DESCRIPTION OF BLACK SEA BASS, *CENTROPRISTIS STRIATA* (LINNAEUS), LARVAE AND THEIR OCCURRENCES NORTH OF CAPE LOOKOUT, NORTH CAROLINA, IN 1966

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ABSTRACT

Larvae of black sea bass collected during RV *Dolphin* ichthyoplankton surveys of the mid-Atlantic continental shelf are described. Development of most meristic characters occurs between 6 and 10 mm standard length. The larvae are identified by characteristic ventral pigment patterns, body shape, meristic counts, and lack of extensive armature. The 147 larvae were taken during cruises from June to November 1966, from 4 to 82 km from shore. They were found in tows from the surface to 33 m in water varying in surface temperature from 14.3° to 28.0°C and surface salinity from 30.3 to 34.6‰.

Black sea bass are of considerable economic importance and occur along most of the Atlantic coast of the United States. Although they were first studied in the late 1800's little is reported on their early life history. Spawning is reported to take place in May off North Carolina and in mid-May and June off New Jersey and southern New England (Bigelow and Schroeder, 1953; Miller, 1959). Wilson (1891) described their embryology as part of an incomplete monograph on the species but did not describe the larvae or provide diagnostic characteristics to identify eggs. Hoff (1970) figured a black sea bass egg and prolarva from artificially reared specimens but gave no written description (Figure 1). The eggs are pelagic, clear, round, and 0.9 to 1.0 mm in diameter. They have a smooth shell, narrow perivitelline space, and a single oil globule. They hatch in 75 hr at 16°C and in 38 hr at 23°C (Wilson, 1891; Hoff, 1970). The larvae remain inadequately described although Pearson (1941) identified specimens collected at the mouth of Chesapeake Bay as black sea bass by comparing them with a known series from southern New England using the ventral pigment pattern and fin ray counts. Apparently Merriman and Sclar (1952) had access to the same or similar specimens as Pearson because they pointed out differences between black sea bass and silver hake, *Merluccius bilinearis,* larvae. O. E. Sette's notes, made in connection with his work on Atlantic mackerel, *Scomber scombrus,* early life history contained a mention of black sea bass in a description of bluefish, *Pomatomus saltatrix,* larvae. Larvae of black sea bass have been identified from other collections of ichthyoplankton along the east coast of North America (Perlmutter, 1939; Herman, 1963) with no reference to means of identification. Figures of juveniles, ranging from 39 to 58 mm total length (TL), are shown in Bean (1888), Hildebrand and Schroeder (1928), and Fowler (1945) and reproduced here (Figure 2).

Three species of *Centropristis* occur along the Atlantic coast; *C. striata* is the most widespread and occurs from the Gulf of Maine to the Florida Keys (Miller, 1959). Rock sea bass, *C. philadelphica,* occurs along the Atlantic coast south of Chesapeake Bay, and bank sea bass, *C. ocyurus,* is found generally offshore south of Cape Hatteras. All three species also occur in the Gulf of Mexico, *C. striata* as the subspecies *C. s. melana* (southern sea bass). Black sea bass generally occur over hard bottoms and migrate along the middle Atlantic coast shoreward and northward in summer and offshore and south in

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Manuscript accepted May 1972.
FISHERY BULLETIN: VOL. 70, NO. 4, 1972.

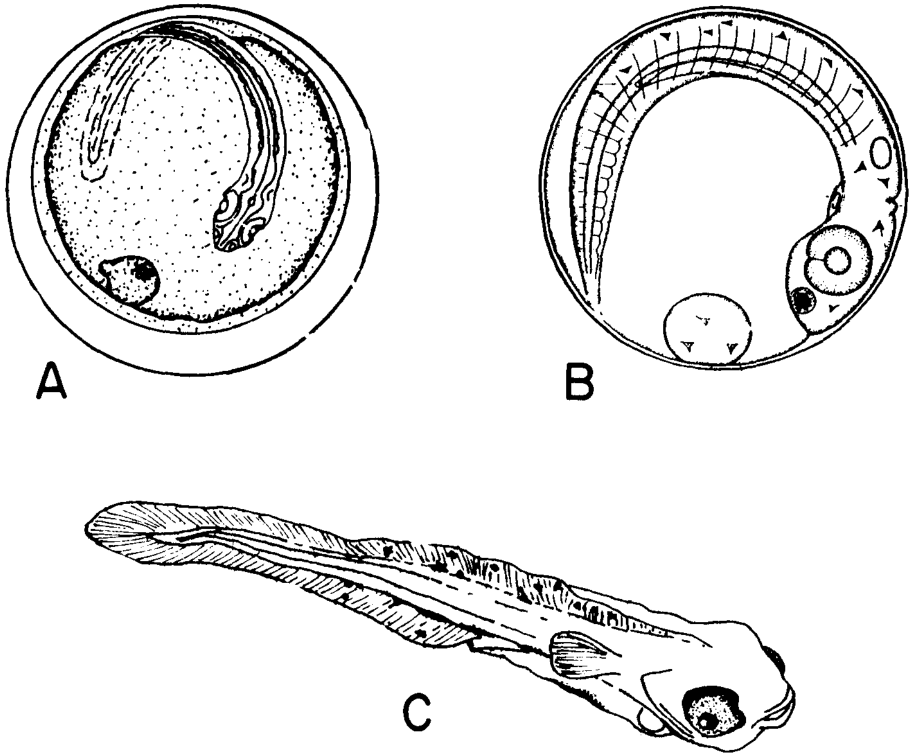

FIGURE 1.—Previously illustrated black sea bass eggs and prolarva. A) egg, 23 hr after fertilization at 23°C, from Hoff (1970, Figure 8); B) egg, 65 hr after fertilization at 16°C, from Wilson (1891, Figure 151); C) prolarva, 54 hr after hatching at 23°C, 2.01 mm TL, from Hoff (1970, Figure 9).

winter. *C. striata* is the only serranid expected to spawn on the continental shelf between Chesapeake Bay and Cape Cod, Mass. (Miller, 1959). Among east coast serranids the unique fin element counts for *Centropristis* for dorsal (X, 11) and anal (III, 7) fins allowed me to determine that I had larvae of this genus. The modal pectoral fin ray count of 18 for black sea bass is distinctive among *Centropristis* and seen on larger larvae. The pigment patterns on larger larvae, whose fin complements were complete, were seen in smaller larvae which appeared to be developing the meristic characters of black sea bass. This was the rationale for identifying the larvae described here as *Centropristis striata*.

On five ichthyoplankton surveys by the RV *Dolphin* between June and November 1966, we collected larval black sea bass at stations between Barnegat Bay, N.J., and Cape Lookout, N.C. This paper describes these larvae and their occurrences.

PROCEDURES

Collecting methods and hydrographic data from the 1965-66 RV *Dolphin* ichthyoplankton survey are reported in detail by Clark et al. (1969). Gulf V plankton tows were taken at 92 stations on eight cruises between Cape Cod, Mass., and Cape Lookout, N.C. The oblique tows covered 4.6 km with one net fishing from the surface to 15 m and, simultaneously, a second, from 18 to 33 m. Samples fixed in 5% buffered

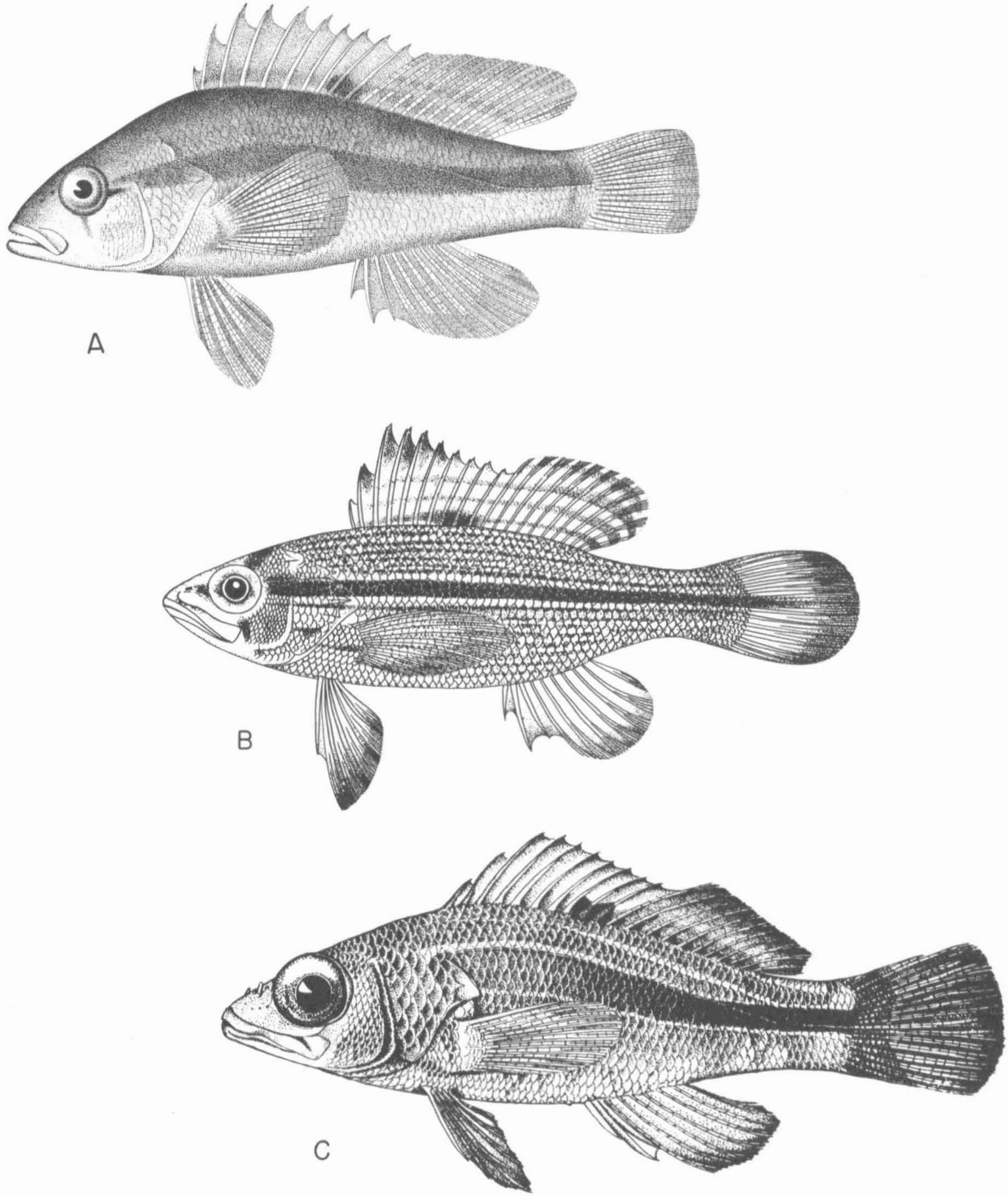

FIGURE 2.—Previously illustrated juvenile black sea bass. A) 39 mm SL, from Bean (1888, Figure 12); B) 42.4 mm SL, from Fowler (1945, Figure 263); C) 58 mm TL (?) from Hildebrand and Schroeder (1928, Figure 144).

Formalin[2] were returned to the laboratory where fish eggs and larvae were removed.

Black sea bass larvae were identified using criteria described, separated from the rest of the larvae in the *Dolphin* collections, counted and measured in standard length (SL). Black sea bass eggs are not well described, and several of their characteristics apply to many other species, so they were not identified in our samples. Other young black sea bass examined included one larva (13.0 mm SL)[3] and several juveniles (37-73 mm SL).[4] Body proportions were measured to the nearest 0.1 mm on selected larvae in Formalin on a depression slide with an ocular micrometer. The base points for larval measurements approximate those used by Ahlstrom and Ball (1954) except body depth, which was measured at the junction of the cleithra, and standard length, measured to the distal ends of the hypurals when formed. Base points for measurements of juveniles follow Hubbs and Lagler (1958). We determined meristic counts on selected specimens lightly stained with alizarin red. Osteological examination was made from specimens cleared and stained following Clothier's (1950) method. Michael P. Fahay illustrated the larvae (Figures 3 and 9).

DESCRIPTION OF LARVAE

In the following description, features useful in identifying black sea bass larvae are emphasized rather than those demonstrating general teleostean development. The approach follows Ahlstrom and Ball (1954) in that each feature is at once traced through its development within the size range (2-13 mm) of the available larvae. Four areas of development are described: armature, body shape, meristic characters, and pigment patterns. Stages of development of black sea bass larvae are illustrated in Figure 3.

ARMATURE

Among larvae of serranids which have been described there is diversity of development of armature. Species of *Epinephelus* develop anterior dorsal and pelvic spines nearly as long as the larva. These spines are barbed and serrated. Preopercular spines are also well developed (Sparta, 1935; Mito, Ukawa, and Higuchi, 1967; Presley, 1970). Larvae of other genera are less ornate and the relative length of fin spines is near that of the adults in some (Bertolini, 1933). Black sea bass larvae are among the serranids with little development of armature. No fin spines are either serrated or pronounced. Pelvic fin spines do not reach the vent; the dorsal and anal fin spines are shorter than the rays. Four to seven short, widely spaced spines are present on the posterior margins of the preopercle and opercle on larvae longer than 5 mm. The three small spines on the opercular flap of the adult form at 8 mm (Figure 3C). Preopercular serrations characteristic of the adult develop early in the juvenile stage.

BODY SHAPE

Changes from larval to adult body form take place over a narrow size range, and the extent of development among fish with similar standard lengths varies. Some body proportions of juvenile and adult black sea bass given by Miller (1959) are compared to those of the developing larvae in this section and in Figures 4 to 6. Between 2 and 5 mm the body proportions remain fairly constant with a slight increase in snout and eye length, and body and caudal peduncle depth, relative to standard length. Most head and body proportions increase significantly between 5 and 6 mm then level off as they approach those of the adult. Caudal peduncle depth and total length, relative to standard length, continue to increase through the larval stage as the caudal fin develops. Body depth, head length, and preanal length proportions increase through the juvenile stage. The adult black sea bass is robust with a large terminal mouth and large head. The back is slightly elevated anteriorly. The dorsal fins are contiguous and the pectorals and pelvics

[2] Reference to trade names in the publication does not imply endorsement of commercial products by the National Marine Fisheries Service.
[3] Collected on October 5, 1967, at Corson Inlet, N.J., by Walter S. Murawski, Jr., New Jersey Department of Conservation and Economic Development.
[4] Inshore seining collections of fish from New Jersey taken by Dr. Albert E. Parr.

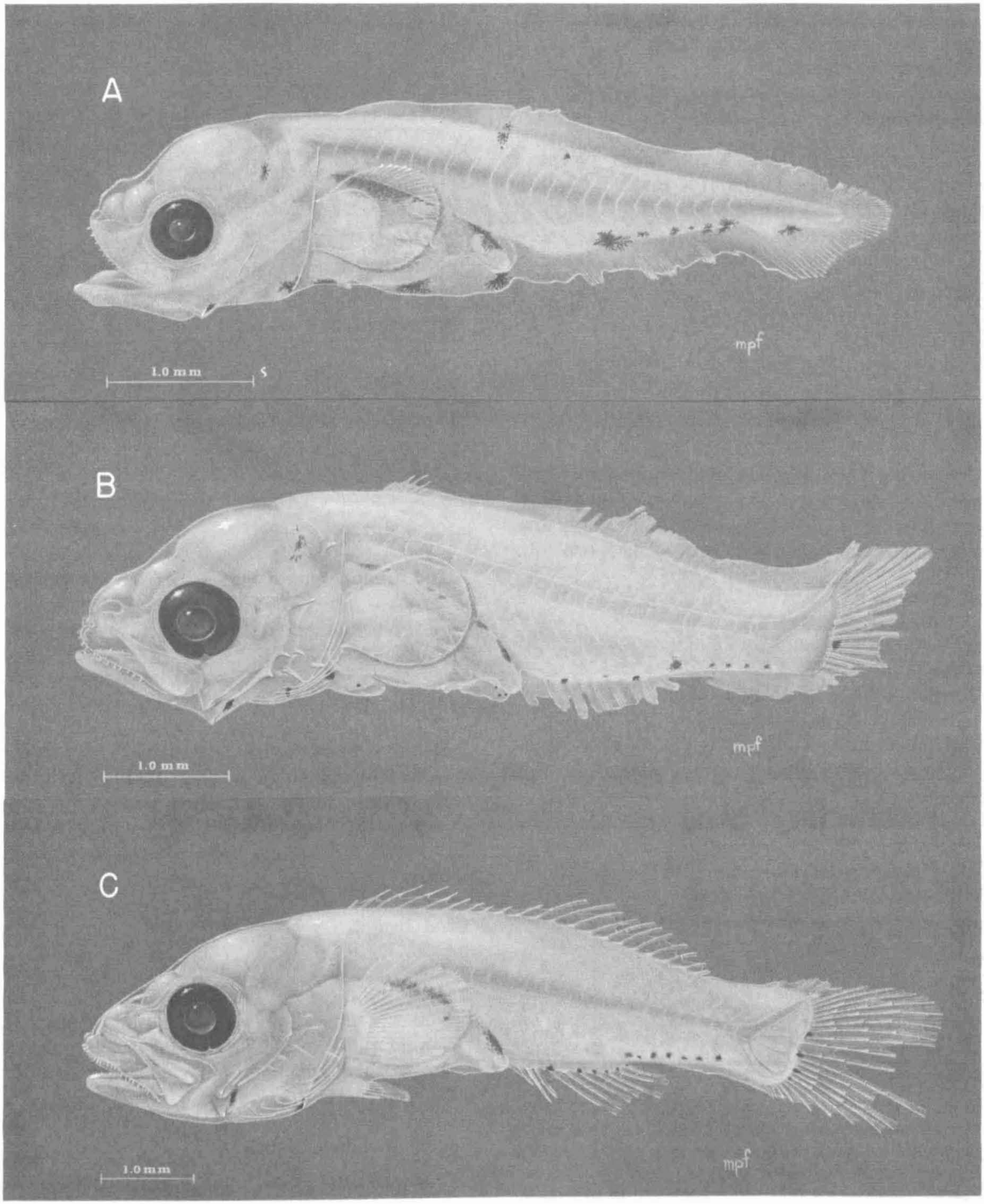

FIGURE 3.—Black sea bass larvae. A) 5.1 mm SL; B) 6.2 mm SL; C) 7.9 mm SL.

are large. The caudal fin outline varies from rounded to trilobed, with one upper ray produced in larger specimens.

Head Length

Between 2 and 4 mm head length averaged about 33% of SL. At 5 mm it reached 37-38% where it remained through 12 mm. Almost all values lie between 30 and 40%, except in a few larvae smaller than 5 mm where precise measurement is difficult. The juveniles demonstrate a continuing trend toward a longer head ranging from 34 to 45% of SL. Miller (1959) gives 40-41% as the proportion in his specimens (Figure 4A).

Eye Length

Eye length remained constant throughout larval development at about 9-10% of SL. Most juveniles as well as Miller's (1959) adult specimens also ranged from 9 to 10% (Figure 4B).

Snout Length

In larvae between 2 and 6 mm snout length increased from 6 to 11% of SL where it holds through adulthood (Miller, 1959) (Figure 4C).

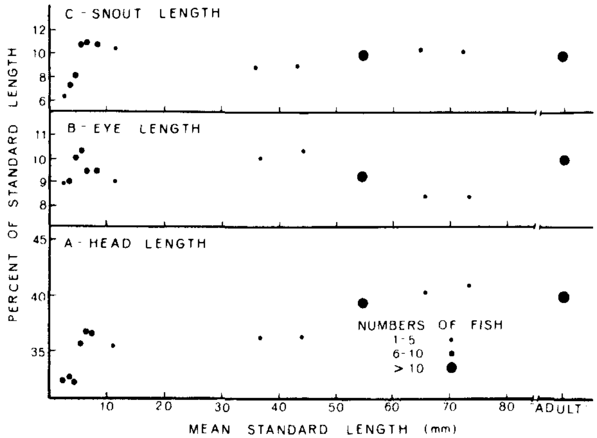

FIGURE 4.—Body proportions of black sea bass associated with the head plotted as percentages of standard length. A) head length; B) eye length; C) snout length. Each point represents the mean of several observations. "Adult" points from Miller (1959).

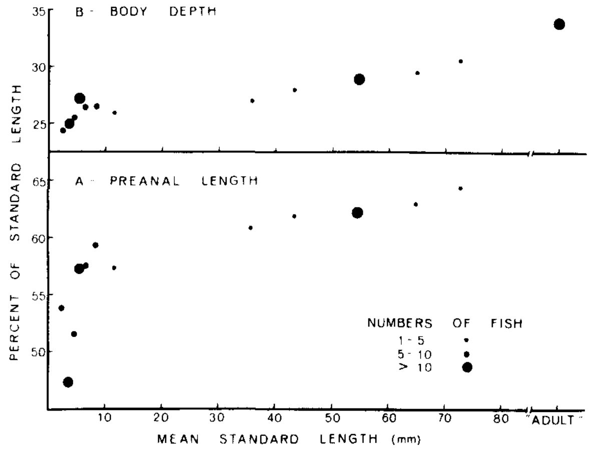

FIGURE 5.—Body proportions of black sea bass associated with the trunk plotted as percentages of standard length. A) preanal length; B) body depth. Each point represents the mean of several observations. "Adult" points from Miller (1959).

Preanal Length

The preanal length increases from about 50% of SL at 5 mm to 58% at 10 mm. During juvenile development it increases to nearly 65% (Figure 5A).

Body Depth

Relative to standard length, body depth increases from about 25 to 27% during larval development. During the juvenile stage it continues to increase to about 30% (Figure 5B). The adult proportion is about 34% (Miller, 1959).

Total Length

Total length is 102% of SL from 2 to 5 mm. As caudal fin development proceeds total length becomes a larger portion of standard length, reaching 120% in our largest larva. It remains constant through juvenile development at about 125% of SL (Figure 6A).

Caudal Peduncle Depth

From 4 mm where caudal peduncle depth is 6% of SL it increases steadily through larval

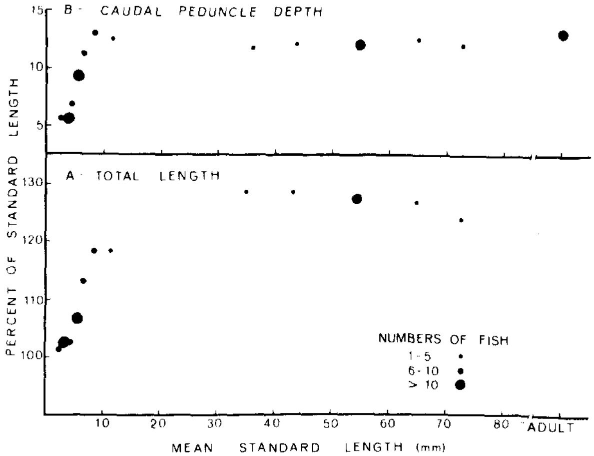

FIGURE 6.—Body proportions of black sea bass associated with caudal fin development plotted as percentages of standard length. A) total length; B) caudal peduncle depth. Each point represents the mean of several observations. "Adult" points from Miller (1959).

development to about 14% where it remains in adults (Miller, 1959) (Figure 6B).

DEVELOPMENT OF MERISTIC CHARACTERS

Most of the meristic features of black sea bass larvae develop within a length range of 4 mm (Table 1). Larvae 5 mm long have undifferentiated finfolds with a few caudal rays, buds of paired fins, some gill rakers and branchiostegal rays, and an incompletely ossified vertebral column (Figure 3A). By 7 mm most median and paired fin elements and branchiostegal rays have formed, some gill rakers are visible, and the vertebral column is ossified (Figure 3B). Other than gill rakers and scales, adult complements of meristic characters are reached by 9 mm (Figure 3C). The following descriptions roughly follow the sequence of attainment of adult characters.

TABLE 1.—Development of meristic characters of larval black sea bass.

SL (mm)	Caudal fin rays: Sec.	Caudal fin rays: Primary		Caudal fin rays: Sec.	Dorsal fin		Anal fin		Pectoral fin rays	Pectoral fin elements	Vertebrae	Branchiostegal rays	Gill rakers
	Upper	Upper	Lower	Lower	Spines	Rays	Spines	Rays					
3.2													
3.4													
4.0													
4.1													
4.5												2	
4.5												4	
4.6					1	1					3	7	5
4.8													
4.9											9	4	
5.0											10	4	8
5.0		6	5			1					12	5	6
5.2		6	6						2		14	5	5
5.3		8	6								15	5	5
5.5		6	7								15	5	6
5.5		5	4		5	6		5	3		11	5	5
5.9		6	4			5		5	7		18	3	6
5.9		7	5		7	6		7	5		20	6	8
6.0		8	7		8	8		8	9	3	22	6	8
6.1		5	4		6	9		7	7		22	5	8
6.3		8	7		2	10		8	9	3	16	6	9
6.5		9	7	2	9	8	2	8	12	5	23	7	8
6.6		9	8	1	8	[1]8	2	8	14	4	23	6	8
6.7		9	8	1	[1]4	11	2	8	16	4	24	7	11
6.7		9	8		8	11	2	8	12	4	23	6	7
7.0		9	8	2	9	10	3	7	10	5	24	7	10
7.1		9	8	2	10	[1]10	3	7	14	5	24	7	10
7.7		9	8	3	10	8	3	7	13	6	24	7	11
8.7	4	9	8	4	10	11	3	7	18	6	24	7	10
9.9	4	9	8	3	10	11	3	7	19	6	24	7	11
10.6	9	9	8	8	10	11	3	7	18	6	24	7	14
11.0	9	9	8	8	10	11	3	7	18	6	24	7	16
11.8	5	9	8	5	10	11	3	7	18	6	24	7	15

[1] Damaged.

Teeth

At 5 mm, widely spaced small conical teeth are visible on the premaxillaries (Figure 3A). By 6.5 mm teeth are fairly closely spaced all along the premaxillaries and medially on the dentaries (Figure 3B). By 10 mm the teeth on the premaxillaries are very closely spaced and slightly recurved; those on the dentaries are enlarged and more widely spaced posteriorly but resemble those on the premaxillaries anteriorly.

Axial Skeleton

Ossification of the vertebral column proceeds posteriorly beginning between 4.5 and 5.0 mm. Neural and hemal spines form concurrently with their associated vertebrae. By 5 mm the anterior 12 vertebrae have ossified. By 6.5 mm all of the vertebrae are ossified except two or three anterior to the urostyle. The urostyle ossifies at 6 mm. The penultimate and antepenultimate vertebrae ossify last at 7 mm (Table 1). The first caudal supports to ossify are the medial four hypurals at 6.5 mm. Hypural 1 is ossified at 8.0 mm and hypural 6 is ossified at 8.5 mm. The uroneural and epurals form at 10 mm.

The structure of the caudal region at 11.8 mm (Figure 7) varies only slightly from the typical perciform type described by Gosline (1961). As in other serranids, the two separate uroneurals have fused, but no fusion of the hypurals has occurred. Otherwise the caudal skeleton is typical, having three epurals, a urostyle with a single ossification, and the hemal arch on the antepenultimate and penultimate vertebrae being autogenous (not fused to the vertebrae). There are 15 branched segmented rays supported by six hypurals, 7 ventrally on hypurals 1, 2, and 3 and 8 dorsally on hypurals 4, 5, and 6. One ray dorsal and one ray ventral to these are also segmented but not branched. About eight raylets form dorsally and an equal number form ventrally anterior to the segmented rays. If the first hypural is considered a parhypural (Nybelin, 1963), black sea bass have only two ventral hypurals.

Branchiostegal Rays

The first branchiostegal rays form at about 4.5 mm. By 5 mm four to six rays have formed and at 6.5 mm the adult complement of seven rays is reached, with the medial ones being the last to form (Table 1).

Caudal Fin

From 2 to 4 mm the finfold is symmetrical around the tip of the notochord. Actinotrichs are formed adjacent to the posterior 10% of the

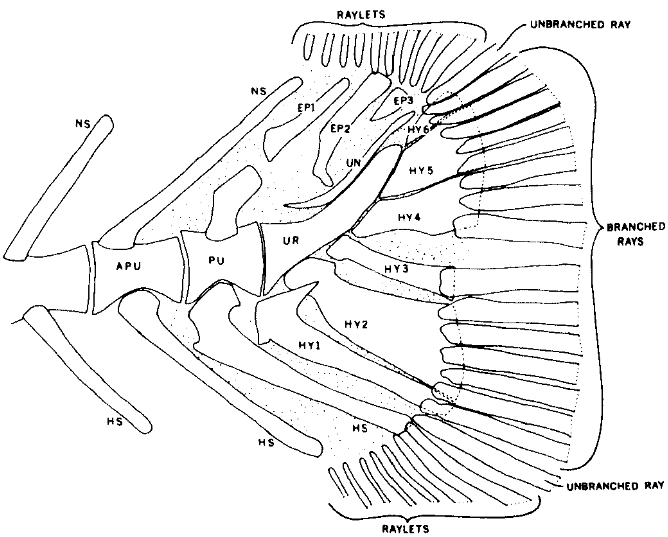

FIGURE 7.—Caudal skeleton of a black sea bass larva 11.8 mm SL. APU = antepenultimate vertebra; EP = epural; HS = hemal spine; HY = hypural; NS = neural spine; PU = penultimate vertebra; UN = uroneural; UR = urostyle.

notochord. Between 4 and 5 mm the anlage of the base of the caudal fin starts to form ventral to the notochord, just anterior to its tip (Figure 3A). By 5.5 mm the notochord is slightly upturned, the developing hypural region appears bilobed and about nine primary caudal rays are formed. The caudal fin at 6 mm has a rounded homocercal outline and eight segmented principal rays in the superior lobe and seven in the inferior lobe (Figure 3B); the rays are branched and some secondary procurrent rays are present. At 8 mm the dorsal hypurals are slightly longer than the ventral ones and the rays and raylets are more clearly defined and approaching the adult complement (Table 1).

Anal Fin

Between 2 and 5 mm there is an undifferentiated finfold in the area of the anal fin. Between 5 and 6 mm, fin rays start to form in the anal finfold between the vent and the most prominent pigment spot on the ventral surface of the trunk (Figure 3A). By 6 mm about six rays and one anal spine are seen (Figure 3B). The finfold posterior to the fin is reduced. By 7 mm the three anal spines are formed. The second spine is first to form and is most prominent throughout development (Figure 3C). The third spine forms as a ray; by 7 mm the spinous form is apparent. The first spine is smaller than the others and forms last at 6.5 mm. By 7 mm the adult complement of seven anal rays is reached and some are branched (Table 1).

Dorsal Fins

The undifferentiated dorsal finfold extends from the nape to the caudal region at 4 mm. By 5 mm the finfold becomes elevated about halfway back on the body where fin ray development begins (Figure 3A). Rays and spines develop along the dorsal fin base and the dorsal finfold posterior to the dorsal fin disappears between 5.5 and 6.5 mm. The anterior spines and posterior rays develop at a smaller size than intermediate fin elements.

The first four dorsal spines are visible by 6 mm. The second through fourth are longer and remain so. The first dorsal spine is about half as long as the second. The second and third spines are the same length at 6.5 but, by 10 mm, the third has become 1.5 times longer than the second. The fourth spine, the longest, is slightly longer than the third. The final complement of 10 spines and 11 rays is attained by 8.7 mm (Table 1). The rays are branched and segmented by 8 mm (Figure 3C).

Median Fin Supports

Anterior interneurals and the interhemal supporting the second anal spine ossify concurrently at about 8.5 mm. By 10 mm most of the interneurals and interhemals are formed. The anterior two interneurals fuse to support the first two dorsal spines (Figure 8). The first two anal spines are supported by one interhemal, apparently formed by fusion of two elements (Figure 8).

Pelvic Fins

Buds of the pelvic fins are seen on 4-mm larvae. Fin rays form between 4 and 6 mm. Rays and spines are first seen between 5 and 6 mm (Figure 3B). At 8 mm the adult complement of one spine and five rays has formed, with the smooth spine two-thirds as long as the longest ray (Table 1).

Pectoral Fins

Pectoral fin buds are present on the smallest larvae (2.1 mm) examined. The early pectorals change little until fin rays appear between 5 and 6 mm. By 6.5 mm the rays are mostly formed and the adult complement of 18 or 19 rays is reached by 9 mm (Table 1).

Gill Rakers

At 5 mm gill rakers appear as a few tubercles on the gill arches. By 6 mm there are nine rakers on the lower limb and none on the upper. At 10.6 mm there are 4 rakers on the upper and 10 on the lower limb. The adult complement of about 10 upper and 18 lower is reached in juveniles.

Scales

Scale formation occurs at a size between the largest larva (13.0 mm), which is scaleless, and the smallest juvenile (37 mm) in our collections.

PIGMENT PATTERNS

Pigmentation on Formalin-preserved black sea bass consists of a few melanophores in characteristic positions, mainly along the ventral part of the larva (Figure 9). Other kinds of larvae in the collections with spots in similar positions had meristic counts and body shapes approximating black sea bass. However, the relative size of the various spots in combination with examination of the sequence of development of meristic characters, the distinctive fin element counts on larger larvae, and body shape assured separation of black sea bass from other larvae.

Head Region

At 5 mm one spot usually forms ventrally on the median cartilage between the dentaries and urohyal. A second forms posterior to this on some specimens (Figure 9). A spot forms at 4 mm on each angular (Figure 3A). A characteristic transverse dentritic spot forms immediately anterior to the symphysis of the cleithra. Usually there is a spot between the bases of the pelvic fins. Dorsally there is a variable number of spots irregularly spaced on the posterodorsal covering of the cerebellum, and generally a pair of spots internally on the posterior surface of the midbrain. Between 12 and 13 mm a band of minute melanophores develops from the angular, past the eye, to the anterior part of the cerebellum. There are also several larger spots on the anterior halves of the cerebral hemispheres and a group of spots which originate at the eye and extend posteriorly to the opercular flap.

Gut Region

Considerable internal pigmentation develops in the dorsal area of the gut cavity, mostly on the surface of the viscera. These are large spots but superficially not readily definable. In larvae up to about 6 mm, this pigment reaches the exterior as a large intense spot on the posterior region of the renal tract (Figures 3A and B). In some specimens there is a smaller spot just anterior to the vent and another one about midway between the origin of the pelvic fins and the vent, along the midventral line (Figure 9).

Trunk and Caudal Region

Occasionally a few irregular spots occur dorsally on the trunk about midway on the body. Between 12 and 13 mm, a series of about six groups

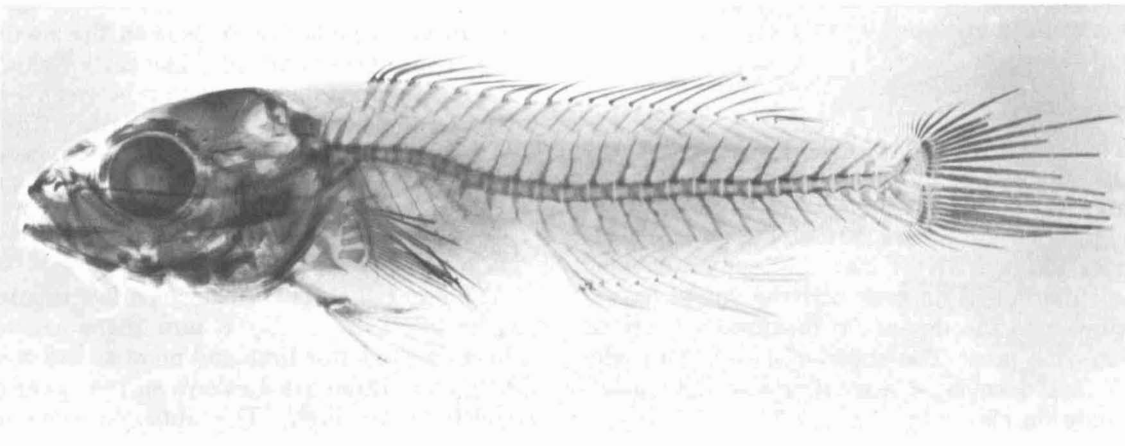

FIGURE 8.—Cleared and stained black sea bass larva 11.8 mm SL.

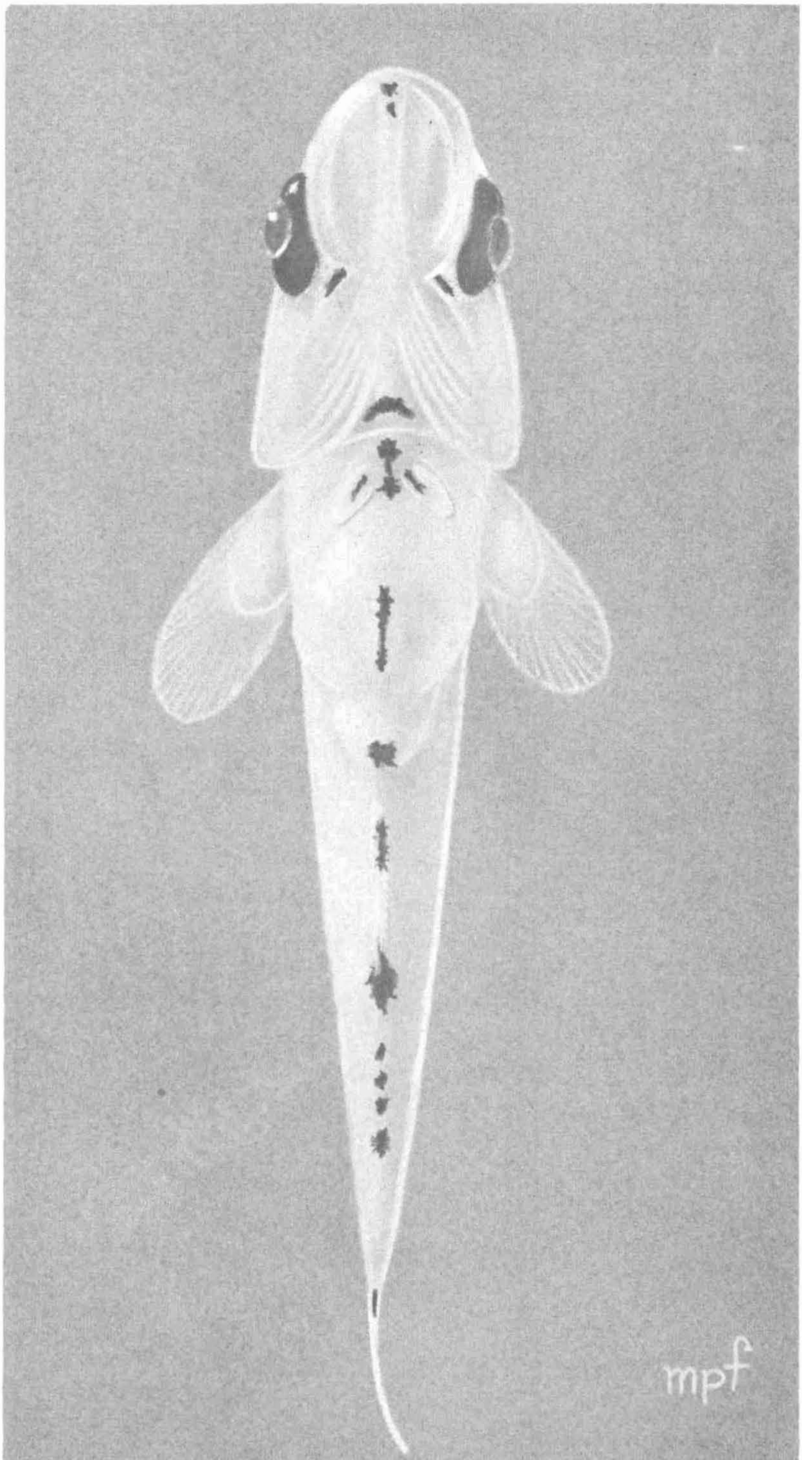

FIGURE 9.—Ventral view of pigment on a 5.4-mm black sea bass larva.

of small melanophores develops along the lateral line. At this length a few spots also develop at the origin of the dorsal fin. As the anal fin rays form, spots develop at some of their bases. A prominent spot forms early, near the posterior end of the anal fin; it is followed by four to six smaller spots along the midventral line that extends to the base of the caudal fin where there is another large spot. Before notochord flexion there is a prominent spot on the developing fin rays (Figure 9). This persists as the fin develops and reaches a position at the bases of some of the ventral rays of the caudal fin. As the caudal rays develop, some less prominent spots appear on rays dorsally and ventrally from the first spot. The pigment in the caudal region and along the midventral line persists through larval development.

LARVAL OCCURRENCES

Black sea bass larvae were taken on five cruises from June to November 1966, between Sandy Hook, N.J., and Cape Lookout, N.C. (Appendix Table). Of 39 tows containing black sea bass larvae, 20 had only one larva, and only two had more than 20 larvae; thus only limited inference about their distribution and relative abundance can be derived from these data. Larvae were taken in both shallow (0-15 m) and deep (18-33 m) tows from 4 to 82 km from shore. Water depths in the areas of capture ranged from 15 to 51 m. Surface temperature varied from 14.3° to 28.0°C; that on the bottom from 8.3° to 26.6°C. Surface salinity varied from 30.3 to 34.6‰.

Seasonally, there seems to be some northerly progression of spawning. During June one larva was taken off Oregon Inlet, N.C., and one off Paramore Island, Va. (Figure 10). During August, larvae occurred from Cape Henlopen, Del., to Ocracoke Inlet, N.C., being most abundant off Maryland and Virginia (Figure 11).

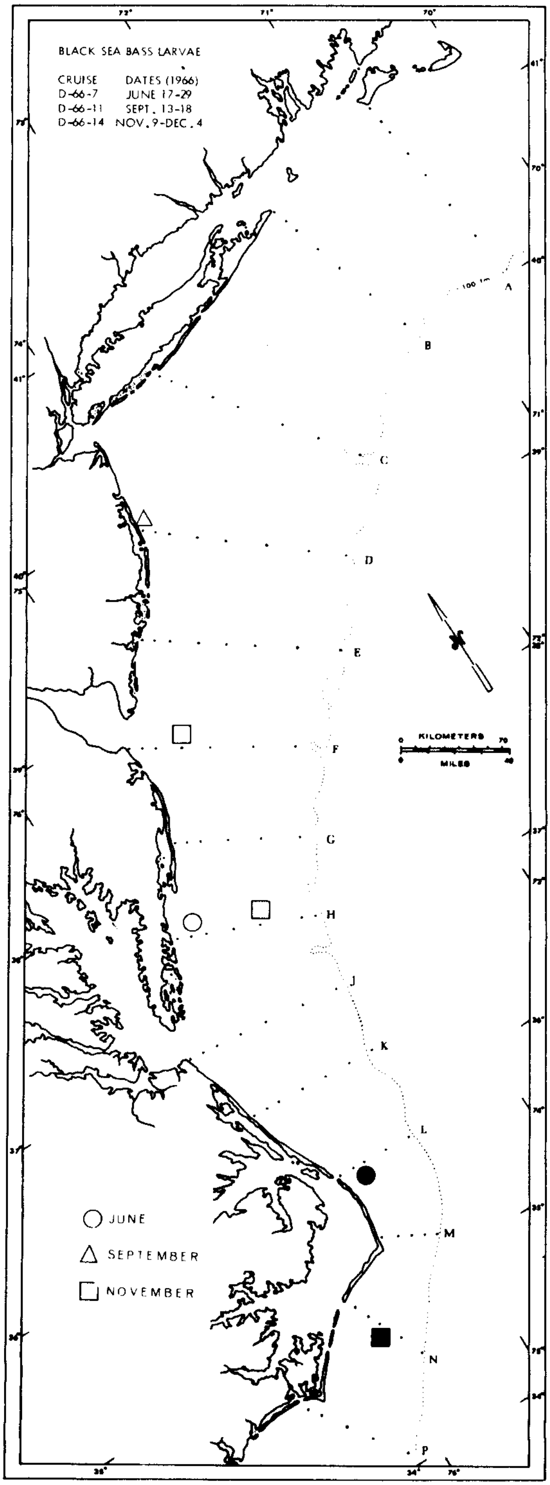

FIGURE 10.—Occurrence of black sea bass larvae in shallow (0-15 m) (open symbols) and deep (18-33 m) (solid symbols) tows. Three RV *Dolphin* cruises, 1966.

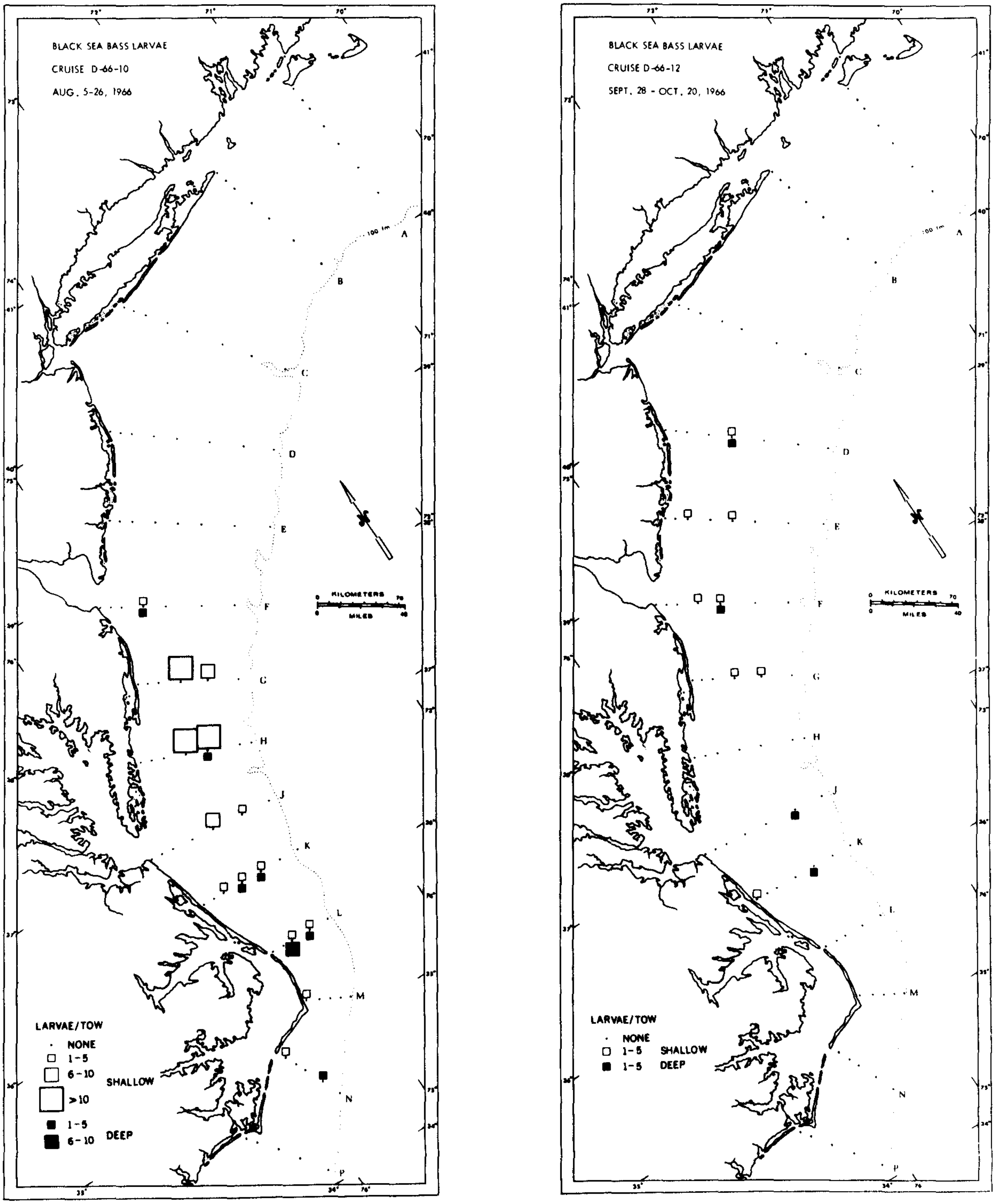

FIGURE 11.—Distribution and abundance of black sea bass larvae in August (left) and October (right) from RV *Dolphin* cruises.

During September only the four northern transects were sampled and the only larva taken was off Barnegat Inlet, N.J. (Figure 10). During October larvae ranged from Great Egg Inlet, N.J., to Currituck Light, N.C. In November four larvae occurred between Cape Henlopen, Del., and Ocracoke Inlet, N.C. (Figure 10).

The larvae ranged from 2.1 to 13.0 mm SL (Figure 12). Among the cruises the mean size of larvae was nearly constant. The length-frequency curve indicates that we undersampled small larvae (< 4 mm), probably because they were extruded through the meshes of the net. Comparisons of mean lengths of larvae taken during day and night and in shallow and deep tows for the individual cruises were made. Larvae in the deep net were slightly larger than those in the shallow net. Day-night differences in size were inconclusive (Table 2). Geographic variations in size are not apparent.

A comparison of fish caught per successful tow in shallow and deep tows taken during day and night shows that more fish were taken in shallow than in deep tows and more were taken at night than during day (Table 2). Our data on size and diurnal and depth distribution of the larvae indicate several things. More and slightly larger larvae were taken at night than during the day. Also, larvae in the deep net were slightly larger than those in the shallow net. More larvae were taken in the shallow than in the deep net. Thus it appears that larvae are more abundant near the surface (0-15 m) than deeper (18-33 m) waters and that visual warning allows larger larvae to escape in near surface waters, particularly during the day.

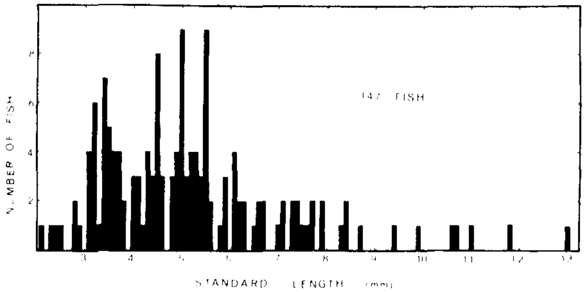

FIGURE 12.—Length distribution of black sea bass larvae from RV *Dolphin* cruises, 1966.

DISCUSSION

The general distribution of larvae and juveniles of black sea bass can be deduced from their occurrence in several disjunct studies of estuaries and coastal waters of the Atlantic coast. Early larvae (< 6 mm) have been found at the mouth of Chesapeake Bay (Pearson, 1941), in Long Island Sound (Perlmutter, 1939), and in Narragansett Bay (Herman, 1963). The lack of black sea bass larvae in some intensive sur-

TABLE 2.—Black sea bass larvae from 1966 RV *Dolphin* cruises. Total numbers, numbers per positive tow, and lengths in shallow and deep tows by cruise and time of day.

Cruise	Time of day	Shallow				Deep			
				Length (mm)				Length (mm)	
		No.	No./tow	Range	Mean	No.	No./tow	Range	Mean
June	Day	1	1.0	4.6	4.6				
	Night					2	2.0	5.5- 5.9	5.7
Aug.	Day	32	6.4	2.1- 5.5	3.7	2	1.0	5.4- 7.9	6.7
	Night	72	9.0	2.8-10.7	5.4	16	3.2	2.5-11.8	6.3
Sept.	Day	1	1.0	5.4	5.4				
	Night								
Oct.	Day	7	1.8	4.3- 6.3	5.5				
	Night	6	1.5	3.5- 6.1	5.1	4	1.0	3.6- 7.3	5.5
Nov.	Day	1	1.0	7.5	7.5	2	2.0	7.6-13.0	10.3
	Night	1	1.0	5.2	5.2				
Day total or mean		42	3.5	2.1- 7.5	4.2	4	1.3	5.4-13.0	6.8
Night total or mean		79	6.1	2.8-10.7	5.4	22	2.2	2.5-11.8	6.1
Grand total or mean		121	4.8	2.1-10.7	5.0	26	2.0	2.5-13.0	6.5

veys along the Atlantic coast is remarkable (e.g., Merriman and Sclar, 1952; Wheatland, 1956; Richards, 1959; Massmann, Joseph, and Norcross, 1962; Marak et al., 1962). Ichthyoplankton sampling in more enclosed areas, such as Indian River, Del. (Pacheco and Grant, 1965) and Sandy Hook Bay, N.J. (Croker, 1965), has failed to reveal larvae. Juveniles (25-75 mm) have been taken from saline areas of estuaries from Florida (Tagatz, 1968), Maryland (Schwartz, 1961, 1964), Delaware (de Sylva, Kalber, and Shuster, 1962), New York (Perlmutter, 1939; Greeley, 1939; Richards, 1963), Rhode Island (Herman, 1963), and Massachusetts (Lux and Nichy, 1971). Bean (1888) reported that young about 1 inch (25 mm) long were common in Great Egg Harbor Bay, N.J., and Nichols and Breder (1927) reported 20-mm fish over oyster beds off Staten Island, N.Y., in August. Massmann et al. (1962) found one 43-mm juvenile in the ocean off Virginia.

Black sea bass spawn offshore along the coast from Florida to New England. Spawning takes place earlier in the southern part of the range than in the northern part; in May off North Carolina (Smith, 1907); in late May off Chesapeake Bay (Hildebrand and Schroeder, 1928); and into early summer off southern New England (Bigelow and Schroeder, 1953). At least some of the young, less than 30 mm, enter open estuaries near inlets where they spend their first summer associated with hard bottoms such as oyster shells (Nichols and Breder, 1927; Arve, 1960; Richards, 1963). Young leave the estuaries during fall and return during spring. Enough return to estuaries in subsequent years to support fisheries there. From references made to black sea bass abundance around the turn of the century (Bean, 1888; Smith, 1898; Sherwood and Edwards, 1901), it seems that present stocks in the northern part of the range are diminished. This decrease in abundance may be associated with decrease in oyster beds (Arve, 1960). Commercial catch records show recent catches near the historical mean, but indicate a shift in abundance from the New York-Delaware to the Chesapeake region (Lyles, 1967).

Our data on offshore occurrences of larvae complement work in estuaries where early stages have been found. However, a definitive picture of the early life history of this species is still lacking. The small numbers of larvae taken in this survey do not seem consistent with the population size and extent of adult black sea bass along the coast. Possibly we sampled in a year when spawning was unsuccessful or our sampling was not effective for capturing black sea bass larvae in proportion to their abundance.

The pelagic existence of this fish is short. Larvae longer than 13 mm were not taken, presumably because near that size they assume demersal or estuarine habits. Few of these late larvae and early juveniles have been collected, and it is still not known what part of the population may enter estuarine waters and what part remains at sea. The routes and mechanisms of larval transport from spawning grounds to nursery areas are also unknown.

The known seasonal distribution of larvae shows that black sea bass spawn over a long period. The range of juvenile sizes taken in individual samples also indicates a long spawning season. Details of the suggested northward progression of spawning need clarification. Intensive sampling of the water column and bottom offshore, at inlets, and in open estuaries could resolve these deficiencies in our knowledge of black sea bass life history.

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APPENDIX TABLE.—RV *Dolphin* 1965-66 ichthyoplankton survey. Data associated with Gulf V catches of black sea bass larvae.

Cruise station	Tow depth (m)	Larvae Number	Larvae Lengths (mm SL) Mean	Larvae Lengths (mm SL) Range	Date (1966) D	Date (1966) M	Tow start time (EST)	Light condition[1]	Water depth (m)	Temperature (°C) Range	Temperature (°C) Mean	Temperature (°C) Surface	Temperature (°C) Bottom	Thermocline Degree	Thermocline Depth (m)	Salinity (‰) Range	Salinity (‰) Mean
D-66-7																	
H 2	0- 6	1	4.6		27	6	1521	Day	22	18.1-21.2	19.6	21.2	15.5	Weak	2-11	30.3-31.0	30.7
L 3	18-24	2	5.7	5.5- 5.9	22	6	2144	Night	38	15.3-15.4	15.3	16.7	15.6	None	--	32.8-32.8	32.8
D-66-10																	
F 5	0-15	3	3.6	2.8- 4.5	9	8	2352	Night	34	14.8-22.4	20.7	22.4	8.6	Strong	9-19	30.9-30.9	30.9
F 5	18-24	1	3.7		9	8	2352	Night	34	8.8-11.5	9.5	22.4	8.6	Strong	9-19	31.1-31.3	31.2
G 4	0-15	17	3.6	2.3- 5.1	21	8	0930	Day	28	15.8-23.6	21.9	23.6	9.7	Strong	8-18	30.7-31.0	30.9
G 5	0-15	7	4.0	3.1- 5.5	21	8	1255	Day	49	16.3-24.2	21.2	24.2	5.8	Strong	3-23	30.1-30.8	30.4
H 4	0-15	24	5.9	3.2-10.6	22	8	0305	Night	26	12.6-24.5	21.6	24.5	9.8	Strong	10-17	30.5-31.1	30.6
H 5	0-15	28	4.9	3.2- 7.3	22	8	0139	Night	40	18.8-25.4	23.7	25.4	8.4	Strong	11-22	30.5-31.0	30.7
H 5	18-24	3	5.3	4.8- 6.1	22	8	0139	Night	40	9.7-14.8	11.7	25.4	8.4	Strong	11-22	31.0-31.2	31.1
J 5	0-15	8	6.5	4.2-10.7	22	8	2347	Night	26	15.7-26.1	21.2	26.1	10.3	None	--	30.4-31.2	30.7
J 6	0-15	1	9.4		23	8	0335	Night	35	18.5-25.8	23.6	25.7	8.3	Strong	6-24	30.3-30.6	30.5
K 3	0-15	2	4.6	3.2- 6.1	24	8	1954	Night	25	15.0-24.4	22.1	24.4	14.8	Strong	7-15	30.7-31.1	30.8
K 4	0-15	[2]1			23	8	1857	Night	27	14.5-25.5	22.0	25.5	10.5	Strong	8-18	30.3-31.3	30.9
K 4	18-24	2	11.4	11.0-11.8	23	8	1857	Night	27	10.8-12.9	11.7	25.5	10.5	Strong	8-18	30.8-31.6	31.3
K 5	0-15	2	5.0	5.0- 5.0	23	8	1718	Day	30	19.4-26.4	22.9	26.4	9.6	Strong	7-23	31.2-31.3	31.3
K 5	18-24	1	5.4		23	8	1718	Day	30	10.2-15.4	12.3	26.4	9.6	Strong	7-23	31.4-31.7	31.6
L 3	0-15	5	4.5	3.2- 6.3	25	8	0445	Night	33	16.9-24.6	22.2	24.6	16.4	Strong	7-14	31.3-31.9	31.5
L 3	18-24	8	6.6	3.6- 8.4	25	8	0445	Night	33	14.7-16.4	15.6	24.6	16.4	Strong	7-14	32.2-32.7	32.5
L 4	0-15	5	3.2	2.1- 4.3	25	8	0618	Day	41	24.9-25.8	25.6	25.8	16.0	Strong	19-25	31.9-33.6	32.4
L 4	18-33	1	7.9	7.9- 7.9	25	8	0618	Day	41	15.6-24.1	18.1	25.8	16.0	Strong	19-25	31.2-34.5	33.3
M 1	0- 6	1	3.3		25	8	1212	Day	15	25.4-25.4	25.4	25.4	25.4	None	--	31.4-31.6	31.5
N 1	0-15	1	4.5		25	8	2036	Night	22	27.1-27.2	27.2	27.2	26.6	None	--	34.6-34.8	34.7
N 4	18-33	2	2.7	2.5- 2.9	26	8	0009	Night	48	22.9-27.5	25.2	28.0	21.6	Weak	17-41	34.8-35.3	35.0
D-66-11																	
D 1	0- 6	1	5.4		18	9	1413	Day	16	21.0-21.1	21.0	21.1	20.7	None	--	30.4-30.5	30.5
D-66-12																	
D 5	0-15	1	5.0		12	10	2204	Night	36	16.5-16.6	16.6	16.6	11.0	Weak	23-37	31.2-31.3	31.2
D 5	18-24	1	7.1		12	10	2204	Night	36	15.5-16.4	16.1	16.6	11.0	Weak	23-37	31.2-31.4	31.3
E 3	0- 6	1	5.0		5	10	1323	Day	22	17.4-17.4	17.4	17.4	16.9	None	--	30.8-30.9	30.8
E 5	0-15	1	6.1		11	10	2210	Night	35	16.4-16.6	16.5	16.6	9.0	Strong	22-31	31.2-31.4	31.3
F 4	0-15	2	4.2	3.5- 5.0	5	10	0227	Night	22	17.7-18.0	17.8	18.0	17.7	None	--	30.8-30.9	30.8
F 5	0-15	2	5.4	5.3- 5.6	4	10	2151	Night	35	17.4-17.9	17.7	17.9	14.2	Weak	18-24	30.7-30.9	30.8
F 5	18-24	1	3.6		4	10	2151	Night	35	14.9-17.0	16.1	17.9	14.2	Weak	18-24	30.9-30.9	30.9
G 4	0-15	1	6.3		4	10	0627	Day	31	18.1-18.2	18.2	18.2	15.8	None	--	31.0-31.1	31.0
G 5	0-15	4	5.8	5.5- 6.1	4	10	0816	Day	51	17.4-18.0	17.8	18.0	9.4	Strong	19-26	30.9-31.0	30.9
J 6	18-24	1	4.1		2	10	2125	Night	35	14.9-18.0	16.6	19.5	10.1	Weak	16-28	31.5-31.6	31.5
K 1	0-15	1	4.3		1	10	0730	Day	17	19.7-21.4	20.8	21.4	19.7	None	--	30.4-30.9	30.6
K 5	18-24	1	7.3		1	10	0010	Night	33	12.9-15.9	13.9	21.6	12.3	Weak	11-22	30.8-31.0	30.9
D-66-14																	
F 4	0-15	1	5.2		11	11	0312	Night	22	14.2-14.3	14.2	14.3	14.2	None	--	32.8-33.0	32.9
H 5	0-15	1	7.5		12	11	0754	Day	42	14.4-15.3	14.8	15.3	14.0	None	--	33.3-33.6	33.5
N 3	18-24	2	10.3	7.6-13.0	16	11	0833	Day	30	19.4-19.5	19.4	19.3	19.4	None	--	35.8-35.9	35.9

[1] Day tow: start time between sunrise and 0.5 hr before sunset; night tow: start time between sunset and 0.5 hr before sunrise.
[2] Larva too mutilated for accurate measurement.