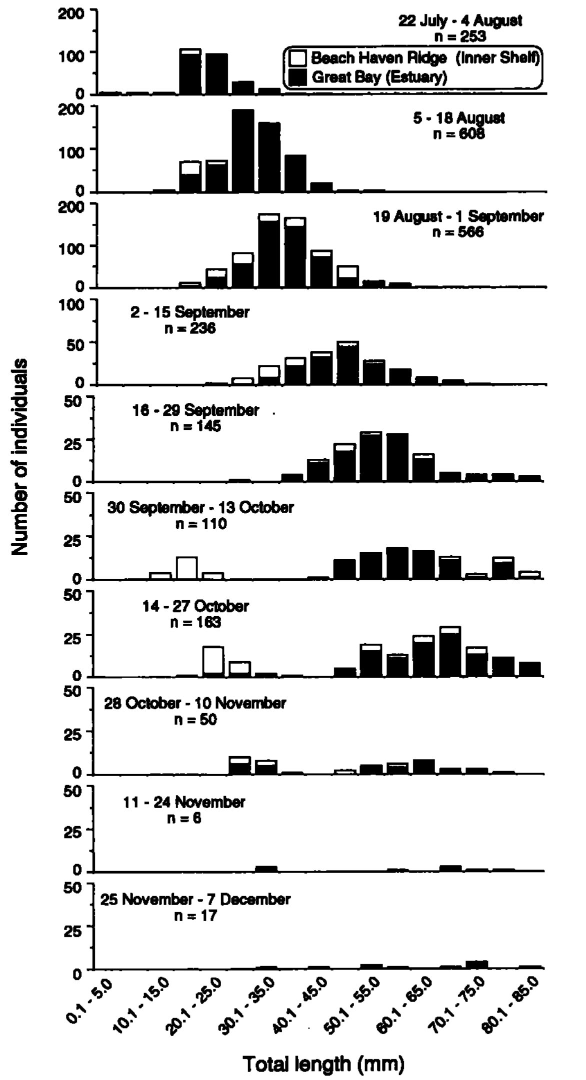

Figure 4

Occurrence and length of black sea bass, *Centropristis striata*, larvae and juveniles collected near Beach Haven Ridge (in plankton, beam trawl, and trap samples) on the inner continental shelf and in the Great Bay estuary (in trap samples) during 1992. See Figure 2 for localities.

Large numbers of 0+ individuals were found in intensive fall surveys in shallower inner continental shelf waters off Massachusetts (Figs. 9 and 10). In the winter, no age 0+ individuals were collected in inner continental shelf waters off New Jersey (Figs. 8 and 10). Most individuals in the winter (January–February) offshore surveys were collected near the edge of the continental shelf. In spring (March–April) surveys over the continental shelf, age 0+ individuals were evident over most depths. Most of these fish were found south of Delaware Bay (Fig. 10), some at a variety of depths off New Jersey. No individuals were collected in inshore spring (April–May) surveys of Massachusetts coastal waters.

Growth

The 1992 year class attained sizes of 18–101 mm TL by October after spawning, which occurred primarily in August (Figs. 4 and 5; Tables 2 and 3). Our estimates of growth rate are confounded somewhat by the occurrence of two length modes of 0+ benthic juveniles (Fig. 4), but calculations, based on the progression of these modes through October, yielded growth rate estimates of 0.45 mm/day for the first and 0.42 mm/day for the second length mode. The 1974 year class appeared to have reached similar lengths by the fall (Fig. 6). In both 1974 and in more recent year classes, sizes of fall fish and those reappearing the following spring were similar (Figs. 5 and 6), indicating very little growth over the intervening winter.

Growth resumed at a relatively fast rate in the spring and continued through the summer. Based on monthly increases (April–September, Fig. 5) in mean size, growth rate was 0.77 mm/day during the period. By July, approximately one year after spawning, these fish were 70–180 mm TL (Fig. 5). By September, when these fish were approximately 14–17 months old, they were 134–251 mm TL. A similar pattern was evident for 1974 (Fig. 6).

Habitat

Juveniles (age 0+) were collected and observed in a variety of habitat types both on the continental shelf and in the estuary. Densities of age 0+ individuals were similar between the inner continental shelf (Beach Haven Ridge) and estuarine study sites in the fall (August and September). When all the values for all habitats were combined, they were virtually identical with 0.33 (±0.007) ind·m^{-2} in the estuary (1-m beam trawl, n=144) and 0.32 ind·m^{-2} (±0.006) on the inner continental shelf (2-m beam trawl, n=57) (Table 1). Age 0+ individuals, both on the inner shelf and in the estuary, were found in habitats with some structure. Visual observations and video records provided evidence that individuals occurred in large linear accumulations or "windrows" of the Atlantic surfclam valves, *Spisula solidissima*, during the day in depths of 14–20 m on the inner continental shelf near Beach Haven Ridge in 1991 and 1992 (Petrecca[4]). Estimates made from video-

[4] Petrecca, R. Institute of Marine and Coastal Sciences, Rutgers Univ., New Brunswick, NJ 08903. Personal commun., 1992.

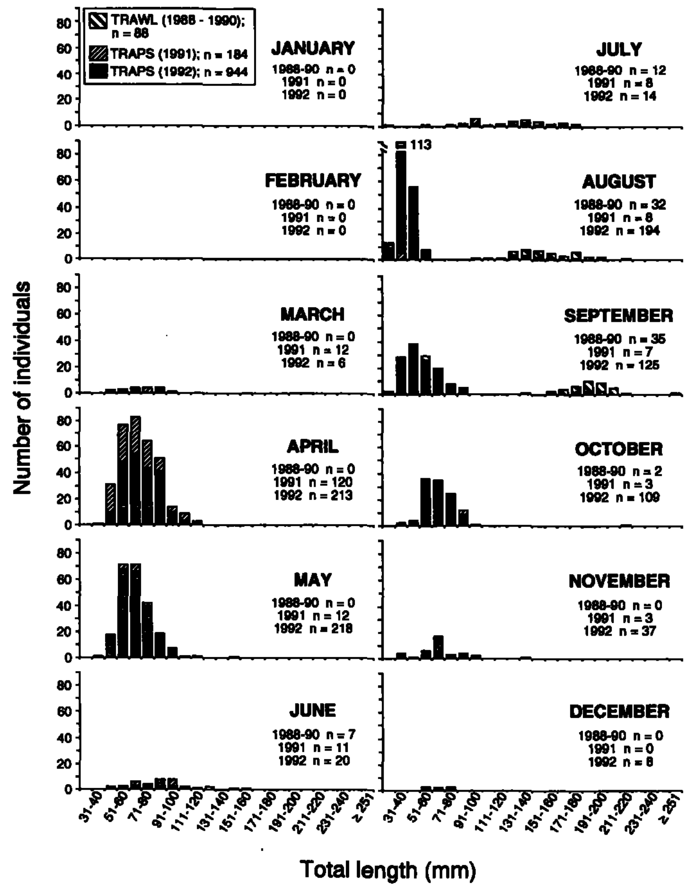

Figure 5

Monthly length frequencies of black sea bass, *Centropristis striata*, from the Great Bay-Little Egg Harbor estuarine system during 1988–92.

tapes taken during 1991 indicated that there were as many as five individuals/m^2 in the surfclam shell habitat. During the same periods they were not observed in adjacent open sand bottom, sand with pronounced megaripples, nor in exposed clay substrate habitats. In situ observations at other locations found age 0+ individuals at a number of continental shelf sites off Barnegat Inlet, New Jersey, in 19–26 m depths. In many of these instances the juveniles were associated with broken mollusk shells on the bottom and were seldom seen over sand substrate without shells (Witting[5]).

In the Great Bay-Little Egg Harbor estuary system (Fig. 2), patterns of habitat use for age 0+ black sea bass were derived primarily from beam trawl catches in 1992 (Fig. 11). They were most abundant in habitats (Fig. 2) with sand and shell (Stn. 5) and in habitats with sand with seasonally varying amounts of amphipod (*Ampellisca*) tubes (Stn. 9). They also occurred frequently in channels with silt substrate (Stn. 10), over silt and shell (Stn. 12), over bare sand (Stn. 8), over sand with seasonally occurring macroalgae (*Ulva lactuca*) (Stn. 11), in marsh creeks (Stns. 25–27), and were less abundant in an area with extensive hydroids (Stn. 6). They were absent in eelgrass (*Zostera marina*, Stn. 3) and in a habitat mixture of sand, shell, sponge, and peat (Stn. 7). All of these habitats were located at depths of 1–8 m in the polyhaline portion of the lower estuary. Separate trap sampling in marsh creeks directed at deep holes (2–3 m) confirmed the presence of age 0+ individuals in these holes but not in uniform, shallow areas (approx. 1 m).

Temperatures of areas where juvenile black sea bass occurred varied seasonally. In the estuary at

[5] Witting, D. A. Marine Field Station, Institute of Marine and Coastal Sciences, Rutgers Univ., Tuckerton, NJ 08087. Personal commun., 1994.

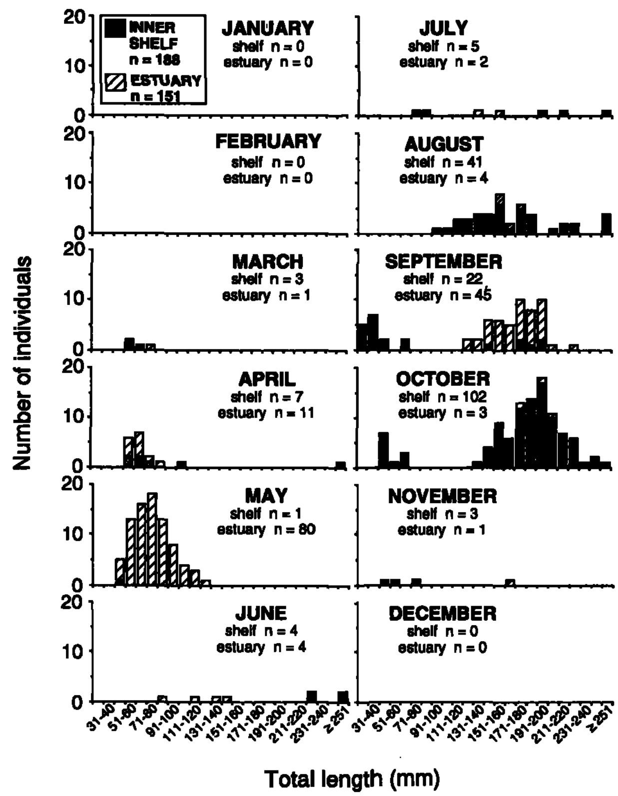

Figure 6

Monthly length frequencies, based on otter trawl collections, of black sea bass, *Centropristis striata*, from the inner continental shelf in the vicinity of Beach Haven Ridge and Great Bay-Little Egg Harbor estuary during 1974.

the time of first spring collections, temperature was approximately 10°C for individuals age 1+ (approximately 9 months old), whereas in the summer temperature was approximately 23°C for age 0+ individuals (Fig. 7). In the vicinity of Beach Haven Ridge, the age 0+ individuals first occurred at approximately 15°C and were most abundant when bottom temperatures reached 20°C (Fig. 7). Over the continental shelf in the fall, the age 0+ cohort was collected primarily at bottom temperatures of 14–17°C (Fig. 12) and at higher average temperatures of 16–21°C in Massachusetts inshore waters (Fig. 12). During winter, most individuals were collected at 6–9°C (Fig. 12), a temperature that probably reflects their greater abundance in deeper waters at that time (Fig. 10). In the spring, this same cohort was abundant at 6–11°C and 15–17°C. In every instance on the continental shelf, with the possible exception of inshore Massachusetts, the fish were found at higher average temperatures than those represented by most of the stations sampled (Fig. 12).

Discussion

Annual cycle in the early life history

Spawning of black sea bass in the mid-Atlantic Bight proceeds from south to north, presumably with warming temperatures. Our interpretation of this geographical pattern is based on extensive collections during 1977–87 and is consistent with that reported for 1966–67 (Kendall, 1972; Kendall and Mercer, 1982). The occurrence of larvae of all sizes in all areas suggests that spawning and development occurs throughout most of the mid-Atlantic Bight. In addition, most larvae were <8 mm TL in our continental shelf collections and were similar to those

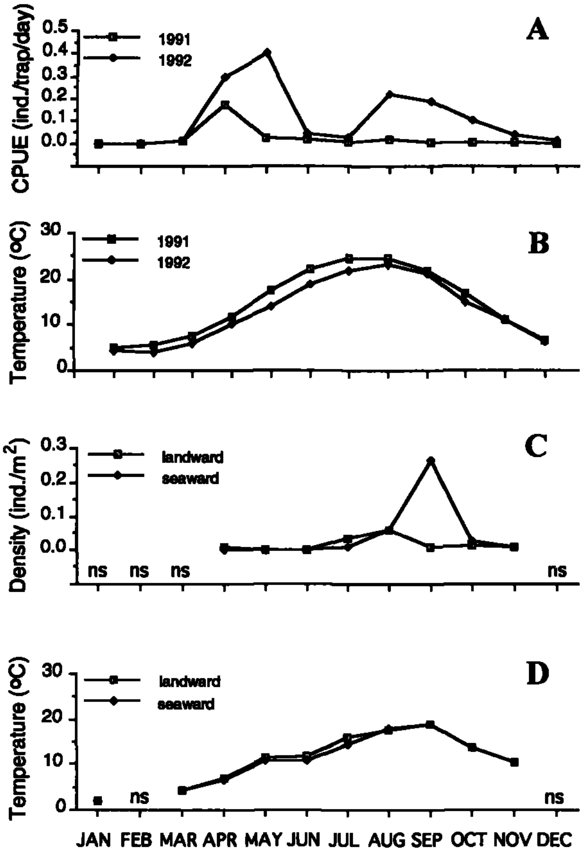

Figure 7

Monthly averages of abundance of age 0+ black sea bass, *Centropristis striata*, and temperature in the estuary (**A** and **B**) and on the inner continental shelf in the vicinity of Beach Haven Ridge (**C** and **D**). Abundance was based on trap collections in the estuary and on beam trawl sampling landward and seaward of the ridge.

reported by Kendall (1972). Thus, black sea bass may settle to the bottom at sizes between 10 and 16 mm TL. This size range also corresponds to the size at which ossification of fin rays and vertebrae is completed (Kendall, 1972). The smallest individual previously reported from the continental shelf was one of 43 mm (Massman et al., 1962). Settlement on the inner continental shelf and in the estuary occurred from July through October according to our estimations based on collections of small individuals (<20 mm TL) throughout that period (Fig. 4). The identification of two length modes during 1992 in both the estuary and on the inner continental shelf (Fig. 4) was not as obvious at the same continental shelf location in 1991 when small juveniles (10–20 mm TL, n=35) occurred from August through October. On the basis of consistent occurrence of age 0+ individuals, it is evident that both the inner continental shelf and estuaries function as nurseries (see below) during the first summer and fall.

Black sea bass (age 0+) appear to leave the estuary and the inner continental shelf off New Jersey during the fall and to move to deeper waters as indicated by the decline in CPUE in the estuary, by the simultaneous increase in numbers on the inner shelf, and by the subsequent complete disappearance of fish from both of these areas by winter. This pattern is evident on the continental shelf throughout the mid-Atlantic Bight from fall collections of the same year class, especially south of Delaware Bay (Fig. 10) as previously observed (Musick and Mercer, 1977). These movements are likely initiated in the fall by decreasing temperatures as suggested by the decrease in fish abundance with declining estuarine

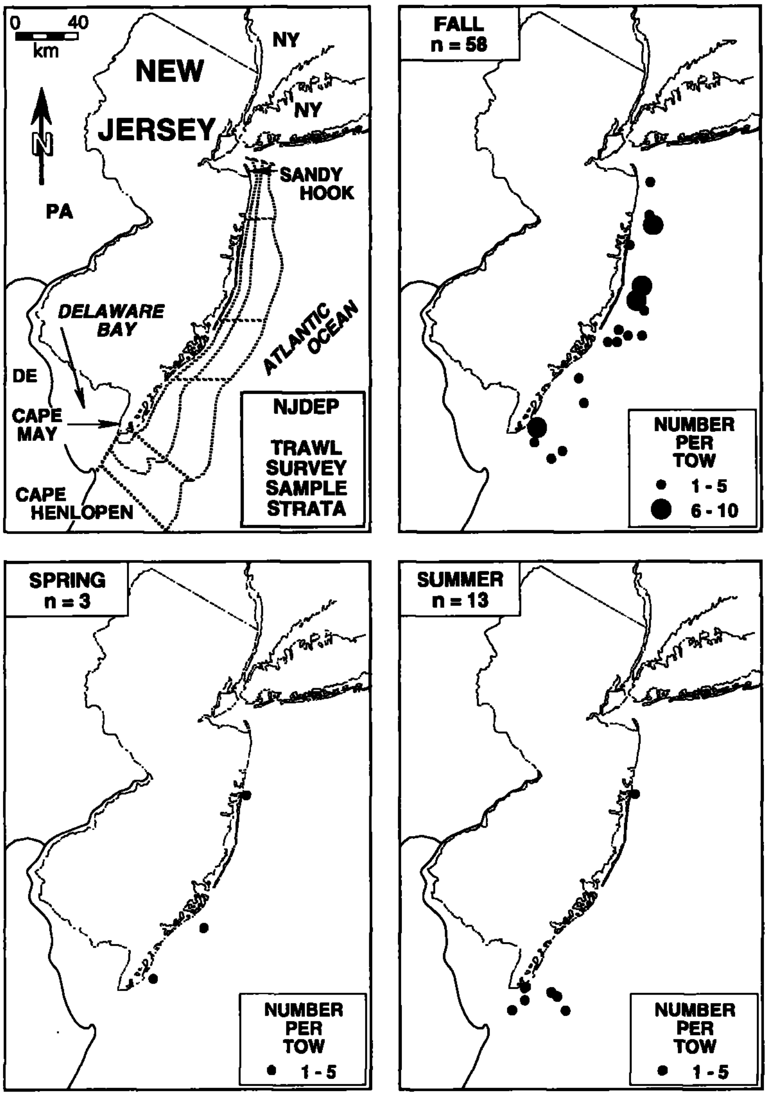

Figure 8

Distribution of age 0+ black sea bass, *Centropristis striata*, during the fall, spring, and summer in inner continental shelf sampling areas off New Jersey during 1988–91. No fish were collected during winter.

temperatures (Fig. 7). This same trend was also noted in Chesapeake Bay estuaries (Musick and Mercer, 1977) and off the coast of Massachusetts (Lux and Nichy, 1971). This response is not surprising given the inability of young (Schwartz, 1964b) and age 0+ (Hales and Able, in press b) black sea bass to tolerate temperatures below 2–3°C, which can occur in the Great Bay estuary during the winter (Able et al., 1992; Szedlmayer et al., 1992). Age 0+ individuals apparently spend the winter on the outer continental shelf, but by early spring they can be found over most of the shelf (Fig. 10). Musick and Mercer (1977) have suggested that they overwinter on the continental shelf in somewhat shallower depths (56–110 m). This year class reenters New Jersey estuaries in the spring, where it spends the summer, then migrates offshore again in the fall. A similar seasonal pattern occurs in Chesapeake Bay estuaries (Musick and Mercer, 1977, and references cited therein).

The 70–180 mm TL size range attained during the first year (ending July) is similar to that reported from back-calculated lengths from scales (approximately 40–159 mm TL; Briggs, 1978) and otoliths (75–107 mm SL; Alexander, 1981). The 1+ age class

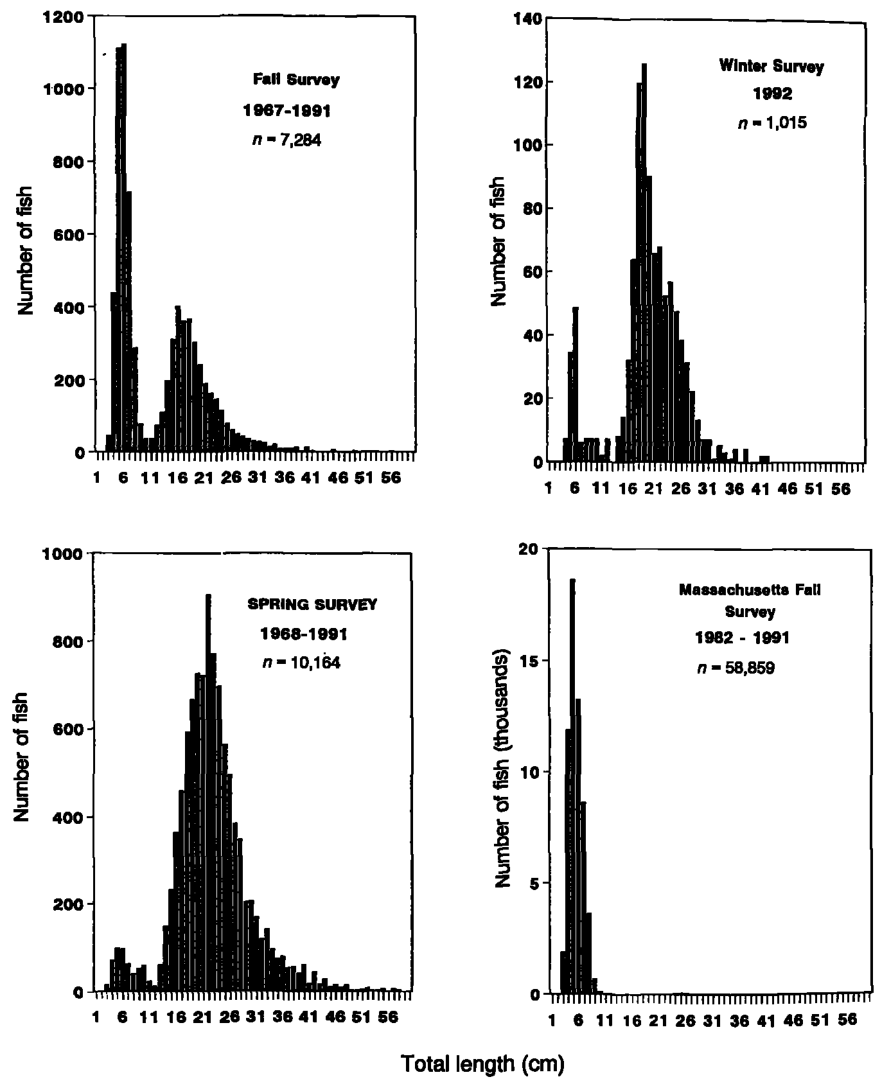

Figure 9

Composite lengths of black sea bass, *Centropristis striata*, from bottom trawl surveys in the mid-Atlantic Bight in (**A**) fall, (**B**) winter, and (**C**) spring, and in Massachusetts waters during the fall (**D**).

appears to follow a similar pattern of inshore-offshore movements as indicated by catches in the estuary over a number of years (Figs. 5 and 6). Thus this annual pattern may be characteristic for age 0+ and 1+ black sea bass for the entire mid-Atlantic Bight.

Nursery habitats

There are inconsistencies between the available data on larval distribution and presumed nursery areas in southern New England. The northern limit of larvae from MARMAP samples for the period 1977–87 was off Long Island (Fig. 3). Earlier studies noted the absence of black sea bass larvae from Block Island Sound (Merriman and Sclar, 1952), Narragansett Bay (Bourne and Govoni, 1988), Long Island Sound (Wheatland, 1956; Richards, 1959), Great South Bay, Long Island (Monteleone, 1992), and offshore of these areas (Kendall, 1972). The only exception was the collection of a few larvae from Georges Bank (Table 2), Cape Cod Bay (Scherer, 1984), and Narragansett Bay (Herman, 1963). However, there was some documentation of spawning aggregations in southern Massachusetts coastal waters (Wilson, 1889).

Despite the scarcity of larvae in southern New England, age 0+ individuals have been very abun-

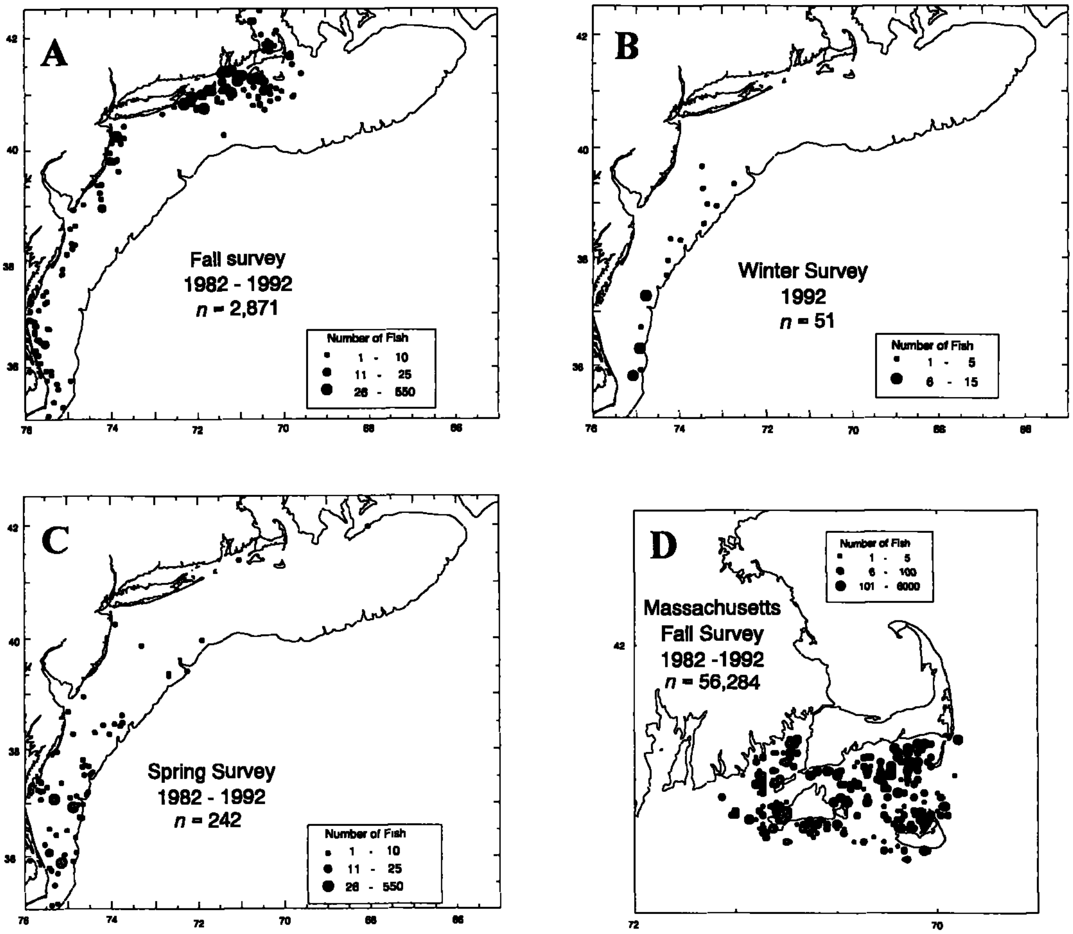

Figure 10

Distribution of age 0+ black sea bass, *Centropristis striata*, in the fall, winter, and spring based on composite collections (1982–92) from the mid-Atlantic Bight and in the fall off the coast of Massachusetts (1982–92).

dant in nearshore waters off Massachusetts (Fig. 10). The age 0+ year class from some estuaries on the south shore of Massachusetts has been described as either rare (Waquoit Bay-Eel Pond estuary [Curley et al., 1967]) or common (Quisset Harbor and Wareham River [Sumner et al., 1913]; Bass River [Curley et al., 1975]; Little Sippewisset Marsh [Werme, 1981]; Great Harbor near Woods Hole [Lux and Nichy, 1971]). In Bass River, where juveniles represented 9.3% (n=69) of the total catch, they were most abundant in deeper (1–3 m) otter trawl catches from August to October (Curley et al., 1975). In Little Sippewisset Marsh they were found in the channels of shallow marsh creeks (Werme, 1981), and juvenile black sea bass were regularly collected in Buzzards Bay and Vineyard Sound during the autumn bottom trawl survey (Fig. 10). The abundance of age 0+ individuals in the region indicates that further

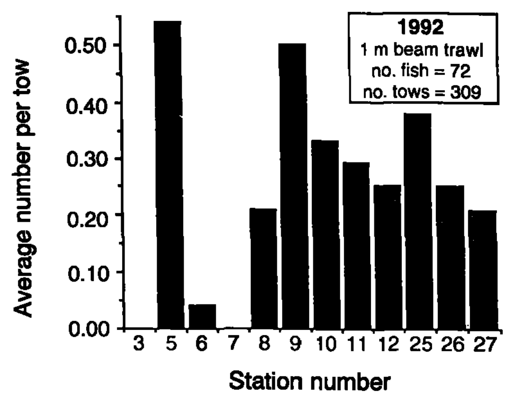

Figure 11

Abundance of age 0+ black sea bass, *Centropristis striata*, in the Great Bay-Little Egg Harbor estuary during 1992. See text for habitat designations and Figure 2 for locations.

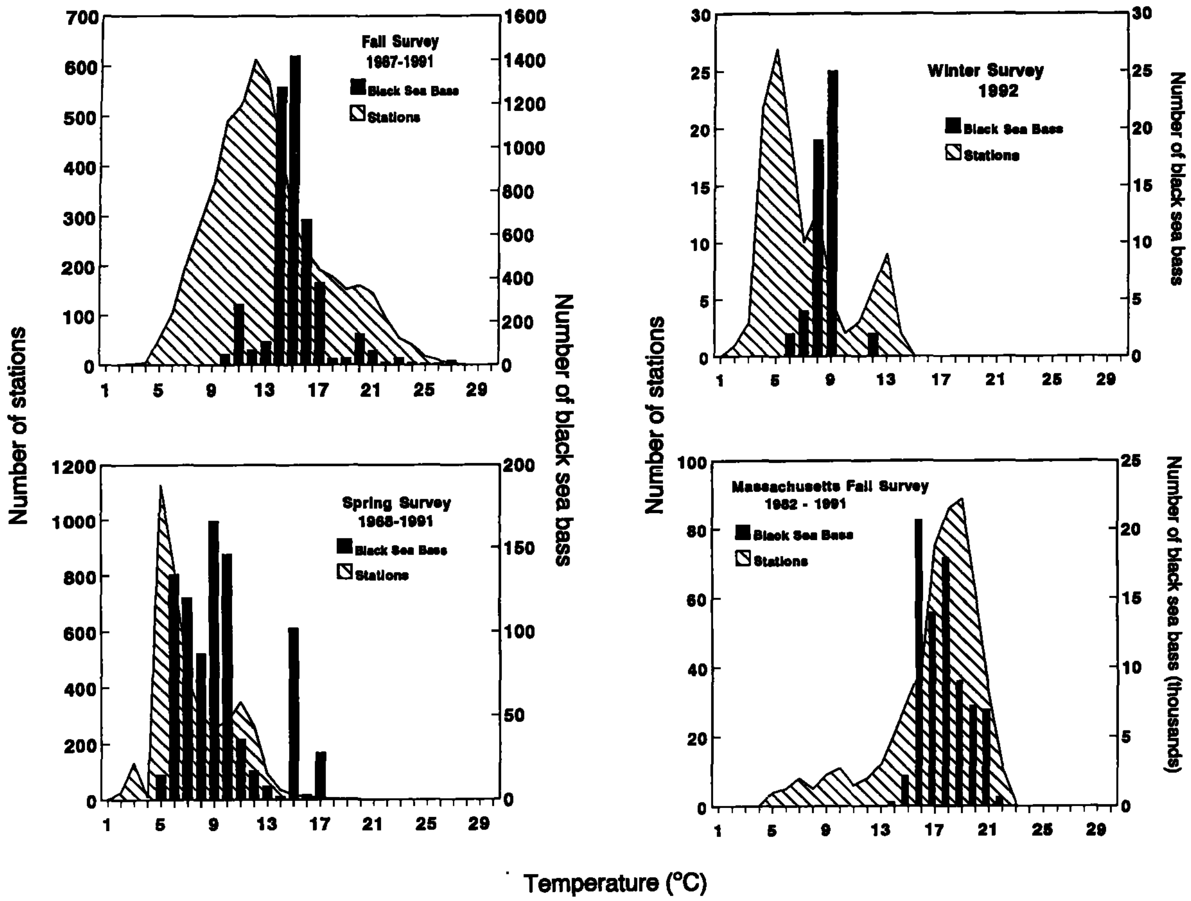

Figure 12

Abundance of age 0+ black sea bass, *Centropristis striata*, relative to bottom temperature in the spring, fall, and winter on the mid-Atlantic Bight continental shelf and off the coast of Massachusetts, based on Northeast Fish. Sci. Cent. and Massachusetts Div. Marine Fisheries bottom trawl surveys (1982–92).

studies are warranted to understand the possible significance of the region as a nursery.

In southern New Jersey, spawning and nursery areas are somewhat better delineated. The larvae clearly occur on the inner continental shelf off New Jersey (Figs. 3 and 4; Kendall, 1972), but there is no evidence of larvae in estuaries and bays in New Jersey (Croker, 1965; Himchak, 1982; Witting[3]) or Delaware (Pacheco and Grant, 1965; Wang and Kernehan, 1979). The apparent absence of larvae in estuaries and the occurrence of larvae and small juveniles (<20 mm TL) at Beach Haven Ridge suggest that settlement may initially occur on the inner continental shelf and that some individuals may remain there while some move into estuaries. Larvae 15–17 mm were reported in late July near Hereford Inlet, New Jersey (Allen et al., 1978), but further details are not available. The only other prior reports of small juveniles in New Jersey estuaries are of 25-mm individuals from Great Egg Harbor (Bean, 1888), 20-mm individuals from Raritan Bay (Nichols and Breder, 1927) and 25–35 mm specimens from lower Delaware Bay (Wang and Kernehan, 1979). The occurrence of juveniles in the York River in Chesapeake Bay (Musick and Mercer, 1977) was based on individuals that may have overwintered on the continental shelf and reentered the estuary as occurs in New Jersey. In other Chesapeake Bay habitats black sea bass (some of them 140–165 mm) were more abundant in eelgrass, *Zostera marina*, both day and night, than in adjacent unvegetated areas (Orth and Heck, 1980).

Our observations suggest that suitable summer nursery habitats, either on the continental shelf or in estuaries, are presumably related to the occurrence of some type of bottom structure, such as peat and shell accumulations. This is further substantiated by the increase in catch rates of black sea bass juveniles when shell was added to estuarine substrate to improve oyster recruitment (Arve, 1960). Dissolved oxygen also may influence patterns of habitat use because juveniles are intolerant of low levels (Hales and Able, in press a). The similarities in the densities and in sizes attained in the fall by juveniles in the estuary and in the adjacent inner continental shelf suggest that habitat quality is similar for both these areas, if one assumes that size differential predation or movements did not occur at either site during the sampling period. In summary, these data indicate that both estuaries and the inner continental shelf are important as nursery areas and that juvenile black sea bass are not strickly estuarine dependent.

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