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FURTHER NOTES ON THE DEVELOPMENT AND LIFE HISTORY OF SOME TELEOSTS AT BEAUFORT, N. C.

By SAMUEL F. HILDEBRAND and LOUELLA E. CABLE

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FURTHER NOTES ON THE DEVELOPMENT AND LIFE HISTORY OF SOME TELEOSTS AT BEAUFORT, N. C.[1]

By SAMUEL F. HILDEBRAND and LOUELLA E. CABLE, *United States Bureau of Fisheries*

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INTRODUCTION

The following accounts of the development and life history of a miscellaneous group of teleostean fishes is a continuation of earlier studies by the same authors, published in the Bulletin of the United States Bureau of Fisheries, volume XLVI, 1930, pages 383 to 488, and volume XLVIII, 1934, pages 41 to 117 (see Bibliography).

Most of the specimens and data used were collected at Beaufort, N. C. However, some of the specimens and data were secured elsewhere, principally by Dr. Lewis Radcliffe and the late William W. Welsh, working aboard the Fisheries vessels *Albatross*, *Fish Hawk*, and *Grampus*.

The authors were very materially assisted in the field work, carried on from 1925 to 1932, by the various members of the staff of the United States Fisheries Biological Station at Beaufort, N. C., especially by Dr. James S. Gutsell and Capt. Charles Hatsel, who accompanied one or both of the writers on many trips, and also collected independently.

The drawings presented herewith were prepared by the junior author, unless otherwise stated in the legends. The junior author, also, did much of the tedious work of sorting the young fishes from other forms and the general debris usually taken in towings, and made some of the preliminary identifications. The senior author, under whose direction the work was carried on, is responsible for final identifications, the interpretation of the data, and for the preparation of the manuscript.

The principal collecting stations are indicated with small circles on the map (fig. 1). One-meter tow nets, one at the surface and one on the bottom, hauled simultaneously, were the only nets used at the farthest offshore stations. At the stations near shore, and at those in the partly enclosed waters, otter trawls and beam trawls also were used. Furthermore, collecting seines, particularly small ones made of bobbinet, were employed along the shores both in the inside waters and along the outside beaches.

An otter trawl having the cod-end surrounded by bobbinet, built as a modified 1-meter tow net, with the collar laced to the meshes of the trawl, was found very useful for collecting young fish. The fish taken in the bobbinet generally were past the larval stage and too active to catch with an ordinary 1-meter tow net, yet small enough to pass through the one-fourth inch square mesh of the collecting trawl. This apparatus proved very satisfactory at Beaufort, where there is little or no rough or rocky bottom.

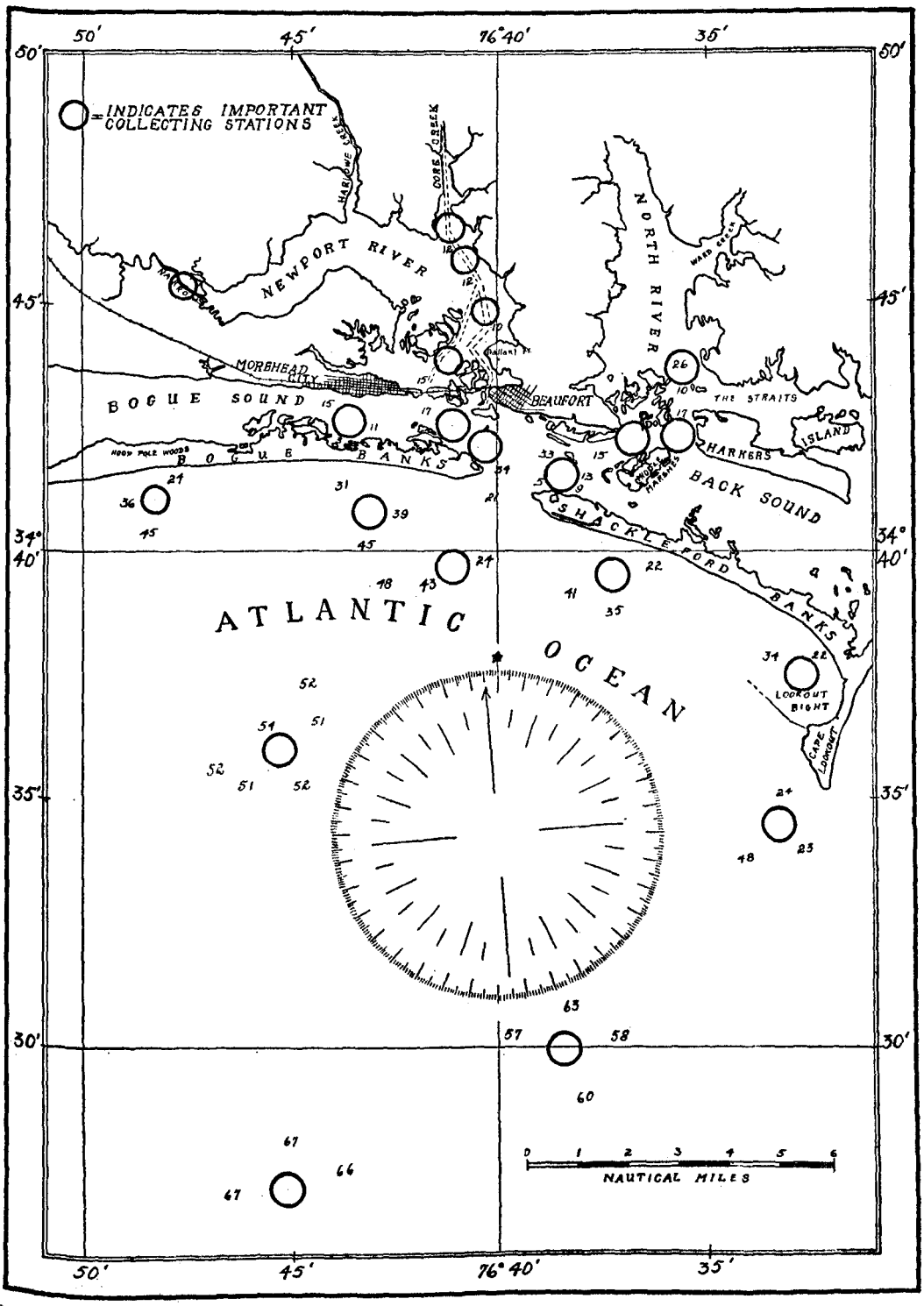

FIGURE 1.—Map of Beaufort Harbor and neighboring waters. Numbers on the map show the depth of the water in feet at the principal collecting stations.

It will be seen from the following accounts that generally many gaps remain in the series of developmental stages of the various species treated. However, in every case enough new information is presented to make publication seem quite worth while.

It has been possible, at least for some of the species discussed, to determine from the time and place of collection of the eggs or early young or both, the approximate duration of the spawning season and also the place of spawning, even though ripe fish were not seen. The movements or migrations of the young, too, were determined for some of the species from the places of collection of immature fish. Considerable information relative to the rate of growth during the first several months of life also was gained for several species, and is shown in tables and graphs presented.

All the species discussed in this paper, exclusive of the pinfish and the hakes, spawn during the summer, and either are scarce or absent in the local shallow water during the winter. The pinfish and the hakes, however, spawn during autumn and winter, and the young sometimes were taken in large numbers during the winter in company with young spots and croakers, the last named species also being winter spawners, as shown in an earlier paper by the writers (1930, pp. 417 and 433).

The drawings of the eggs and newly hatched fish are based on living material. All the rest of the illustrations were prepared from preserved specimens.

SCOMBEROMORUS MACULATUS (MITCHILL). SPANISH MACKEREL, WITH NOTES ON RELATED SPECIES

The development of the eggs and the early larvae, up to 6 days of age, of the Spanish mackerel was described and figured by John A. Ryder (1882, pp. 135–172). It is now possible to describe and figure some older stages of Scomberomorus.

The eggs used in Professor Ryder's study were secured directly from ripe fish at several different points in Chesapeake Bay. The eggs, according to Ryder, float in sea water and vary in size from "one-twenty-fifth to one-twentieth of an inch in diameter." They generally hatched in 24 hours. Segmentation proceeded quite regularly, as usual in teleostean eggs. The newly hatched fish was scarcely 2 mm long. When 3 days old the larvae had absorbed the contents of the yolksac, and the mouth was wide open. On the sixth day after hatching (length not stated), according to Ryder's figure 17, the mouth had grown very large and wide with a sharp angle at the joints of the lower jaw. Prominent teeth already were present. This is the most advanced larva described and figured (anterior part of body only) by Ryder, and it seems to be identifiable with the smallest larvae now at hand.

The specimens upon which the present study is based were caught in nets, mostly on the coast of North Carolina in the vicinity of Beaufort. However, among the larger young, specimens from Massachusetts, South Carolina, Georgia, Florida, Louisiana, Cuba, St. Lucia, and Panama also have been studied. All the larvae under 14 mm in length were taken at sea and mostly several miles offshore along the coast of North Carolina. Neither the larvae nor the older young were found numerous during the extensive collecting done in the vicinity of Beaufort. Nevertheless, adult Spanish mackerel occur there in season (spring and fall) in sufficient abundance to be of considerable commercial value. However, comparatively few seem to remain during the spawning season.

The ceros (locally pronounced "zero") or kingfish, *S. cavalla* and *S. regalis*, are too scarce (especially the last named one) on the coast of North Carolina to be of much commercial importance. They are sought, however, by sportsmen, who prefer them to Spanish mackerel because they run larger in size. *S. cavalla* sometimes

attains a weight of 50 to 75 pounds, and *S. regalis* 25 to 35 pounds, whereas *S. maculatus* attains a maximum weight of only 20 to 25 pounds. The average run in weight of these species respectively in the order named, however, is only about 7, 5, and 2 pounds.

The Spanish mackerel and the ceros or kingfishes are all of wide distribution. The spanish mackerel (*S. maculatus*) ranges from Cape Cod, Mass., (sometimes as far north as Maine) south to Brazil on the Atlantic coast and from San Diego, Calif., to the Galapagos Islands on the Pacific. The ceros (*S. cavalla* and *S. regalis*) are about equally as widely distributed on the Atlantic, though they do not occur on the Pacific coast. *S. cavalla* and *S. maculatus* are recorded also from the Atlantic coast of Africa. All the species seem to be chiefly of southern distribution, large quantities being taken in southern Florida, on the Gulf coast, and southward.

The Spanish mackerel, like the other species of the genus, is migratory. It appears on the coast off Beaufort, N. C., in the spring, generally arriving in April, and it returns again in the fall, comparatively few remaining during the summer. According to local fishermen and fish dealers the fish of the spring run are poor and contain green roe. This statement is affirmed by our limited observations. In the fall the fish are fat and without roe. Spawning takes place during the summer, as shown subsequently, at a time when the fish locally are scarce. Therefore, the vicinity of Beaufort evidently is not an important spawning area.

The ceros occur off Beaufort chiefly in the fall, and are scarce or absent the rest of the year. All three species of Scomberomorus discussed are taken in large numbers in southern Florida and on the Gulf coast during the winter, when they are absent in North Carolina and northward.

CHARACTERS OF THE ADULT

Adult Scomberomorus are recognized by the elongate, little-compressed body; long pointed snout; large mouth with strong teeth; and by a keel of skin on the sides of the tail posteriorly. The dorsal fin is long, composed of 14 to 18 feeble spines, 14 to 18 soft rays, followed by 7 to 10 separate finlets. The anal fin similarly is followed by about an equal number of finlets and the caudal fin is deeply forked. The general color is silvery, generally with spots and markings that differ among the species.

The three species of Scomberomorus herein considered are rather closely related. However, *S. cavalla* is distinguishable by the more slender body and the abruptly decurved lateral line under the second dorsal. Furthermore, the origin of the anal usually is under the middle of the dorsal, whereas in the related species it is a little farther forward. Large individuals of *S. cavalla* are plain bluish above and silvery below, without spots, though young ones are described as having bronze spots.

S. regalis differs from the other species in having scales on the pectoral fins and in having one or two continuous black lines along the side. In addition to the black lines it retains elliptical bronze spots throughout life.

S. maculatus, as stated elsewhere, runs smaller in size than the related species. It has no scales on the pectoral fins, and no black line on the side, though it has bronze spots. The lateral line, as in *S. regalis*, is more gently decurved under the second dorsal than in *S. cavalla*. In *S. maculatus* the anterior part of the first dorsal, back to about the fifth spine, is wholly black, whereas in the limited number of specimens of *S. regalis* examined only the outer two-thirds of that part of the fin are black, the base being white.

SPAWNING

A fairly full report on the spawning season of the Spanish mackerel, *S. maculatus*, was given by R. Edward Earll (1882, pp. 395–426). This writer made a special investigation and stated (p. 404) that this fish begins to spawn in the Carolinas in April, in Chesapeake Bay in June, and in the vicinity of Long Island not until the last of August. Mr. Earll stated, furthermore (p. 405):

* * * The spawning season on our coast continues throughout the summer, and, in any particular locality, it lasts from 6 to upward of 10 weeks. * * * Again, a single individual is a number of weeks depositing its eggs, as shown by the fact that when the first are excluded a large percentage are still small and immature.

It seems to us from the evidence obtained during the investigation upon which this report is based that Mr. Earll set the beginning of the spawning season ("in April") too early for North Carolina. It has been stated already (p. 509) that the Spanish mackerel arriving off Beaufort in April and May contain green roe. Furthermore, no larvae were collected there prior to June 28 (1927).

Other young of sizes stated were taken in the vicinity of Beaufort as follows: Larvae 4.0 mm and less in length, June 28 (1927), August 17 (1927), and August 26 (1929); larger larvae up to 8.0 mm in length, July 12 (1915), and September 1 and 2 (1914); young 14 to 20 mm long, July 7 (1913), July 9 (1915),[2] and September 2 (1914); and specimens up to 80 mm long, August 15 (1913), and October 7 (1930).

The larger young, that is, fish 14 mm and upward in length are capable of swimming and may have traveled some distance from the spawning ground. In fact, some of these larger young were taken in inside waters, whereas the smaller ones were caught only in outside waters. Larvae 8 mm and less in length, as already shown, have no fins and are quite helpless. Except as wafted about by currents and tides, they no doubt remain where they were hatched.

It may be concluded, then, that a limited amount of spawning (for the young, as stated elsewhere, are not numerous) takes place in the open waters off Beaufort Inlet, and apparently none in the inside waters. Furthermore, larvae under 8.0 mm in length quite certainly are only several days old. As these small larvae appeared in the collection from June 28 (1927) to September 2 (1914), it may be concluded also that spawning takes place off Beaufort at least from the latter part of June to near the end of August. It cannot be stated definitely that the earliest larvae of any one season were taken, yet the absence of young in our collections prior to the end of June does in a measure confirm the statement of local fishermen and fish dealers, as well as our observations, that the fish of the spring run (April and May) at Beaufort are not ripe, and that spawning very probably does not take place in the vicinity of Beaufort until sometime in June.

So far as we are aware nothing is known definitely about the spawning habits of *S. cavalla* and *S. regalis*. The limited number of fish examined, taken in the fall of the year, contained no roe. No evidence indicating that they spawn on the coast of North Carolina has been found.

DESCRIPTIONS OF THE YOUNG

It cannot be stated positively that the young fish herein described are all Spanish mackerel, for even the adults of the species of Scomberomorus are rather closely

[2] Some of the small specimens used in the preparation of this report were collected as early as 1913 to 1915 by Dr. Lewis Radcliffe, formerly of the Bureau of Fisheries, who already had identified some of them provisionally when they fell into our hands. Therefore, we wish to credit Dr. Radcliffe with laying the foundation that made this report on Scomberomorus possible.

related, and the young may not be separable. Nevertheless, it seems highly probable that we are dealing with Spanish mackerel only, as shown subsequently.

The descriptions that follow are all based on preserved specimens. Considerable shrinkage takes place during the hardening process. Consequently the smallest larvae herein described, though shorter than the largest ones described by Ryder (1882) in the fresh state, are more advanced in development.

Specimens about 2.5 mm long.—The body is robust, but the tail is long and slender, being notably longer than the head and trunk. The greatest depth is contained in the total length about 3.25 times. The mouth is very large and broad and strongly oblique; the gape reaches under the eye; and the lower jaw projects slightly and is straight and broad. Teeth already are plainly visible. The myomeres are indistinct anteriorly and posteriorly and therefore cannot all be enumerated. They appear to be rather numerous. Slight indications of rays are present above and below the tip of the tail. Pectoral fin membranes are prominent, with indications of rays.

The general color of the preserved specimens is brownish. A dark spot just behind the symphysis of the lower jaw is at least sometimes present, and another one appears on the abdominal wall a short distance in advance of the vent (fig. 2).

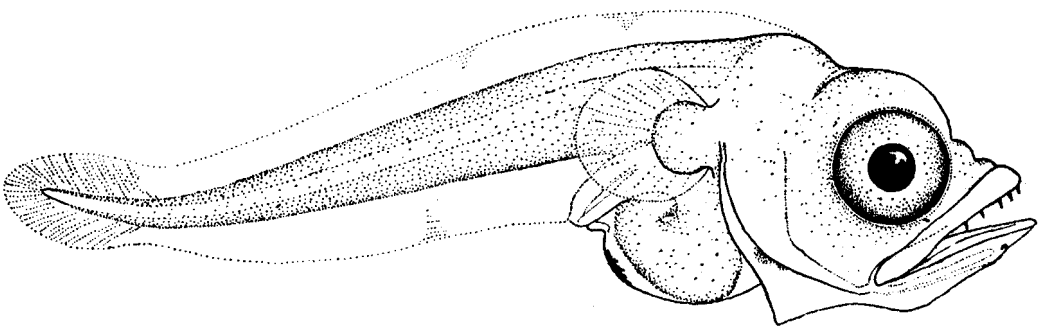

FIGURE 2.—*Scomberomorus maculatus*. From a specimen 2.75 mm long.

The chief distinguishing character, and the one that seems to "link" these larvae with the smaller and larger ones, is the large broad oblique mouth with well developed teeth.

Specimens 3.0 to 3.5 mm long.—The caudal portion of the body has grown proportionately much shorter and deeper, the vent now being situated near midbody length, and the greatest depth is equal to the head, and is contained about 3.0 times in the length. The mouth remains large and wide, and has become more strongly oblique. Two depressions, one over the snout and another at the nape, are present and rather more prominent than in the smaller fish already described. Several prominent spines are present on the preopercular margin (which disappear in the adult). Three slender spines are developed in the anterior part of the dorsal finfold, though no soft rays are developed, a sequence contrary to that found in other species studied, and apparently contrary to the general rule in spiny-rayed fishes, in which the soft rays most usually are developed before the spines appear. A variation in the relative length of the dorsal spines seems to exist among individuals of about this size and larger ones, as in some specimens the first spine is longest and in others the second one.

A few dark spots are present along the ventral surface of the caudal portion of the body, and generally some dark markings appear on the dorsal wall of the abdominal cavity (figs. 3 and 4).

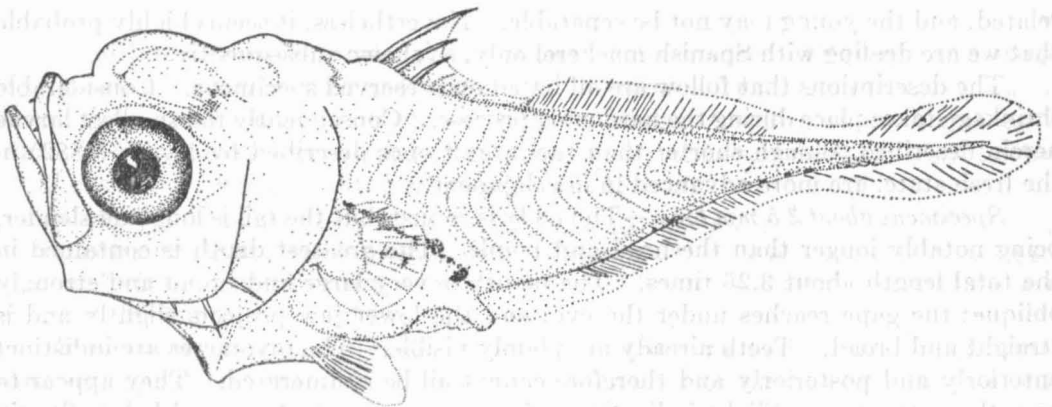

FIGURE 3.—*Scomberomorus maculatus.* From a specimen 3 mm long.

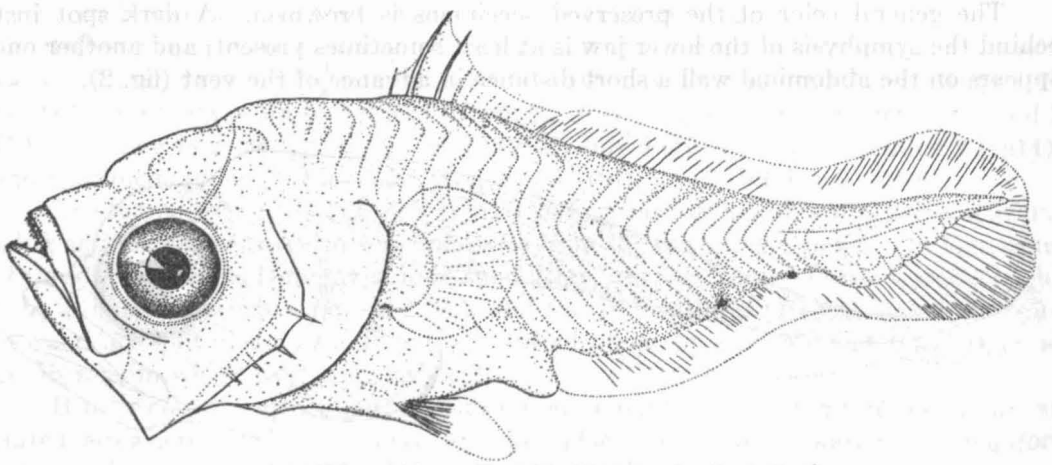

FIGURE 4.—*Scomberomorus maculatus.* From a specimen 3.25 mm long.

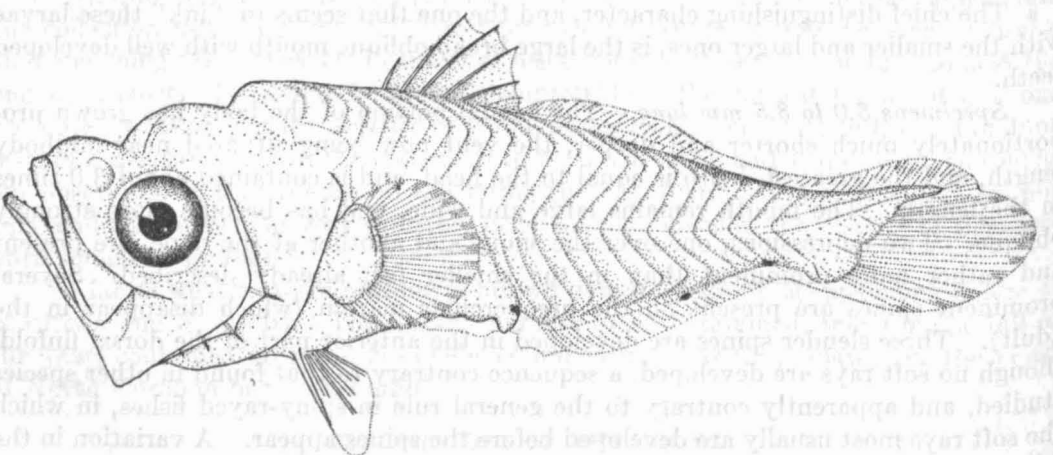

FIGURE 5.—*Scomberomorus maculatus.* From a specimen 4 mm long.

Specimens 4.0 to 4.25 mm long.—Two specimens of this range in size are at hand. They are very similar to specimens 3.5 mm long, differing principally in the development of two additional spines in the dorsal fin, five spines now being present (fig. 5).

Specimens about 6.0 mm long.—The large mouth has become much less strongly oblique, the gape anteriorly being below the level of the middle of the eye, whereas in specimens about 4.0 mm long it is at or above the upper margin of the eye. The maxillary has become narrower, and now reaches well beyond the middle of the eye. Teeth are very prominent. The snout has become much more pointed, and there is a sharp demarcation and depression where the premaxillaries apparently articulate with the skull bones. In advance of this depression or groove there is a pronounced hump in some specimens, which has a tendency to form a backwardly directed hook over the groove. This depression is distinct in the smaller fish described, though the premaxillaries are not definitely outlined. A second depression present at the nape in smaller fish has now disappeared. Dorsal spines have increased to seven in number, and are relatively high, the longest one being a little longer than the snout. There is variation in the relative length of the dorsal spines, the first spine particularly being shorter in some specimens than in others. Soft rays still are imperfectly developed. The notochord is directed upward sharply, as usual at this stage in fishes destined to have homocercal tails. Myomeres are numerous, but cannot be counted accurately. Four spines, though reduced in size, remain present on the preopercular margin as in younger fish.

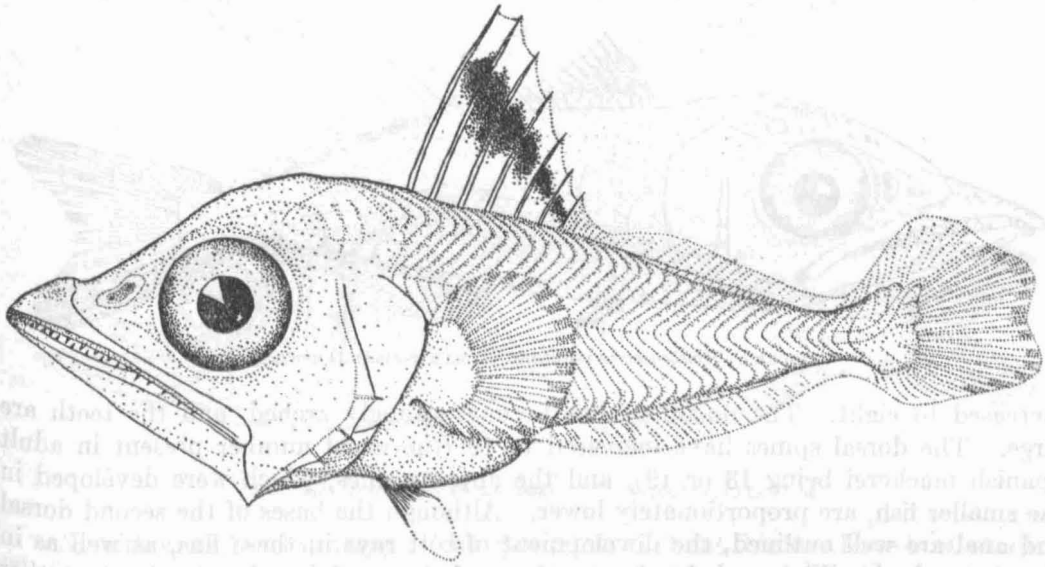

FIGURE 6.—*Scomberomorus maculatus* (?). From a specimen 5.75 mm long.

The general color of the long-preserved specimens at hand is brownish. The only color marking is a broad black band on the dorsal spines (fig. 6).

No specimens between a length of 4.0 and 5.0 mm are at hand. Unfortunately the 5.0-mm specimen is imperfect, especially in having the dorsal spines broken. The next smallest specimen in good condition is 5.25 mm long. Considerable advancement in development took place, if the larvae actually are all of one species, while the fish grew in length from 4.0 to 5.0 mm. The chief connecting "links" between the smaller specimens and the present group are: The very large mouth with prominent teeth; the preopercular spines, four in number in each stage; the retention of the depression over the snout, marking the articulation of the premaxillaries; and the prominent dorsal spines. The great increase in length of the dorsal spines is somewhat disturbing in the absence of intermediate specimens. There can be

no doubt, however, that these fish, if not of the same species as the smaller and larger ones herein described, at least are of a related species.

Specimens 7.0 to 8.0 mm long.—Three specimens of this size are at hand. They differ little from the somewhat smaller ones described in the preceding section. The upper jaw is now slightly arched as in larger fish; dorsal spines have increased to eight, and remain high as in the smaller fish; soft rays are fairly definite in all the fins, though no articulations are evident; the caudal fin shows a tendency to fork; and the color apparently remains unchanged.

Specimen 14 mm long.—Only one specimen of this size is at hand, and none intermediate of this one and those described in the immediately preceding section. Therefore, a considerable gap remains. However, several similar and identical characters "link" this fish with the smaller ones, showing that if not identical they at least are representatives of related species.

The 14-mm specimen is much more elongate than the smaller ones described, the greatest depth being contained about four times in the standard length. The snout has become still longer and more pointed, being contained 2.1 times in the head, and it projects well beyond the lower jaw. The groove at the articulation of the premaxillaries remains prominent. Spines on the preopercular margin have

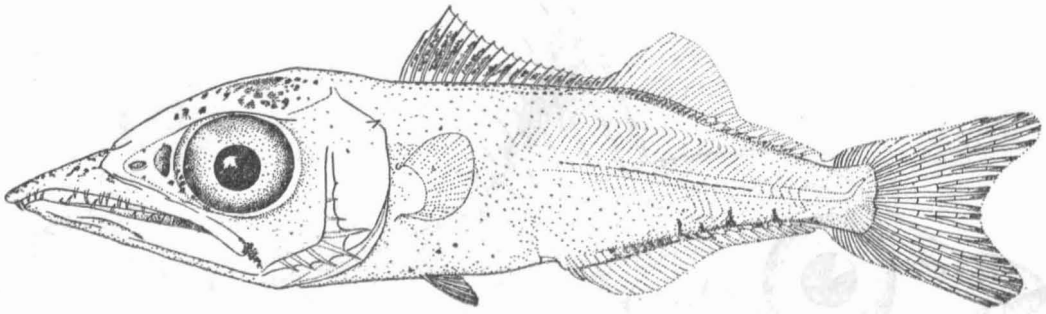

FIGURE 7.—*Scomberomorus maculatus.* From a specimen 14 mm long.

increased to eight. The maxillary has become strongly arched, and the teeth are large. The dorsal spines have increased to 19 (the usual number present in adult Spanish mackerel being 18 or 19), and the anterior ones, which were developed in the smaller fish, are proportionately lower. Although the bases of the second dorsal and anal are well outlined, the development of soft rays in these fins, as well as in the pectorals, is still retarded, whereas those of the caudal and ventrals are rather better developed. The origin of the anal is somewhat in advance of the second dorsal, whereas in adults its origin generally is under or behind that of the second dorsal. Dorsal and anal finlets are not yet definitely developed but thickenings in the fin membranes that will constitute the bases of the finlets are evident. The primitive fin membrane, however, remains continuous in each fin. The caudal fin now is distinctly concave.

The general color of the preserved specimen is brownish, with some black pigment at the posterior end of the maxillary, and scattered black specks on the head and snout. The black band on the spinous dorsal present in smaller specimens remains, but is somewhat broken up into spots in the 14-mm fish. Blackish specks also are visible along the base of the second dorsal and anal fins (fig. 7).

Except for the comparatively great change in the height of the anterior dorsal spines, the 14-mm fish connects up well with the 8.0-mm ones. Additional specimens

will be required to determine positively the identity of this fish and the smaller specimens mentioned.

Specimens about 17 mm long.—Five specimens of about this size are at hand. Development is much further advanced than in the 14-mm fish already described. The finlets of the dorsal and anal, eight or nine in number in each fin, are more distinctly outlined, yet remain connected by the primitive membrane. The caudal fin is now definitely forked. The origin of the anal remains slightly in advance of the origin of the second dorsal.

Pigmentation has increased somewhat. Some specimens are partly silvery in color. The black band on the spinous dorsal, very pronounced in younger fish, is now broken up into spots (fig. 8).

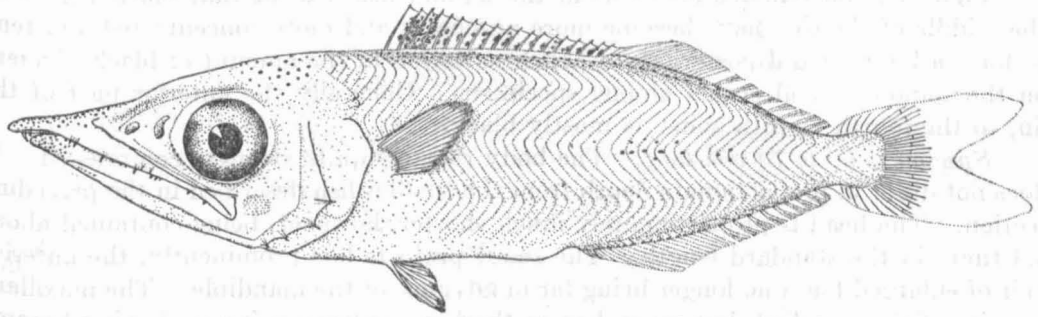

FIGURE 8.—*Scomberomorus maculatus.* From a specimen about 17 mm long.

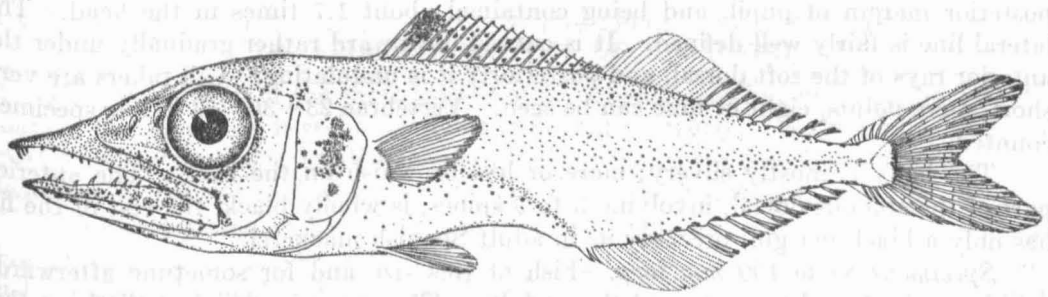

FIGURE 9.—*Scomberomorus maculatus.* From a specimen 22 mm long.

Specimens 22 to 25 mm long.—Ten specimens of about this size have been studied. The body has become rather more slender, the depth now being contained about 4.5 times in the standard length, and it remains rather strongly compressed. The head is long, about 2.5 times in the standard length; the snout is sharply pointed and projects strongly beyond the lower jaw, as in younger fish, its length being contained about 2.2 times in head. The groove at the articulation of the premaxillaries remains evident. The mouth is very large and the teeth are strong, a pair of large canines in the upper jaw being on the part projecting beyond the lower jaw. The maxillary reaches somewhat past the middle of the eye and is contained about 1.4 times in the head. Only two preopercular spines remain. The origin of the anal is now only slightly in advance of that of the second dorsal. The rays of these fins remain imperfectly developed, though those of the other fins are well formed. The finlets are all well developed and separate. The caudal fin is well forked, but not as broadly as in the adults.

Pigmentation has progressed fairly rapidly. The general color is silvery, though the back has a brownish cast. The black markings are shown in figure 9.

Specimens 35 to 40 mm long.—Six specimens of about this size are at hand. The advancement over the 25-mm fish is not great. The upper jaw projects less prominently, and the articulation of the premaxillaries no longer is marked by a definite groove. The preopercular spines have been almost completely absorbed. In some specimens of this size a slight indication of a lateral line is present. The second dorsal and anal now have attained more nearly the relative position occupied in adult fish, as the origins are about opposite each other. (In adult *S. maculatus* and *S. regalis* the origin of the anal generally is slightly behind that of the second dorsal, whereas in *S. cavalla* it often is nearly under the middle of the second dorsal). The rays of these fins now are quite fully developed. The following counts are based on one specimen: D. XIX–17–VII; A. II, 17–VIII; vertebrae 22+31=53.

Pigmentation remains about as in the 25-mm fish, except that black points on the middle of the side have become more numerous and more concentrated and tend to form a lateral band posteriorly. Much variation in the amount of black pigment on the spinous dorsal occurs among specimens. Generally the anterior part of the fin, to the fourth or fifth spine, is mostly black.

Specimens 60 to 70 mm long.—The body remains quite strongly compressed. It does not differ in proportionate depth from the smaller fish described in the preceding section. The head is proportionately much shorter, however, being contained about 3.3 times in the standard length. The snout projects less prominently, the anterior pair of enlarged teeth no longer being far in advance of the mandible. The maxillary remains slightly arched, but much less so than in smaller specimens, having become gradually less bent since a length of about 14 mm was attained, reaching below posterior margin of pupil, and being contained about 1.7 times in the head. The lateral line is fairly well defined. It is curved downward rather gradually under the anterior rays of the soft dorsal, and posteriorly it is undulating. Gill rakers are very short, mere points, eight or nine can be seen. Vertebrae 23+30=53 in one specimen counted.

The body is mostly silvery; more or less brownish on the back. The anterior part of the spinous dorsal, involving 3 to 5 spines, is wholly black, the rest of the fin has only a black margin, precisely as in adult Spanish mackerel.

Specimens 85 to 100 mm long.—Fish of this size and for sometime afterwards remain more strongly compressed than adults. The upper jaw projects little at this size, the teeth remain strong, but less so than in younger fish; and the caudal fin is now broadly forked, about as in the adult. No dermal keel is as yet evident in the lateral line on the caudal peduncle. The following counts and proportions are based on a specimen 97 mm long: Head 3.8; depth 4.6 in standard length; snout 2.8, maxillary 1.8 in head; D. XVII–16–VIII; A. II, 14–IX; gill rakers minute, 9; vertebrae 22+31=53.

The color is bright silvery, rather bluish silvery above. No spots or lines are discernible in the preserved specimens at hand (fig. 10).

Specimen 160 mm long.—A single fish of this length (and none intermediate of this one and one 115 mm long) is at hand. The 160-mm fish does not differ greatly from the smaller group described in the preceding section. The proportions given for the smaller fish have not changed.

No change in color appears to have taken place. No indications of spots or other markings are present on the body in the old preserved specimen studied.

Specimens 210 to 225 mm long.—One specimen of each length given is at hand. These fish were recently preserved. The larger one has dark spots (yellow in life) on the sides as in the adults. The smaller one has none, which seems to show that the

spots are not always developed at a length of 210 mm. In structure these fish do not differ essentially from the 160-mm fish already described. These specimens still remain rather more compressed than large fish. The maxillary remains gently arched, and the snout sharply pointed, projecting slightly, just as in the smaller fish described in the foregoing section. The lateral line remains unchanged, being rather gently decurved under the anterior part of the soft dorsal, precisely as in adult Spanish mackerel. The gill rakers have increased somewhat in length, though they do not yet exceed a fourth the length of the pupil. Scales now are present on the soft dorsal and on the anal, though none can be seen on the pectorals. The dermal keel on the caudal peduncle is quite evident.

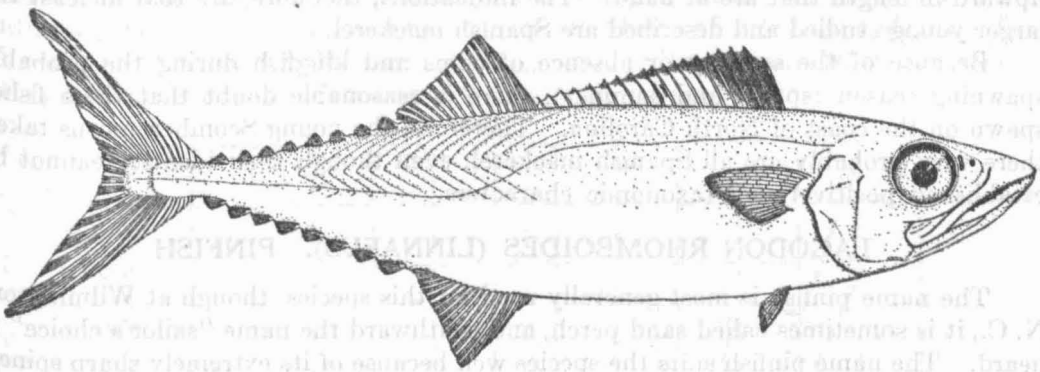

FIGURE 10.—*Scomberomorus maculatus*. From a specimen 97 mm long.

A DISCUSSION OF THE RELATIONSHIP OF THE SPECIES OF SCOMBEROMORUS AND THE PROBABLE IDENTITY OF THE YOUNG

The relationship of the three species of Scomberomorus known from the Atlantic coast of the Americas, is rather close, as indicated elsewhere. We recognize only one species among the young studied, though the identity of the 6.0- to 8.0-mm specimens described is somewhat doubtful, owing to some missing stages.

If the very young are separable into species it would be necessary to use characters different from those employed in recognizing the adults. We have not discovered any distinguishing "juvenile" characters. The first "adult" character that develops, which apparently is of some value in distinguishing the kingfish, *S. cavalla*, from the other local species of the genus, is the relative position of the soft dorsal and the anal. In the kingfish the origin of the anal is well behind the origin of the soft dorsal, often nearly under the middle of the soft dorsal, whereas in the other two species the origin of the anal is under or more usually slightly posterior to the origin of the soft dorsal. The soft dorsal and anal are not well developed until the fish reach a length of about 14 mm, and it is not until the fish reach a length of about 35 mm that the relative position occupied in adults is attained, as the origin of the anal is in advance of the second dorsal in smaller fish. The relative position of these fins remains unchanged in all the larger young (35 mm and upward in length) studied, the origin of the anal being slightly posterior to that of the second dorsal. Therefore, the specimens in our collection probably cannot be identified as *S. cavalla*.

The next distinctive character that develops is the lateral line, which is abruptly decurved under the second dorsal in the kingfish, *S. cavalla*, and rather gradually in the other species. The lateral line sometimes is evident in specimens 70 mm long, but often not until later. Judging from the course of the lateral lines the kingfish again seems to be missing among the specimens that could be checked for this character.

The Spanish mackerel, *S. maculatus*, and the spotted cero, *S. regalis*, are closely related, apparently distinguishable by the presence of scales on the pectoral fins, and by the presence of one or two longitudinal black streaks along the side of the latter. It is not known at what size these distinguishing characters develop. It can only be stated now that no scales are present on the pectoral fins in any of the young at hand. Neither are dark stripes present. In two adult *S. regalis* examined the anterior part of the spinous dorsal is not wholly black, the lower third or so being white. This is shown also in an often reproduced drawing. Adult Spanish mackerel, *S. maculatus*, examined have the anterior part of the fin, involving from three to five spines, wholly black. This is true of young Scomberomorus of about 60 mm and upward in length that are at hand. The indications, therefore, are that at least the larger young studied and described are Spanish mackerel.

Because of the scarcity or absence of ceros and kingfish during the probable spawning season (spring and summer), there is reasonable doubt that these fishes spawn on the coast of North Carolina. Therefore, the young Scomberomorus taken there very probably are all Spanish mackerel, even though their identity cannot be established positively by taxonomic characters.

LAGODON RHOMBOIDES (LINNAEUS). PINFISH

The name pinfish is most generally used for this species, though at Wilmington, N. C., it is sometimes called sand perch, and southward the name "sailor's choice" is heard. The name pinfish suits the species well because of its extremely sharp spines.

The pinfish is known from Cape Cod, Mass., to Texas, and is also reported from Bermuda and Cuba. On our coast it is common from Virginia southward. Its commercial value is not great, however, because of the small size attained. The maximum length reported is 13 inches, but the average length probably does not exceed 6 inches. In the statistical report of the Bureau of Fisheries for 1935, for example, it is listed only from North Carolina (180,000 pounds) and Florida (31,000 pounds). It is marketed in limited quantities in other States, mostly with other species as "mixed fish." Therefore, the exact amount marketed is not obtainable.

The pinfish is of good flavor, and no doubt the demand would be greater if the fish attained a larger size. Occasionally when large catches, running small in size, are made at Beaufort they are taken to the menhaden reduction plants and made into fish meal or fish scrap and oil. The pinfish is said to yield a very high grade of oil.

The pinfish is one of the comparatively few species that is a year-round resident in the shallow water of the estuaries, bays, and sounds at Beaufort. It seems to withstand cold rather better than most of the other species that winter locally. For example, on January 7, 1926, and again January 4, 1928, during rather continued abnormally cold weather many individuals of such species as the speckled trout (*Cynoscion nebulosus*), the spot (*Leiostomus xanthurus*), and the croaker (*Micropogon undulatus*), became numb and floated at the surface. No pinfish were seen among them. However, on December 28, 1925, a large number of this species (5 gallons), mostly rather large ones, were frozen to death in a "fish pool" from which they could not escape and which contained only about a foot of water at low tide. The temperature of the water at the time the fish perished is not known, but the air temperature dropped to 12° F., which is unusually low for Beaufort. It is of interest that some small mullets (*Mugil cephalus*) about 6 inches in length, that had been confined in the pool with the pinfish survived, indicating that this mullet can stand even more cold than the pinfish.

The pinfish is a nuisance in some respects to anglers because of its ability to cut the bait off the hook without itself getting caught, and to net fishermen because when "gilled" it is hard to remove. The sharp spines make the fish difficult to grasp without injury to the hands. Furthermore, a small sharp spine, directed forward, precedes the dorsal fin. This procumbent spine prevents the fish from being forced through the mesh (the usual procedure in removing gilled fish) without lifting the thread over the spine. The fish taken in this way generally are too small to be of much value. Therefore, fishermen often have to labor long at the disagreeable task of removing the fish from the nets without receiving anything in return.

The pinfish also was a most annoying pest to an investigator who had confined crabs in floating wire cages for the purpose of studying their life history. The fish continually mutilated the crabs by biting off their legs and other appendages. The fish could be observed readily while "working" around the float and when underneath it they swam completely upside-down, that is, with the ventral side upward.

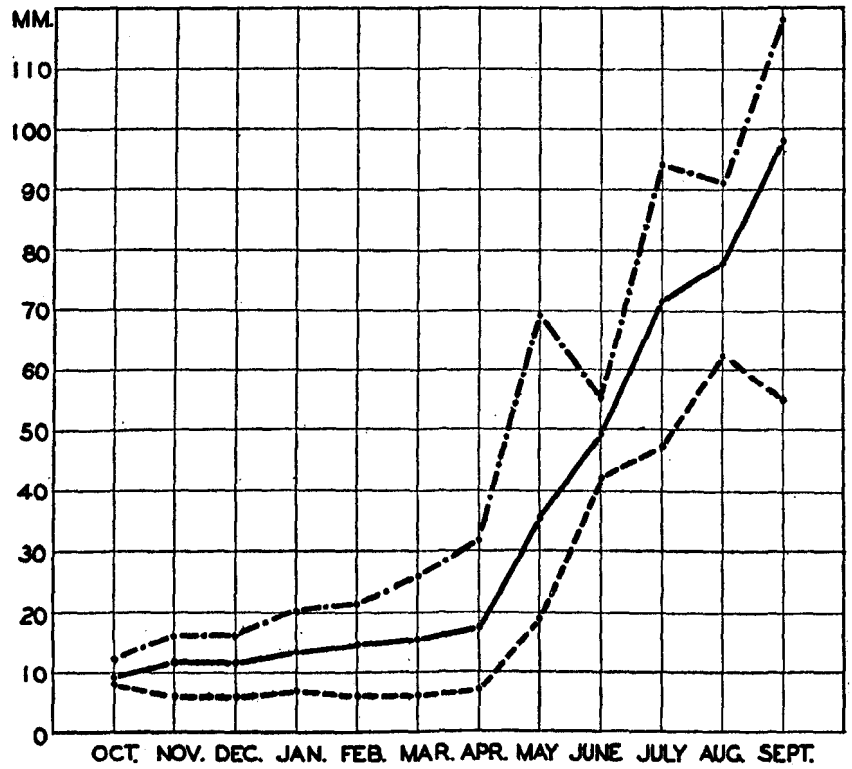

FIGURE 11.—Growth curve based on length measurements of 3,348 *Lagodon rhomboides* of the 0-class. Solid line, average length for each month of all fish measured; dot and dash (upper) line, largest fish; dot and several dashes (lower) line, smallest fish.

CHARACTERS OF THE ADULT

The pinfish (*Lagodon rhomboides*) belongs to the family Sparidae with the sheepshead (*Archosargus probatocephalus*), discussed elsewhere in this publication.

The adult pinfish is most readily recognized by its rather deep, compressed body, crossed by four to seven dark bars, and by its prominent deeply notched incisor teeth. The depth of the body is quite variable among specimens, being contained 2.2 to 2.9 times in the length to the base of the caudal. The head is rather long, and the snout is moderately pointed, being notably longer than the eye. The mouth is small and

horizontal, with the maxillary reaching only to the eye. D. XI or XII, 10 to 12; A. III, 10 to 12; scales 62 to 68; vertebrae 9+15.

SPAWNING

Many adult fish were examined in the vicinity of Beaufort, from 1914 to 1917 and from 1925 to 1931, as to the state of development of the gonads. However, no ripe fish, nor even fish with developing roe, was found, notwithstanding that Smith (1907, p. 300) reported that a ripening female was seen at Beaufort on August 6 (1903), and a ripe male on November 20 (1903). The virtual absence of ripe, or ripening, fish in the local inshore waters suggests strongly that the fish go elsewhere to spawn. The collection of small young near the inlet and at offshore stations, only, as shown subsequently, seems to indicate that spawning takes place at sea, probably a considerable distance offshore. The presence of rather early young in the local waters over a long period of time, as shown in the following paragraph, indicates a long spawning season.

Young, 10 mm and less in length, first appeared in the tow toward the end of October, and continued to be taken each succeeding month until toward the end of April. However, they were most numerous in December and January. The presence of such small fish over this long period of time seems to show that spawning begins in October and that it continues until the following March.

All the smaller young, consisting of 242 fish of 10 mm and less in length, either were taken at offshore stations or in or near Beaufort Inlet, some of the stations being as much as 12 or 13 miles offshore, beyond which no collecting was done. However, as the eggs and early larvae, or fry under 5.0 mm in length, were not found, it seems probable that spawning takes place beyond the most distant stations made. Therefore, the young taken at sea presumably were migrating from the spawning grounds to the inshore waters where the larger young, of 12 to 15 mm and upward in length, and the adults are numerous.

DESCRIPTIONS OF THE YOUNG

The early larvae were not taken, and therefore remain unknown, as already stated.

Specimens about 5.0 to 5.5 mm long.—Two specimens with damaged caudal fins are at hand. The body is decidedly elongate and compressed, the depth being contained 3.6 to 3.9 times in the length without the caudal fin. The dorsal outline is concave just in advance of the eyes and also at the nape, or just posterior to the brain, which is visible through the thin walls of the skull. The head is rather low, compressed 2.9 to 3.0 in length. The snout is moderately pointed, as long as the eye, 3.0 to 3.5 in head; the maxillary reaches nearly opposite the anterior margin of the pupil; and the gape anteriorly is very slightly below the level of the middle of the eye. Teeth are not evident. About 22 myomeres may be counted. The vent is situated slightly nearer the base of caudal than tip of snout. The primitive dorsal fin membrane in the 5.0-mm fish has suggestions of rays in the region of the anterior part of the soft dorsal of the older fish. These rays are considerably further developed in the 5.5-mm specimen. Rays are rather more definitely developed in the anal fin than in the dorsal. The notochord is bent upward posteriorly, and well-developed caudal fin rays appear below it, which are broken distally. Therefore, the exact shape of the fin cannot be determined. However, as somewhat larger specimens have a rounded caudal, it may be assumed that the fin also was more or less rounded in the small specimens. Pectoral fins are quite well developed and rather long, but the ventrals are minute.

The general color is pale. On the median ventral line are three dark spots, one near the isthmus, another on the chest, and a third one just in advance of the vent. A row of black dots occurs along the ventral outline from the origin of the anal to the base of the caudal. A dark area, apparently internal, is visible on the side above and slightly posterior to the vent (fig. 12).

Specimens 6.0 to 7.0 mm long.—The advancement over the 5.0-mm fish, already described, is not great. The body apparently has become slightly more elongate, the depth in three specimens measured is contained 3.8 to 4.0 times in the length to the base of the caudal fin. The concavities in the dorsal outline (in advance of the eyes and at the nape) remain, but are less pronounced. No change, worthy of note, has

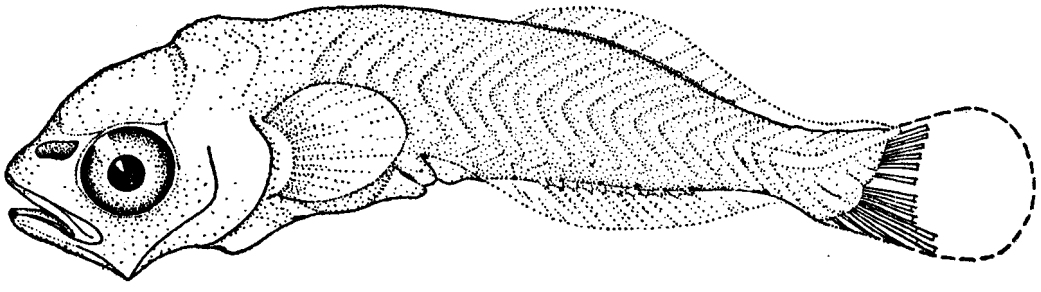

FIGURE 12.—*Lagodon rhomboides*. From a specimen 5 mm long.

taken place in the shape of the head, snout, eyes, or mouth. The principal advancement is the development of more definite soft rays in the dorsal and anal fins, of which about 12 can be counted in each fin. The spines, however, are not yet well differentiated. The caudal fin is quite long and round. The pectoral fins are long and reach to the vent, but the ventral fins are scarcely differentiated.

The black dots, present in the smaller fish described, persist and are more definite. In addition a few to several black dots now are present on the base of the caudal, two or more on the upper surface of the caudal peduncle, one at the nape, and generally an elongate blackish one above the base of the pectoral (fig. 13).

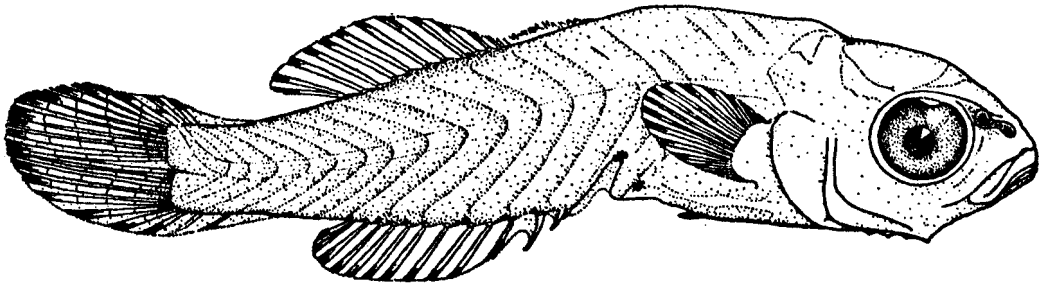

FIGURE 13.—*Lagodon rhomboides*. From a specimen 7 mm long.

Specimens 8.0 to 10 mm long.—Development has progressed rather slowly. The body has become somewhat more slender, but it remains about equally compressed, the depth now being contained 4.3 to 4.6 times in the length to the base of the caudal. The dorsal outline remains as in the smaller fish, except that depressions in advance of the eyes and at the nape have disappeared, but the brain remains visible. The head now is contained 3.5 to 3.6 in head; eye 2.9 to 3.1 in head; and the snout 3.0 to 3.3. The mouth remains oblique, with the maxillary reaching nearly opposite anterior margin of pupil. Jaw teeth now are evident, but contrary to most spiny

rayed fishes studied, no spines are visible at this size on the preopercular margin. The vent now is situated at midbody length, without caudal. The development of the fins has progressed rather rapidly. The spines in the dorsal and anal are well differentiated; the caudal fin is long and round, being nearly as long as the head; the pectoral fins, too, are long, reaching the vent; but the ventral fins are minute, being scarcely longer than the pupil.

The only change in color, worthy of note, is the development of additional dark dots along the ventral outline of the chest and abdomen, which vary in number among individuals. Some specimens also have developed a few extra chromatophores on the dorsal surface of the head.

Specimens 13 to 15 mm long.—No measureable changes in the proportions of the body have taken place. However, the snout has decreased in proportionate length and is definitely shorter than the eye, 3.6 to 4.0 in the head, whereas the eye is contained 2.8 to 3.0 times in the head. The mouth remains oblique, the gape anteriorly being only slightly below the level of the middle of the eye; the maxillary reaches only slightly beyond the anterior margin of the eye; and the teeth remain minute. The skull remains transparent, leaving the brain plainly visible from above. The rays in the dorsal and anal are all developed as the usual number present in adults may be counted, but the spines remain proportionately much shorter than in the

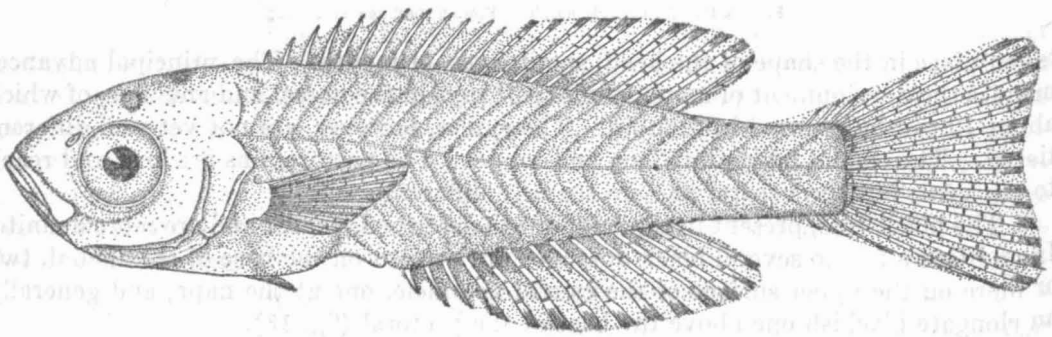

FIGURE 14.—*Lagodon rhomboides*. From a specimen 13 mm long.

adult. The caudal fin becomes square when the fish attains a length of about 12 mm and is definitely concave at a length of about 14 mm. The pectoral fins remain long, reaching nearly to origin of the anal; and the ventral fins have increased greatly in size, being nearly as long as the eye in 15-mm fish, but the spine is not yet well differentiated.

No changes in color markings worthy of note have taken place since a length of about 10 mm was attained (fig. 14).

Specimens 18 to 20 mm long.—Specimens of this length are variable in shape and color. Some specimens up to 20 mm in length remain quite as slender as 15-mm fish, whereas others are notably deeper. The slender specimens of this size are as void of pigmentation as 15-mm fish, whereas the deeper bodied specimens are profusely pigmented and have dark cross bars as in the adult. A few specimens only 16 to 17 mm long already have increased considerably in depth and have evident cross bars, whereas others up to 20 mm in length remain slender and pale. It is evident, therefore, that pigmentation and the deepening of the body take place simultaneously and that these changes occur at varying lengths. These changes apparently are associated with a change in habitat, as shown subsequently.

The depth is contained in the length to the base of the caudal 4.3 to 4.5 times in three unpigmented specimens measured, whereas in three pigmented fish of the

same size it is contained 3.5 to 3.9 times. Other proportions do not differ measurably in the two groups, the head in six specimens (three of each group) measured being contained 3.3 to 3.6 times in the length without the caudal fin, eye 2.8 to 3.2 in the head, and the snout 3.3 to 3.8 in head. The teeth remain small and equally developed in the pigmented and unpigmented specimens. Pigmented specimens about 20 mm in length are at least partly covered with scales but smaller pigmented fish and unpigmented ones, up to 20 mm in length, have none. The ctenoid character of the scales is evident as soon as the scales are developed. The fins are longer and more fully developed in the pigmented fish, though the ventral spine is differentiated in each group. The pigmented specimens, however, have the first soft ray of the ventral produced into a short filament, which is not present in unpigmented fish. The caudal fin is deeply concave in all specimens.

The specimens referred to in the foregoing paragraph as unpigmented retain a few dark markings, essentially as in much smaller fish. The pigmented ones already

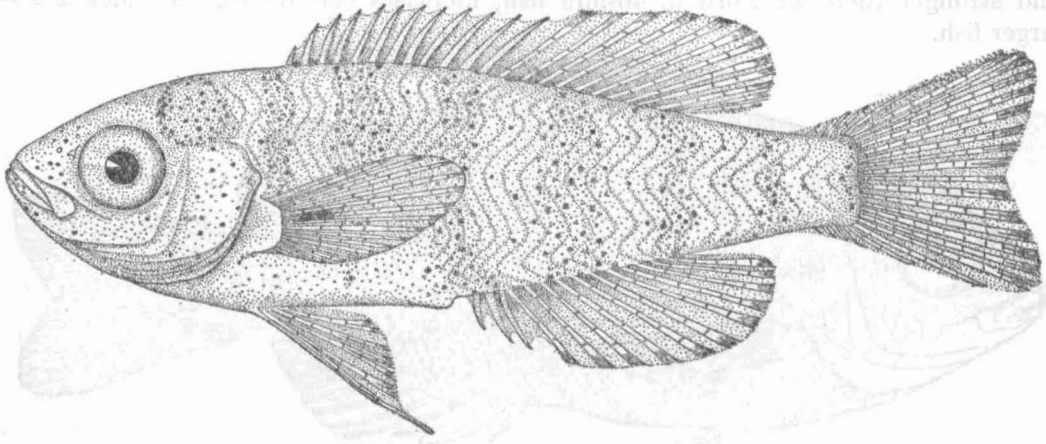

FIGURE 15.—*Lagodon rhomboides*. From a specimen 18 mm long.

are more or less greenish in life. The preserved specimens, as seen under magnification, are profusely dotted with black; these dots being concentrated in certain places where they form cross bars. The dark spots extend more or less on the dorsal and anal fins (fig. 15).

Specimens 25 to 30 mm long.—The body is strongly compressed and it has continued to increase in depth, which now is contained 2.5 to 3.0 in the length without the caudal fin, proportions found also in adults. The dorsal profile is strongly elevated and round, being much more strongly curved than the ventral outline. The head is rather short and deep, being contained 2.8 to 3.1 times in the length without the caudal fin; the snout remains blunter and proportionately shorter than in the adult, 3.5 to 3.8 in head; eye 3.1 to 3.5. The mouth has become almost horizontal, the gape being wholly below the eye; the maxillary reaches slightly past the anterior margin of the eye; and the anterior teeth are somewhat enlarged. The exposed tips of the anterior teeth are pointed, and under magnification it is evident that these tips arise in pairs from a common base. The body is fully scaled; the pectoral and ventral fins remain shorter than in adults; the first soft ray of the ventral retains a short filament, which reaches the origin of the anal; and the second anal spine already is stronger than the third one, though not as much so as in the adult.

In the general color pattern specimens 30 mm long do not differ greatly from larger fish (fig. 16).

Specimens 40 mm and upward in length.—The body is quite variable in depth among individuals, and it may be deeper in rather smaller fish than in much larger ones. For example, the depth is contained 2.3 times in the length to the base of the caudal in a 40-mm specimen, whereas in a 125-mm one it is contained 2.6 times. The snout continues to become more pointed and proportionately longer with age, being contained 3.1 times in the head in a 40-mm fish and 2.5 times in 165-mm ones. The mouth has become horizontal and much below the eye, and the teeth already are broad and well notched in fish 40 mm long. The caudal fin becomes more deeply forked with age, and the lobes become more sharply pointed. The pectoral and ventral fins increase in length and become pointed with age. The pectoral fins reach the vertical from the vent in specimens about 40 mm long, whereas in large specimens they reach beyond the origin of the anal. Specimens up to about 100 mm in length retain the filament on the first soft ray of the ventral which thereafter decreases in length and is missing in large fish. The second anal spine, though already longer and stronger than the third in 40-mm fish, increases considerably in thickness in larger fish.

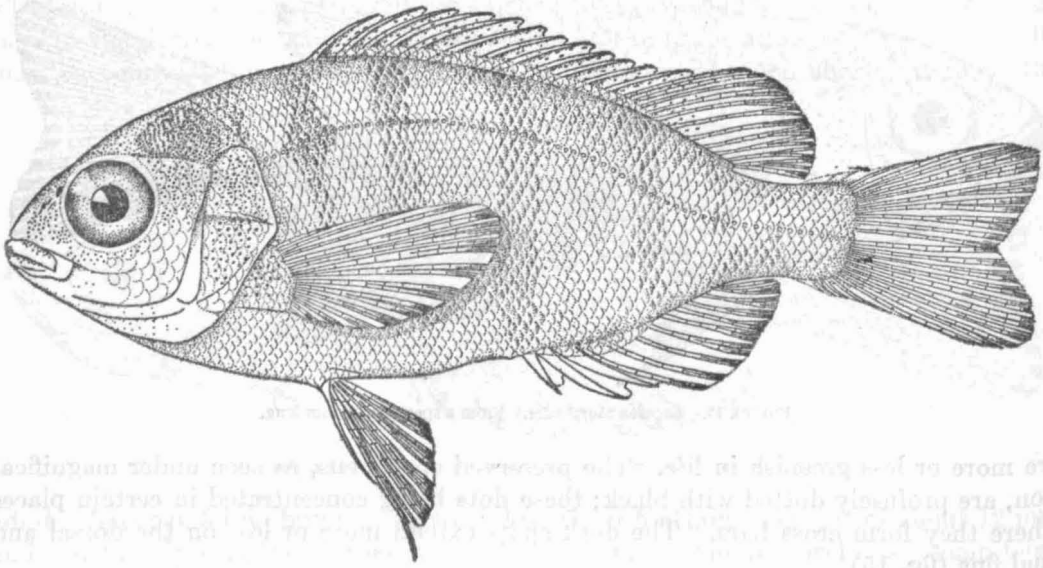

FIGURE 16.—*Lagodon rhomboides*. From a specimen 27 mm long.

The color is extremely variable. Dark cross bars are present in all specimens at hand, though variable in intensity. Furthermore, some specimens have prominent alternating bluish- and yellowish-green longitudinal lines which are indistinct or wanting in others (fig. 17).

DISTRIBUTION OF THE YOUNG

The smallest young (5.0 to 10 mm in length) secured were all collected offshore or in or near Beaufort Inlet. These young presumably were en route from the spawning grounds to inshore waters. Exactly where spawning takes place is not known. However, the indications are that it occurs a considerable distance offshore. The early larvae (under 5.0 mm in length), missing in the collections, which were made within 12 or 13 miles from the shore, would be expected to occur near the spawning grounds, as such small fish, lacking self-directive powers, could not have drifted far. The discovery of the habitat of these early young therefore remains for future investigation, but apparently should be sought a considerable distance offshore.

The smallest fry collected, ranging from 5.0 to 10 mm in length, were nearly all taken with 1-meter tow nets, and mostly at the surface. Young ranging upward of 10 mm in length enter the sounds and bays and estuaries freely, though some remain in the open outside waters until a length of about 20 mm or more is attained. After the fish enter the inshore waters they tend to settle more or less on the bottom.

Many of the young after entering the inshore waters occupy areas overgrown with eelgrass or other bottom growths, a habitat also occupied by their relatives, the young sheepshead.

It is interesting that the fish occupying the weedy areas become pigmented much earlier than those remaining in open water. In the description of young 18 to 20 mm in length it is shown that some specimens are well pigmented at a length of 18 mm and a few at even a smaller size, whereas others still are virtually unpig-

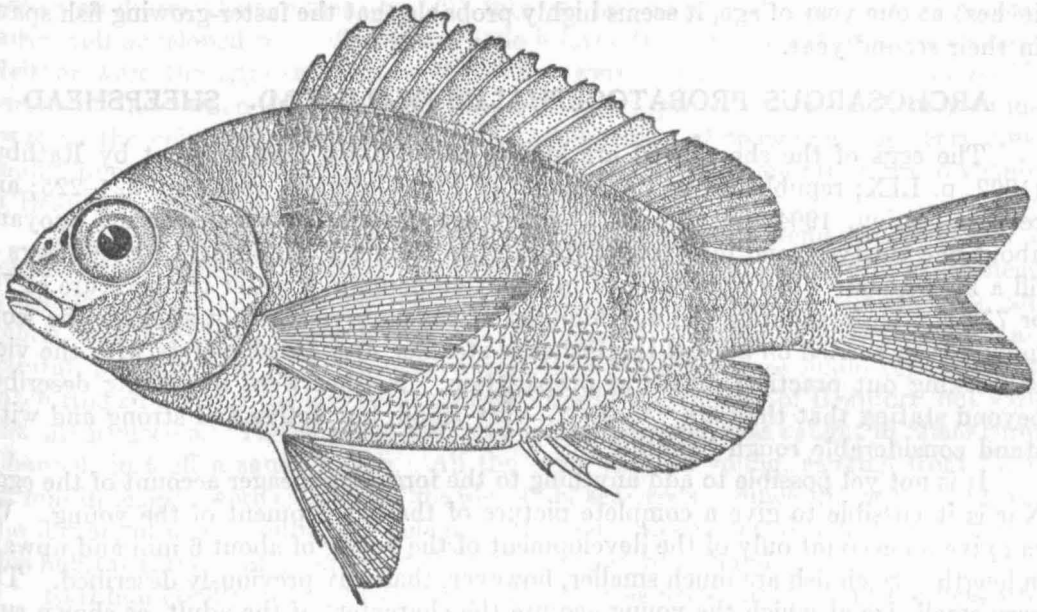

FIGURE 17.—*Lagodon rhomboides*. From a specimen 63 mm long.

mented when 20 mm long. It is shown, also, that a pronounced deepening of the body occurs simultaneously. In every instance the specimens acquiring pigmentation, as well as the deeper body early, were collected in weedy areas, whereas the large (up to 20 mm in length) unpigmented ones were taken in open water.

During the winter (December to February) young ranging from about 12 to 16 mm in length are often numerous in the deeper channels, in the sounds and estuaries, in company with young croakers and spots of about the same size. At this season of the year large schools of young pinfish, and spots, were frequently seen in quiet coves of the breakwater and jetties along the eastern shore of Pivers Island. When winter is over young pinfish are not abundant in the deeper channels, as they then chiefly occupy the shallow weeded areas; and they are seen also around piers, breakwaters, jetties, wrecks, etc., where presumably they find the food they need, which seems to be virtually identical with that of the sheepshead (see p. 532).

GROWTH

The rate of growth of the pinfish during the first several months of life, as shown in figure 11, is very slow, owing no doubt to the cold weather of winter. Other common fall- and winter-spawned fish, such as the spot and the croaker, also grow slowly at first (Hildebrand and Cable, 1930, pp. 426 and 443). However, in May when the water became warmer, and food probably became more plentiful, the fish began to grow rather rapidly, and this rate of growth apparently was maintained for several months, not slowing down again until after September.

According to measurements taken the fish ranged from 50 to more than 100 mm in length when a year old. Since the average length of the usual catch of adult pinfish at Beaufort probably does not exceed 150 mm (6 inches) early maturity is probable. As some of the fast-growing fish already exceeded a length of 100 mm (4 inches) at one year of age, it seems highly probable that the faster-growing fish spawn in their second year.

ARCHOSARGUS PROBATOCEPHALUS (WALBAUM). SHEEPSHEAD

The eggs of the sheepshead are known only from a brief account by Rathbun (1892, p. LIX; republished in "A Manual of Fish Culture", 1898, pp. 224–225; and revised edition, 1904, pp. 226–227). They are described as transparent, buoyant, about one thirty-second inch (about 0.8 mm) in diameter, requiring 1,600,000 eggs to fill a fluid quart. The eggs hatched in about 40 hours in a water temperature of 76° or 77° F. Unfortunately the development of the embryo was not studied, the work having been carried on aboard the Fisheries steamer *Fish Hawk* merely with the view of working out practical means of propagation. Neither were the young described beyond stating that they are "* * * very small, but active and strong and withstand considerable rough handling."

It is not yet possible to add anything to the foregoing meager account of the eggs. Nor is it possible to give a complete picture of the development of the young. We can give an account only of the development of the young of about 6 mm and upward in length. Such fish are much smaller, however, than any previously described. The very small size at which the young acquire the characters of the adult, as shown subsequently, is quite remarkable.

The salt water sheepshead is of wide distribution, ranging from Cape Cod, Mass. (rarely to the Bay of Fundy), south to Tampico, Mexico. At Beaufort, N. C., it is a year-round resident, though more numerous in the summer than winter.

The sheepshead is sought not only by commercial fishermen, but also extensively by anglers, as it is one of the gamest of salt-water fishes. It is a food fish of excellent flavor and brings a good price in the market. It attains a maximum weight of 30 pounds according to published reports. However, the largest one which we saw at Beaufort, during 10 years of intermittent angling, collecting, and observation of fishermen's catches, was a female weighing 12 pounds (length not recorded). This fish was taken in a seine on Shackleford Banks (inside) by commercial fishermen. Fish weighing from 1 to 2 pounds (11 to 15 inches long) make up the principal catch of the angler locally, though individuals up to 5 pounds (20 inches in length) are not rare.

CHARACTERS OF THE ADULT

Adult sheepshead are characterized by the oblong, deep, compressed body, crossed by about seven black bars on a greenish-yellow background. The mouth is rather small, nearly horizontal, and is provided in front with incisor teeth, which are entirely

or only slightly notched (not deeply notched as in some related species). The posterior teeth are composed of strong molars, which are used for crushing crustaceans and mollusks. The dorsal fin is long and continuous, being composed of 11 or 12 strong spines and 11 to 13 soft rays, and it is preceded by a short spine directed forward (more or less imbedded in large specimens). The caudal fin is forked; the anal consists of 3 sharp spines (the second one the largest) and 10 or 11 soft rays; and the pectoral fins are long, reaching to or beyond the origin of the anal. Vertebrae 9+15.

SPAWNING

No opportunity was found to examine a large number of sheepshead as to the development of the gonads. Of the comparatively few fish examined in the spring, when spawning evidentally takes place (many more specimens became available for dissection during the summer and fall) only one fish, taken June 16 (1926), contained fairly well developed roe. Therefore, little information was gained from that source. Neither were the eggs secured, or if so they were not recognized.[3] Therefore, the period of time when comparatively small young appeared in the collections must serve as the chief indication of the time and duration of spawning. As very small young, under 6 mm in length, are not represented, the spawning areas in the vicinity of Beaufort cannot be determined from the collections.

According to Rathbun (1892) the sheepshead spawns along sandy shores in southwestern Florida. A sandy shore is not the usual habitat of the sheepshead, which lives principally among rocks, piers, breakwaters, wrecks, sunken logs, and debris, and in Florida among mangroves. Therefore, it seems to leave its customary habitat to carry out its reproductive activities. Efforts were made repeatedly to catch ripe adults and the larvae on sandy shores in the vicinity of Beaufort, but without much success. The smallest specimen taken, however, was caught in Shackleford Channel, just off a sandy beach. All the other smaller young, ranging from 7.5 to 65 mm in length, were caught in "meadows" of seaweeds. Since the eggs are pelagic the larvae, also, no doubt, are pelagic. However, the young fish seem to abandon this habitat early in life, as indicated by the collections at hand.

Rathbun (1892) stated, furthermore, that it was necessary to haul the nets after 4 o'clock in the afternoon to catch ripe females, the best time being about sunset. Late evening spawning seems to be quite general among marine fishes producing pelagic eggs.

The smallest young secured at Beaufort was taken on May 20 (1930), in a tow net hauled at the surface in Shackleford Channel. This fish apparently was still living in its larval habitat, though already well past the larval stage. Why only this single specimen was taken in the pelagic stage cannot be explained, as great effort was made to secure others, many hauls with tow nets having been made in the same general vicinity from 1927 to 1931. Apparently the fish simply were not there. The next smallest young, ranging from 7.5 to 18 mm in length, were caught June 21 (1926), with a bobbinet seine hauled in eelgrass along the shores of Pivers Island. Small young, 11 to 21 mm in length, were taken as late as July 8 (1931). Thereafter they ran larger in size. However, a few specimens of 19 to 21 mm in length, and one 25 mm long, were taken as early as June 14 (1929). The range in length of the young collected each month, arranged in 5-mm groups, is shown in figure 23.

[3] The several years of experience gained in endeavoring to identify marine-fish eggs taken in tow taught us that the task is very difficult. Aside from the many that obviously were unknown, we never could be quite certain that we recognized all the species included among the supposedly known ones. To gain an idea of the great similarity of the eggs of some of the common marine species the reader is referred to earlier papers (1930 and 1934) by the writers.

Fish 6 to 8 mm long probably are not over 2 weeks old, but individuals 19 to 25 mm long, judging from the rate of growth of other species for which more data are at hand, may be 4 to 6 weeks old. It may be concluded, then, from the dates when young fish were caught, given in the preceding paragraph, supported by the single female with developing roe caught on June 16 (1926), that the sheepshead spawns from sometime in April to perhaps the latter part of June in the vicinity of Beaufort.

DESCRIPTIONS OF THE YOUNG

Specimens under 6 mm in length have not been taken. Therefore, the larvae, as already stated, remain unknown. The small size at which young sheepshead acquire the characters of the adults is remarkable.

Specimen 6.0 mm long.—A single specimen with a damaged caudal fin of about 6.0 mm (5.2 mm to base of caudal) in length is at hand. This fish already is well past the larval stage, as will be brought out in the following description.

Body elongate, compressed, its depth 3.4 times in length to base of caudal; head rather short, compressed, 3.0 in length to base of caudal; snout short, blunt, with rounded profile, 4.2 in head; eye wholly lateral, rather small for such a young fish, 3.1 in head; mouth small, oblique, almost terminal; maxillary reaching about to pupil;

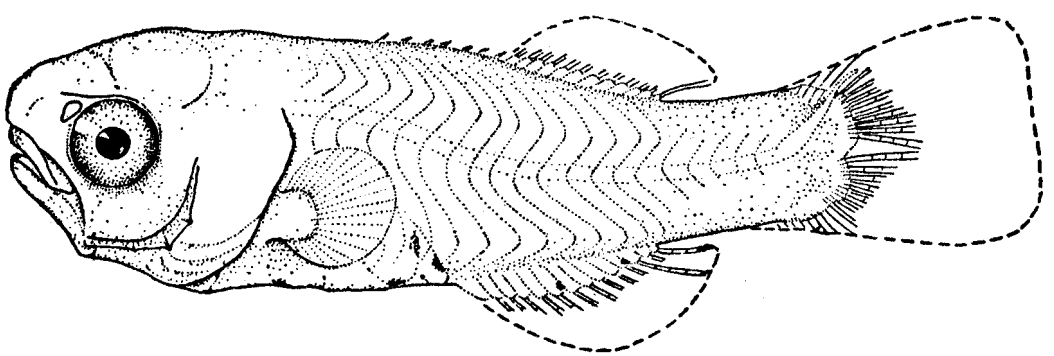

FIGURE 18.—*Archosargus probatocephalus.* From a specimen about 6 mm long.

preopercular spines present, but very short; vent a little behind midbody length; notochord bent upward posteriorly as usual in young teleosts having homocercal tails; myomeres about 27 (vertebrae in adults 9+15=24). The fins are remarkably well developed for such a small fish. Dorsal spines very short, about 7 discernible at this size (adults with 11 or 12); soft rays 12 (11 to 13 in adults); caudal fin with well developed rays (broken); anal fin with 13 rays, the spines not well differentiated (adults with 3 spines and 10 or 11 soft rays); ventral fins not yet discernible; pectoral fins broad, damaged, apparently rather short.

The general color of this preserved specimen is brownish, without very definite markings. Median ventral line with three obscure dark spots, one slightly behind isthmus, another below vertical from base of pectorals and the third one a very short distance in front of vent. A slight dark coloration is evident on side just posterior to vent, and two dark specks are present on the base of the anal fin (fig. 18).

Specimen 7.5 mm long.—A single specimen with a damaged caudal fin of about 7.5 mm (6.25 mm to base of caudal) in length is at hand. A fairly complete description of this specimen when fresh, was prepared. It was then about 8 mm long, having shrunken somewhat during preservation.

The differences between this specimen and the smaller one already described are not pronounced, except in color. The body has become somewhat more slender, the depth now being contained 3.9 times in the length to base of caudal, and the head remains short, compressed, 3.7 times in length to base of caudal. The snout also remains short, blunt, with a steep profile, only a little shorter than the eye, and is contained 3.0 times in the head. The mouth is slightly less oblique than in the smaller specimen.. The dorsal spines remain short and feeble, though 13, the full number (11 to 13) present in the adult, may be counted. The three anal spines now are differentiated. However, the spines are more retarded in development than the soft rays. The caudal fin (broken now) was described as "slightly concave" in the field notes. The ventral fins are quite evident, though minute, being scarcely longer than pupil, and are inserted very slightly behind the base of the rather broad well-developed pectorals.

The color of a fresh specimen is described in the field notes in part as, "pale, without cross bars, though small dark chromatophores are present along the side of body, but not yet forming cross bars." However, the preserved specimen does show an arrangement of chromatophores which suggest a bar between the anterior part of the soft dorsal and anal, and another just posterior to these fins (see fig. 19), precisely where bars are present in larger fish. The upper margin of the eye in the fresh

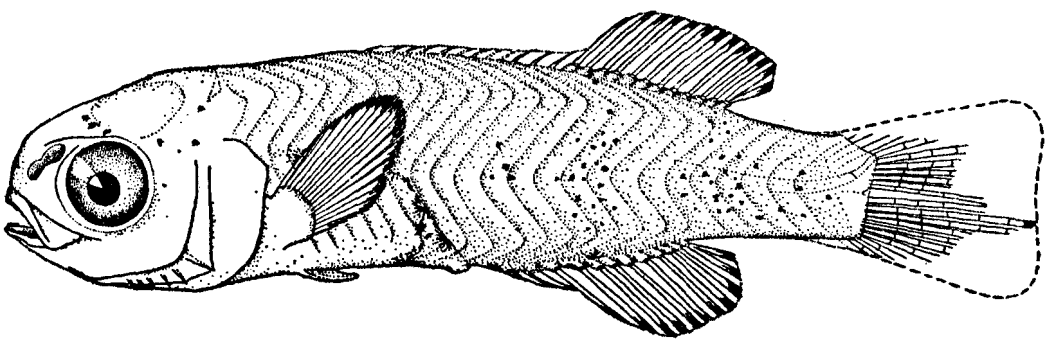

FIGURE 19.—*Archosargus probatocephalus*. From a specimen 7.5 mm long.

specimen was dark, and black chromatophores were present on the interorbital and also along the chest, abdomen, and base of anal. The three obscure dark spots along the median ventral line in the smaller fish described persist in the larger one, the posterior one situated somewhat in advance of the vent having become rather more prominent (fig. 19).

Specimens 10 to 12 mm long.—Several specimens ranging from about 10 to 12 mm in length were collected. These fish already resemble the adults so much that they are not difficult to identify.

The body has become deeper, and it is much more robust, the depth being contained about 3.0 to 3.2 times in the length to base of caudal. The head has become notably broader and is now contained 3.0 to 3.25 in the length. The snout remains short, rounded, with a steep profile, and much shorter than the eye, its length 4.3 to 4.7 in head; eye 3.0 in head. The mouth remains small, slightly oblique, and nearly terminal, the maxillary reaching about to pupil. The lateral line has made its appearance, being represented by a few pores anteriorly. The body is almost fully covered with scales at a length of 12 mm, though not so indicated in figure 20. The dorsal and anal spines are much better developed, but still proportionately much shorter than in adults. The caudal fin is distinctly concave, and the ventral fins have increased greatly in length, being longer than eye and reaching nearly to vent.

Pigmentation has progressed rapidly, though it is not complete. Individual chromatophores are present everywhere and are concentrated in definite areas to form bars which are not developed equally early in all specimens. Usually, however, they are more or less definite in specimens 10 mm long, quite distinct in 12-mm fish, and generally 7 in number, as in the adult (fig. 20).

Specimens 15 to 18 mm long.—The body has become somewhat deeper, the depth now being contained about 2.9 in the length to base of caudal. The head remains short and deep, about 3.0 in length. The snout is a little less blunt and slightly longer, about 4.1 in head; eye longer than snout, about 3.0 in head. The mouth

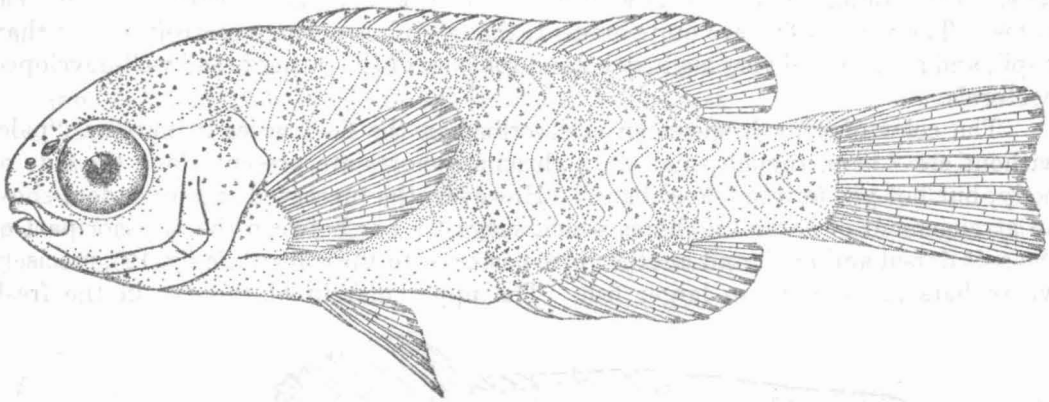

FIGURE 20.—*Archosargus probatocephalus.* From a specimen 12 mm long.

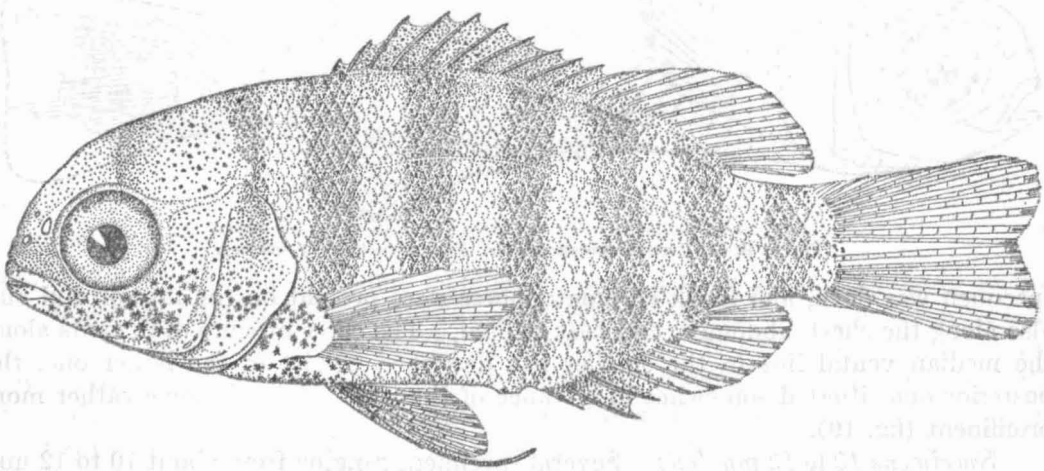

FIGURE 21.—*Archosargus probatocephalus.* From a specimen 17 mm long.

remains small, slightly oblique, the gape anteriorly being nearly on the level with the lower margin of the eye; maxillary reaching slightly past anterior margin of eye. Preopercular spines, present in smaller fish, no longer are evident. The lateral line generally is rather fully developed in specimens 18 mm long, and the body is covered with scales. The dorsal spines have increased in proportionate length, but remain notably shorter than the soft rays. The anal spines are well developed, the second one already being the strongest as in the adult. The outer unbranched ray of the ventral is not yet fully developed as a spine; the second ray with a free filament distally, frequently reaching origin of anal.

Specimens 18 mm long, in the fresh state, have the general color of the adult, including the characteristic black cross bars (fig. 21).

Specimens 25 to 30 mm long.—The body has increased still further in depth, which is now contained about 2.3 to 2.5 in the length to the base of the caudal. The head has become longer, 2.8 to 2.9 in length. The snout is longer and more pointed, 3.4 to 3.7 in head; eye longer than snout, 2.6 to 2.9 in head. The mouth is nearly horizontal, and wholly below the lower margin of the eye; maxillary scarcely reaching past anterior margin of eye. The lateral line is fully developed. The dorsal spines are strong and proportionately about as high as in adults; those of the anal also as in adults, the second one notably longer and stronger than the others. The caudal fin is slightly forked as in large individuals. The filament on next to the outermost ray of the ventral persists, reaching about to the origin of the anal, the outermost ray now being developed quite definitely as a spine. The pectoral fin has increased somewhat in length, its distal margin, instead of being round as in the smaller fish is now oblique, the longest rays being in the upper half of the fin, reaching nearly to origin of anal.

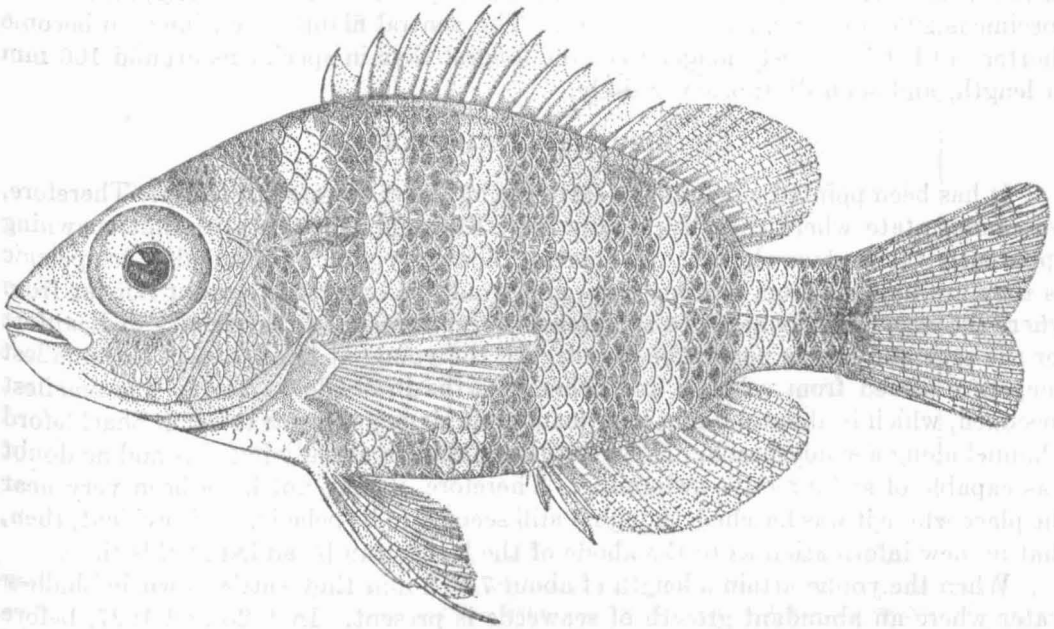

FIGURE 22.—*Archosargus probatocephalus.* From a specimen 30 mm long.

The general color of the adults develops early, as already shown. Scarcely any changes of note have developed since a length of 18 mm or so was attained. Some specimens, though not all, have the ventrals quite black (fig. 22).

Specimens 50 to 60 mm long.—The fish have continued to increase in depth, and are now proportionately as deep as large specimens, depth 2.0 to 2.1 in length to base of caudal. The snout has become proportionately longer and more pointed, though still notably shorter than in large individuals, equal to or a little longer than the eye, 2.8 to 3.1 in head; eye 2.8 to 3.3. The incisor teeth now are prominent, and the posterior molarial teeth are strong. The pectoral fin has acquired the shape it will retain, the fourth ray being longest with the rays below becoming shorter gradually, making the lower posterior margin straight and oblique. The ventral filament has become proportionately shorter, reaching vent in some specimens and to origin of anal in others.

The color, though somewhat variable, does not differ from that of somewhat smaller and larger fish. Some specimens have two dark spots on the base of the caudal fin which are missing in others. Many specimens have the ventral fins mostly black, and most individuals have a definite dark shoulder spot near the beginning of the lateral line, partly in and partly in advance of the second cross bar.

Specimens 75 mm and upward in length.—Although the proportionate depth of large specimens is attained when the fish reach a length of 50 to 60 mm, a pronounced change in the shape of the head and snout takes place as the fish continues to grow. The upper profile becomes notably more gently elevated, and the snout proportionately much longer and more pointed. In specimens about 75 mm long the snout (measured from anterior margin of eye to tip of upper jaw) is contained about 2.6 times in the head; in specimens about 100 mm in length, 2.3; and in specimens about 225 mm long, 2.1 times. The eye, as usual, becomes proportionately smaller as the fish grows, but the difference in the present species is unusually great. In fish about 75 mm long it is contained about 3.2 in head; in specimens 100 mm long, 3.5; and in specimens 225 mm long, about 4.5 times. The ventral filament continues to become shorter until it is scarcely longer than the longest rays in specimens around 100 mm in length, and soon disappears entirely.

DISTRIBUTION OF THE YOUNG

It has been pointed out that the early young (larvae) were not taken. Therefore, we cannot state where they live. However, Rathbun (1892) stated that spawning apparently takes place along sandy shores. The early young presumably are pelagic as they are hatched from floating eggs, and would be expected to occur not far from where the eggs are spawned. In an extensive search made in the vicinity of Beaufort for the eggs and larvae none were found. All the young at hand, except the smallest one, were seined from eelgrass and other growths in shallow water. The smallest specimen, which is about 6.0 mm long (caudal fin damaged), was taken in Shackleford Channel along a sandy beach. However, this specimen already had fins and no doubt was capable of self-directive swimming. Therefore, it may not have been very near the place where it was hatched, though it still seemed to be pelagic. It is evident, then, that no new information as to the abode of the larvae can be added at this time.

When the young attain a length of about 7 to 8 mm they settle down in shallow water where an abundant growth of seaweeds is present. In 1926 and 1927, before the eelgrass began to disappear, young sheepshead, ranging in length upward of 8.0 mm, were common to numerous along the south shores of Pivers Island, Beaufort, N. C., where most of the specimens upon which the present study is based were taken by "cutting", as far as possible, a bobbinet seine through dense growths of eelgrass. There the young remained until they reached a length of about 40 mm. Thereafter they seemed to become less abundant, though some stayed until they attained a length of 60 mm or so, when they left to occupy the habitat of the adults, which already has been described.

When the young sheepshead has attained a length of about 40 to 50 mm the teeth are developed essentially as in the adult and thereafter they may be observed along stone jetties, breakwaters, around piers, and wrecks where larger fish also live.

FOOD

The chief food of young sheepshead, ranging from 9.0 to 55 mm in length, while dwelling in shallow water in weeded areas, according to the contents of 111 stomachs, is copepods. Those under 30 mm in length utilized ostracods, which were rarely eaten

by larger fish. Gammarus were sparingly eaten by the smaller fish, but abundantly by the larger ones. Small mollusks appeared early and continued to be eaten also by the larger fish. A few worms were eaten, and also some small decapod crustaceans, especially shrimp.

In addition to the animal foods named filamentous alga was present in such abundance in the stomachs of fish ranging from 25 to about 40 mm in length that it quite certainly was not taken by accident. Some stomachs, in fact, contained almost nothing else. It seems definitely to constitute a part of the food of fish of the size range mentioned. Larger fish ate of it more sparingly if at all.

The food of adults consists chiefly of mollusks and crustaceans which the fish find numerous along the breakwaters, piers, wrecks, etc., where the adult fish live. A favorite bait at Beaufort is the fiddlar crab. The teeth of the sheepshead, described elsewhere, are well adapted for seizing and crushing these common foods.

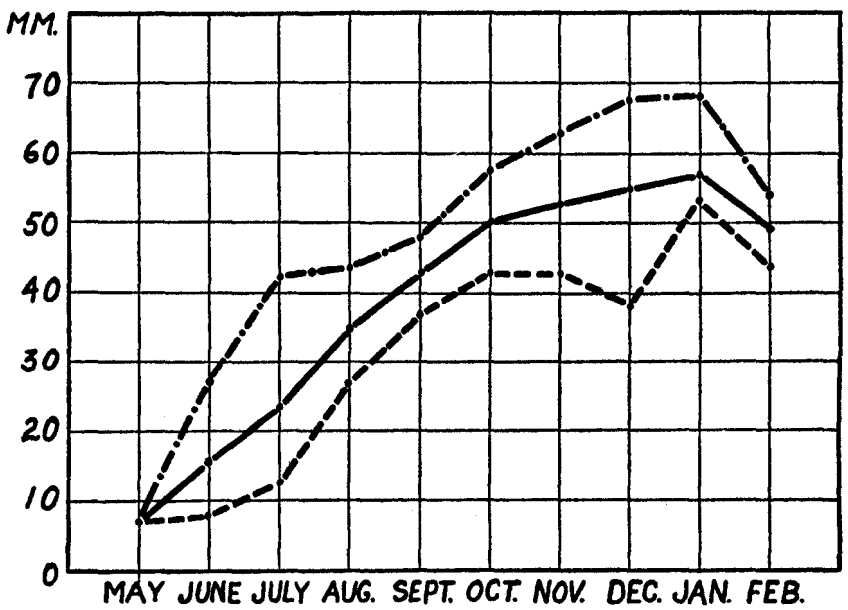

FIGURE 23.—Growth curve based on length measurements of 512 *Archosargus probatocephalus* of the 0-class. Solid line, average length for each month of all fish measured; dot and dash (upper) line, largest fish; dot and several dashes (lower) line, smallest fish.

GROWTH

Limited information relative to the rate of growth of the young during the first few months of life was obtained, and none for the older ones (fig. 23). After the fish leave their early habitat among seaweeds they no longer are obtainable in sufficient numbers, without much effort, to follow the rate of growth.

It seems quite certain that as early as August some of the larger young of the season already had deserted their habitat among seaweeds. Therefore, the range at the upper limit and consequently the average length, of those taken in the habitat of the juveniles no longer give correct information as to the rate of growth. In September many young definitely had moved away from their earlier habitat, as the fish had become comparatively scarce, though a few remained there nearly all winter.

The range in length of 46 young taken among seaweed in June from 1926 to 1931, is 7 to 25 mm. However, only one specimen, apparently a very fast growing one, exceeds a length of 21 mm. The average length of the 46 specimens is 12.8 mm.

The range in length of 311 young taken during July under the same general conditions and over the same number of seasons is 11 to 42 mm, the average length being 21.8 mm.

In August the range in length of 79 specimens, from the same localities and the same years, is 27 to 44 mm having an average length of 36.6 mm.

In September only 20 specimens, ranging in length from 38 to 47 mm, with an average length of 42.1 mm, were secured.

It seems probable that the measurements for July alone show fairly accurately the range in length, as well as the average size, of the young fish for that month. In June the smallest young of the season had not arrived in the weeded areas. Therefore, the lower limit of the range, and consequently the average length, are not correct. By August some of the larger young had left the weeded areas, and therefore the upper end of the range, as well as the average, is incorrect. In September the fish had gotten so scarce that with the same fishing effort put forth each month in 1926 only 20 specimens were secured, whereas in August 69 were taken, in July 299, and in June 36.

The data seem to justify the conclusion, however, that in June the largest young of the current season are around 20 to 25 mm long, the lower limit of the range and the average length being unknown. In July young range in length from about 11 to 42 mm, and the average length is close to 21.8 mm. In August the smallest young are about 27 mm long, and in September they are around 38 mm in length, the upper limit of the range and the average length being unknown for both months.

A fairly slow rate of growth seems to be indicated if the evidence produced elsewhere, showing that spawning at Beaufort begins sometime in April and ends near the end of June, is correct. A slow rate of growth and late maturity would explain, in part at least, why the sheepshead has diminished rapidly under heavy fishing, whereas other, presumably faster-growing, species have withstood it without a serious decline.

CHAETODIPTERUS FABER (BROUSSONET). SPADEFISH

The development of the eggs and recently hatched larvae of the spadefish was described and figured by Ryder (1887, pp. 521–523). It is possible now to describe and figure some more advanced stages, though the series is not yet as complete as desirable.

Professor Ryder did not state specifically that the eggs used in his study were taken directly from ripe fish caught in Chesapeake Bay, though this apparently may be assumed. He merely said, "This species spawns in the Chesapeake during the latter part of June and the early part of July. It is prodigiously fertile, the female probably discharging a million ova during a single season." It must be further stated, however, that the number of eggs deposited probably depends on the size of the female, because large fish generally, if not always, produce more eggs than smaller ones of the same species.

The eggs were not seen by us. Ryder states that they are pelagic, "somewhat over a millimeter in diameter", and have a single oil globule. Cleavage took place rapidly, as only an hour intervened between the first cleavage and the morula stage. Hatching took place in about 24 hours in a water temperature of 80° F.

The newly hatched fish were "about 2.5 mm in length." In 63 hours the yolk was nearly all absorbed, young fish had increased greatly in depth, and were nearly 4.0 mm long. The snout was very blunt, the mouth (according to the figure) was

large and somewhat oblique, with the lower jaw projecting. An aggregation of pigment cells formed indications of a band above the base of the pectoral, and another at about midcaudal length.

The specimens forming the basis of the present study were collected mostly at Beaufort, N. C. Other young were taken on the coast of Georgia and on the Gulf coast of the United States. Unfortunately, stages in development connecting directly with the largest larvae described by Ryder are not at hand. The smallest specimen in the collections, identified as a spadefish, is only about 2.5 mm long in the preserved state. Although this larva is shorter than the oldest one described by Ryder, which was about 4.0 mm long when alive or fresh, it is much further advanced in development, showing apparently that much shrinkage took place during the hardening process. The characters connecting this larva with the younger ones described by Ryder are pointed out in the description of the specimen.

The spadefish is known in some localities as angel fish and also as moonfish. At Beaufort it is called porgee (or pogee), a name also heard in the lower Chesapeake. This species ranges from Cape Cod, Mass., at least as far south as Rio de Janeiro, Brazil. It is not common north of Chesapeake Bay. On the Atlantic coast of Panama it is one of the common food fishes, and is seen in the market almost daily. It is not caught in large quantities on the coast of the United States. Indeed, the statistical report of the Bureau of Fisheries for 1935 lists a catch of only 6,000 pounds, which was made in North Carolina. However, the fish is taken commercially all along the Atlantic and Gulf coasts from Chesapeake Bay southward. It is a fish of good flavor and always in demand. Consequently, much of the catch is consumed locally and it often does not enter the markets. Therefore, it fails to get into the records, which do not show its full importance as a food fish.

The spadefish is a summer resident at Beaufort, where it arrives in May and departs by about the beginning of October. At Key West, Fla., it is present the entire year, though most common during the summer. The species tends to congregate in small schools. It is caught chiefly with seines. However, it will take a hook baited with small bits of meat. Because of its small mouth, small hooks must be used. Furthermore, because of its tendency to nibble instead of swallowing the bait, considerable patience and skill must be exercised by the angler. If he is successful in hooking one, a good fight follows.

CHARACTERS OF THE ADULT

The spadefish belongs to the family Ephippidae, of which it is the only representative on the Atlantic coast of America. It is readily recognized by the very short, deep, compressed body which is only a little longer than deep. The teeth in the jaws are in brushlike bands, the outer series being slightly enlarged. In large individuals the anterior rays of the second dorsal and anal are considerably produced, and the caudal fin is deeply lunate. Fish under a foot or so in length bear four to six broad black cross bars, which tend to fade in large individuals. The ground color varies from brown to silvery green.

The maximum size of the spadefish is given as 20 pounds. However, fish weighing as much as 12 pounds are comparatively rare. The average weight of the fish seen in the Beaufort market probably did not exceed 1½ pounds, and those in the Colon, Panama, market were even smaller.

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SPAWNING

According to Ryder (1887, p. 521) the spadefish spawns in Chesapeake Bay during the latter part of June and the early part of July. Hildebrand and Schroeder (1928, p. 307) stated, "Fish with well-developed roe were taken at Crisfield, Md., on May 26, 1916," and Smith (1907, p. 335) said "At Beaufort, ripe male and female fish have been found early in June." We can add to these observations only that we saw some females with developing roe at Beaufort on May 25, 1916.

The eggs either were not taken, or not recognized if taken, during the investigation at Beaufort. The scarcity of the young locally indicates that the vicinity of Beaufort is not an important spawning area.

The smallest larva caught, which is about 2.5 mm long, was taken July 11 (1929). The next smallest one, which is about 4.25 mm long, was caught July 12 (1915); another small one, 9 mm long, was taken July 9 (1930); and still another one, 17 mm long, August 16 (1916). Larger young were taken locally in 1930 as follows: 10, ranging in length from 49 to 62 mm, August 23; 21, varying in length from 57 to 86 mm, from September 4 to 16; and 1 each on October 18 and 21, respectively, 72 and 74 mm long. These young no doubt are all in their first summer. Their size, especially that of the smallest ones, suggests that at Beaufort spawning takes place at least during June, as indicated also by the few observations of ripe and ripening fish reported in a preceding paragraph. A definite determination of the duration of spawning, however, remains for future determination.

The 3 smallest young were all taken at sea, suggesting that the fish may spawn offshore. Offshore spawning is indicated, furthermore, by the absence of small fish under about 15 mm in length, in the extensive and thorough collecting done in the inside waters in the vicinity of Beaufort.

DESCRIPTIONS OF THE YOUNG

Specimen about 2.5 mm long.—A single specimen of this size is at hand. The body is deep anteriorly, decreasing greatly in depth just posterior to the vent, the greatest depth being contained 1.9 times in the length to the end of the notochord. The head is very deep, with a steep profile, which is slightly concave just above upper jaw. The snout is short and blunt, and not quite as long as the eye. The mouth is strongly oblique, the gape anteriorly being on a level with the middle of the eye, and the maxillary reaches opposite the posterior margin of the pupil. The preopercular margin is provided with a few prominent spines, and a sharp transparent dermal crest is present on the occiput. The notochord remains straight. The primitive vertical fin membranes persist and contain only slight indications of rays where the soft dorsal, caudal, and anal develop later in life. The ventral fins are not evident, but the pectorals are short and broad.

The general color of the preserved specimen is pale gray. Several dark chromatophores are present on the chest and the abdomen, and also a few on the gill covers (fig. 24).

This specimen resembles the largest larvae described by Ryder (1887, p. 522) in having a deep body, which seems to have grown much deeper in the older fish herein described. It, also, resembles the younger fish in the steep anterior profile and oblique mouth. The younger larvae had dark chromatophores on the abdomen, which have been retained by the older one at hand. However, no indications of dark chromatophores, suggesting bands (one above the base of the pectoral and another at midcaudal length), described and illustrated for the younger larvae by Ryder, are evident in the fish before us. Ryder does not mention nor illustrate a dermal ridge

or crest at the occiput, present in the specimen herein described, and retained by somewhat larger fish. It may be assumed, therefore, that the ridge is not present in the early larvae. This ridge is suggestive of the crest bearing a spine in the young fool fishes (Monacanthus).

Specimen about 4.25 mm long.—Only one specimen of this length is at hand. The body remains deep anteriorly, but no longer decreases as abruptly in depth just posterior to the vent as in the smaller specimen already described. However, the body tapers sharply posteriorly. Its greatest depth is contained 1.7 times in the length to the end of the notochord. The head remains deep, with a somewhat more sloping anterior profile. Its length is contained 2.9 times in the length to the end of the notochord. The snout remains shorter than the eye, and the mouth is quite oblique, the gape anteriorly being about on a level with the lower margin of the pupil. The maxillary reaches below the middle of the eye. The crest or ridge on the head remains prominent, and slightly spinelike. The spines on the preopercular margin persist, but are less prominent. The notochord now is bent upward posteriorly, and

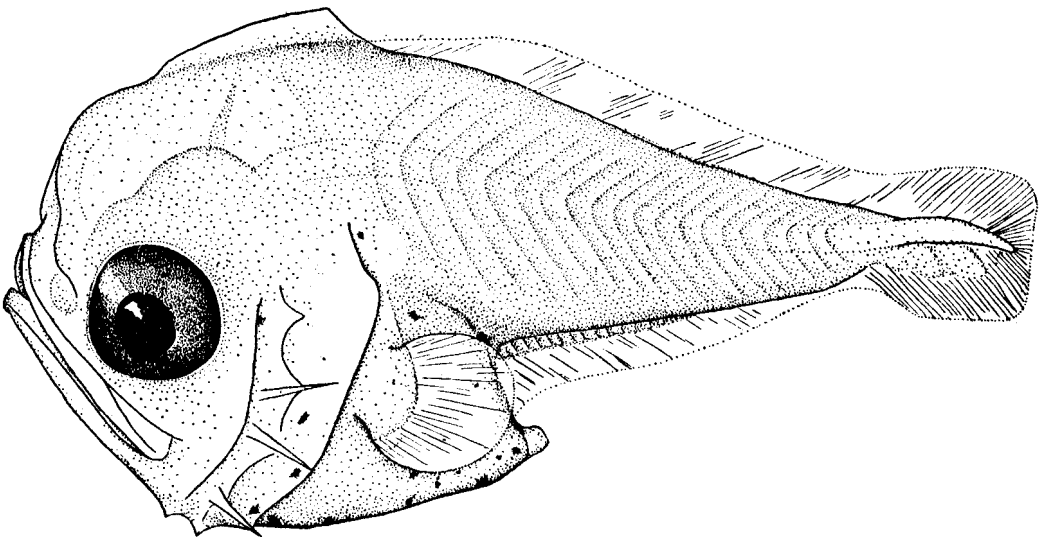

FIGURE 24.—*Chaetodipterus faber.* From a specimen 2.5 mm long.

below it are rather well developed rays, forming a moderately long caudal fin, the shape of which cannot be determined definitely because of the damaged condition of the fin, but it presumably had a round margin as in somewhat larger fish. The spines in the dorsal and anal fins are more retarded in development than the soft rays and cannot be enumerated definitely. About 23 soft rays may be counted in the dorsal and 20 in the anal. The pectoral fins are broken, and the ventral fins appear as mere tufts of dermis.

The preserved specimen at hand is very dark, apparently having become darkened by the action of a chemical in the denatured alcohol used. However, black chromatophores are visible along the side of the abdomen, on the head and back, and at midcaudal length. The last-mentioned ones are concentrated and slightly suggestive of a cross bar, shown by Ryder (1887, p. 522) for much younger fish, (fig. 25).

Specimen 9.0 mm long.—The body remains short and deep and has become somewhat more robust, the greatest depth being contained 1.8 times in the length without the caudal fin. The dorsal profile remains quite steep anteriorly, and rather more

strongly curved than the ventral outline. The head has become broader. It is scarcely as deep as in smaller fish, and its length is contained 2.5 times in the length without the caudal fin. The snout remains blunt and shorter than the eye, being contained 4.2 times in the head, whereas the eye is contained 3.1 times. The mouth has become less strongly oblique, the gape being wholly below the eye, and the maxillary scarcely reaches beyond the anterior margin of the eye. Small pointed teeth now are evident in the jaws. Preopercular spines remain quite prominent. The dermal crest, or ridge, at the occiput has become proportionately shorter, and ends in a blunt spinelike point. The body now is covered with blunt spinelike plates, scarcely resembling scales (not shown in fig. 26), and the upper surface of the head (where the plates are missing) bears short hairlike spines. The fins are all developed and have the usual number of spines and soft rays present in adults. However, the spines still are somewhat retarded in development and proportionately shorter than in the adult. The margins of the vertical fins are all rounded. The ventral fins are quite large, and exceed the length of the pectorals.

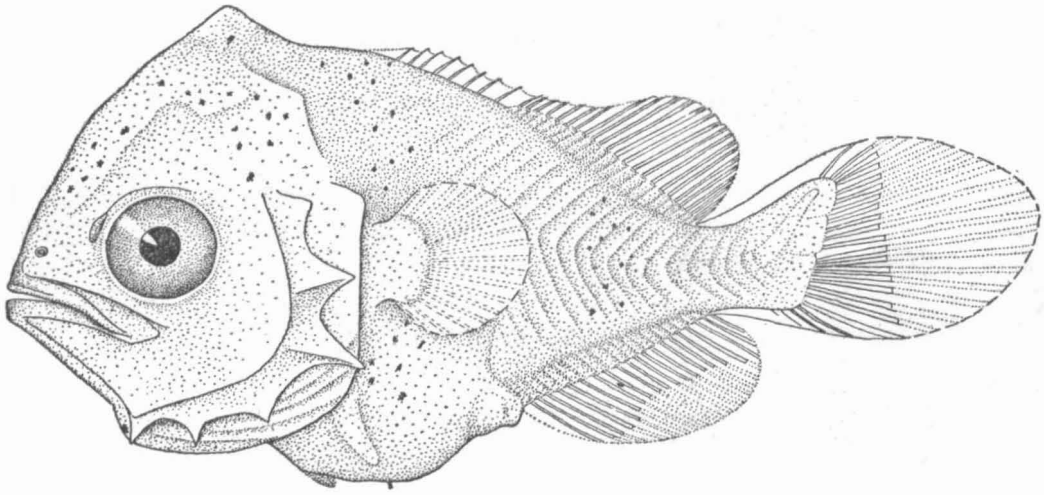

FIGURE 25.—*Chaetodipterus faber*. From a specimen 4.25 mm long.

The general color of the preserved specimen is dark brown. Dark chromatophores present in younger fish and in large specimens at hand are not visible in the 9.0 mm specimen. A few dusky markings are present at the shoulder. The soft dorsal, caudal and anal are colorless, but the ventrals are dark brown (fig. 26).

Specimen 11 mm long.—The body is proportionately a little deeper than in the 9.0-mm fish, the depth now being contained 1.5 times in the length without the caudal fin. The general shape of the head, and the proportions of the eye and snout have changed little. The preopercular spines have become rather shorter and blunter, and the occipital ridge of smaller fish now is represented by a small blunt projection. The lateral line is well developed. The scales no longer look like plates, and the spiny projections on them are smaller. The hairlike spines on the head, noted in the 9.0 mm specimen, have become minute. The dorsal spines have increased in length, but remain proportionately shorter than in larger fish. The ventral fins have continued to increase in length, and now reach the vent.

The general color is brownish, and the head and body nearly everywhere are dotted with black chromatophores. An indefinite pale crossbar on the back of the head extends down on the preopercle. The ventral fins are black, and spinous parts

of the dorsal and anal are brownish and dotted with black, but the rest of these fins and the caudal and pectorals are entirely colorless (fig. 27).

Specimens 15 to 18 mm long.—The differences between these larger specimens and the 11 mm one are not great. The depth remains proportionately about the same, being contained 1.4 to 1.6 times in the length without the caudal fin. The snout,

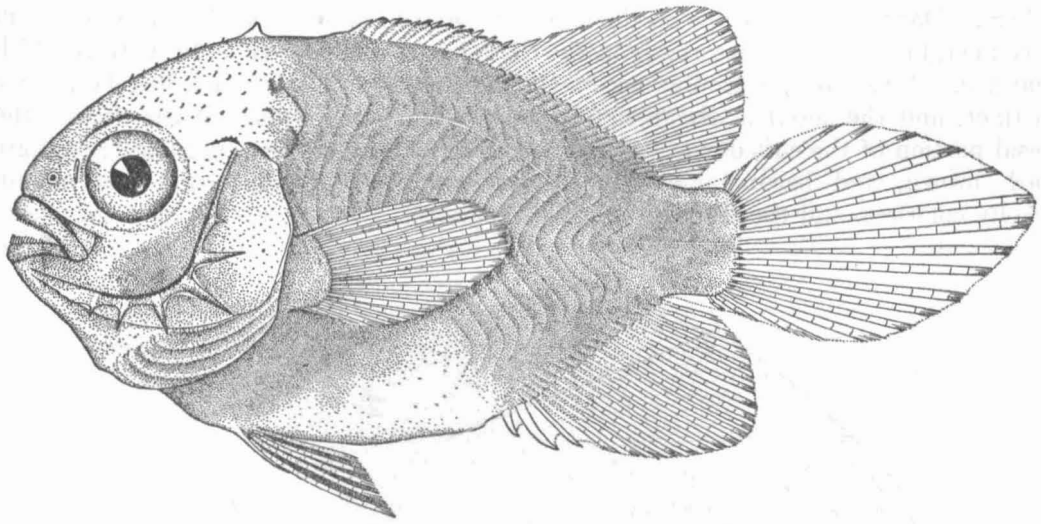

FIGURE 26.—*Chaetodipterus faber*. From a specimen 9 mm long.

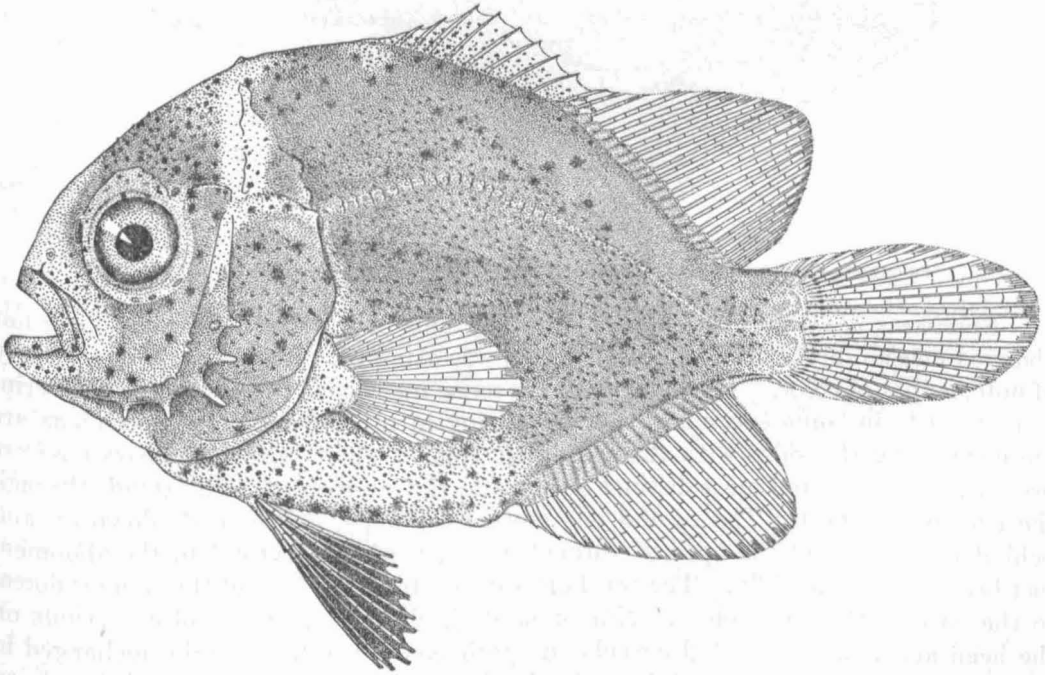

FIGURE 27.—*Chaetodipterus faber*. From a specimen 11.5 mm long.

which is shorter than the eye in younger fish, now is as long as the eye. The mouth is nearly horizontal and terminal, and the maxillary reaches scarcely to the eye. The preopercular spines have become quite small, and the occipital ridge is missing. Scales are well developed; they extend forward on the head to interorbital, and are

strongly ctenoid. Very short hairlike spines remain visible on the head. The lobes of the soft dorsal and anal are high, and slightly pointed. The caudal fin, also, is somewhat pointed. The pectoral fins remain moderately short and rounded, whereas the ventral fins have increased still further in length, reaching fully to the origin of the anal.

The general color is brownish, some specimens being much darker brown than others. Dark dots are visible on the lighter-colored specimens, much as in the 11-mm specimen, but none are discernible in the darker ones which have scales with blackish margins. A pale bar, extending across the nape and down on the preopercle, is very distinct, and the snout is about equally pale. The spinous part of the dorsal, the basal portion of the soft dorsal, as well as the basal parts of the anal and caudal are dark brown, and become abruptly entirely colorless. The pectoral fins remain wholly colorless, and the ventrals are black (fig. 28).

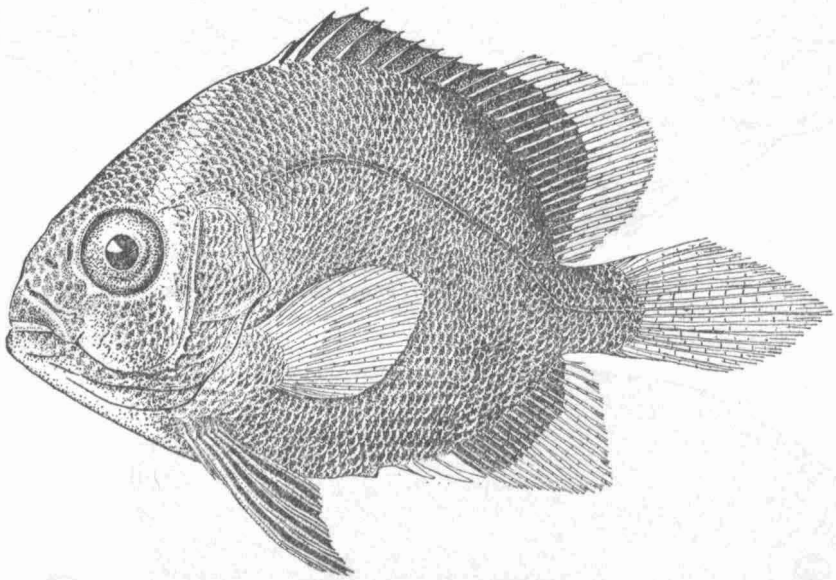

FIGURE 28.—*Chaetodipterus faber*. From a specimen 17 mm long. (Drawn by Mrs. E. B. Decker.)

Specimens about 20 mm long.—The proportions of the head and body have not changed measurably since a length of 18 mm was attained. The only change, worthy of note, is that of color. The pale bar at the nape, mentioned in the preceding description, persists in some specimens, but is missing in others, and some specimens are blotched along the sides with the same pale color. Three dark cross bars now are present. The first and most distinct one crosses the interorbital, and extends through the eye to the chest. The second one crosses the nape, and extends down on and behind the margin of the opercle, through the base of the pectoral to the abdomen, just behind the ventral fin. The third one extends from the base of the spinous dorsal to the base of the anal spines. Numerous dark chromatophores still are visible on the head and body of the lighter-colored specimens. The fins remain unchanged in color, except that the brown color extends higher on the dorsal and anal, involving fully the basal half of the soft rays.

Specimens 25 to 30 mm long.—The depth in proportion to the length of the body has increased still further since a length of about 15 to 18 mm was attained, being contained 1.25 times in the length without the caudal fin. The general shape of the body now is very similar to that of the adult. The head is proportionately shorter, as

usual in larger fish, and is contained 2.75 in the length to the base of the caudal fin. The eye and snout are of equal length, being contained 3.2 to 3.5 in the head. The mouth is horizontal and terminal. The brushlike teeth are developed as in the adult. Preopercular spines remain present, but have become very small. Scales are fully developed, strongly ctenoid, and the hairlike spines present on the head in smaller fish have disappeared. The lobes of the dorsal, anal, and the caudal fins remain round. The ventral fins are long, the second ray (first soft ray) being produced and reaching about to the base of first soft ray of the anal.

The general color of preserved specimens varies from light to dark brown. Some specimens retain a trace of the pale bar crossing occiput, and the pale blotches of smaller specimens. A fourth dark cross bar, extending from about the middle of the base of soft dorsal to the base of the anal, now is more or less distinct. The dark brownish color of the dorsal and anal extends farther on the fins, leaving only the margins translucent. The caudal and pectorals remain translucent, and the ventral fins are mostly black.

Specimens 40 to 50 mm long.—The body has continued to increase in depth, and has attained about the proportions of full-grown fish, the greatest depth being contained 1.1 to 1.2 times in the length without the caudal fin. The snout is definitely longer than the eye, being contained 2.75 to 3.0 times in the head, whereas the eye is contained 3.3 to 3.7 times. Preopercular spines virtually have disappeared, only a few slight points remaining at and below the angle. In somewhat larger fish they no longer are evident. The dorsal spines are about as high as in full-grown fish, the third and largest one reaching the base of the last one if deflexed. Posterior to the longest spine is a black membrane, which reaches beyond the tip of the spine. The lobes of the soft dorsal and anal have become broadly rounded, and the caudal fin is broadly rounded to nearly square.

The general color is not much different from that of fish 25 to 30 mm long. A fifth black bar, situated on the caudal peduncle, however, is present. The color of the fins remains unchanged, except that the lobes of the soft dorsal and anal are wholly dark brown and the interradial membranes of the spinous dorsal are partly black (fig. 29).

Specimens 75 mm and upward in length.—Specimens 40 to 45 mm long already have acquired essentially the shape and proportions of the body of much larger fish. However, a notable change in the shape of the soft dorsal, anal and caudal takes place in larger fish. At a length of 75 mm the anterior soft rays of the anal in some specimens already are produced, as in large fish, making the margin straight or even slightly concave. The dorsal fin apparently is a little more retarded in this same forthcoming development. The caudal fin margin is slightly rounded to nearly straight in fish around 75 mm long.

It has been indicated already that development of the fins does not proceed equally in all spadefish. Thus, a specimen 90 mm long has the anterior rays of the soft dorsal and anal produced so as to form pointed lobes, and the outer rays of the caudal are sufficiently produced to make the margin of this fin slightly concave. Another specimen, 105 mm in length, by contrast, still has these fins shaped essentially as in specimens 40 to 45 mm long. The anterior rays of the dorsal and anal, as well as the outer rays of the caudal continue to increase in length, though unequally fast, as the fish grow, and become long and pointed in large individuals, often reaching beyond the midlength of the caudal fin. The membrane behind the third dorsal spine, already present in fish 40 to 45 mm long, which is at least somewhat longer than the spine, persists. This spine also develops, apparently reaching its maximum

length in fish about 135 mm (5.5 inches) long, when it reaches to or sometimes beyond the base of the first soft ray of the dorsal, and thereafter it again becomes proportionately shorter. In a specimen 262 mm (10.5 inches) long it reaches only to the middle of the sixth spine if deflexed. The filament on the first soft ray of the ventral also persists in big fish, wherein it reaches to the origin of the anal.

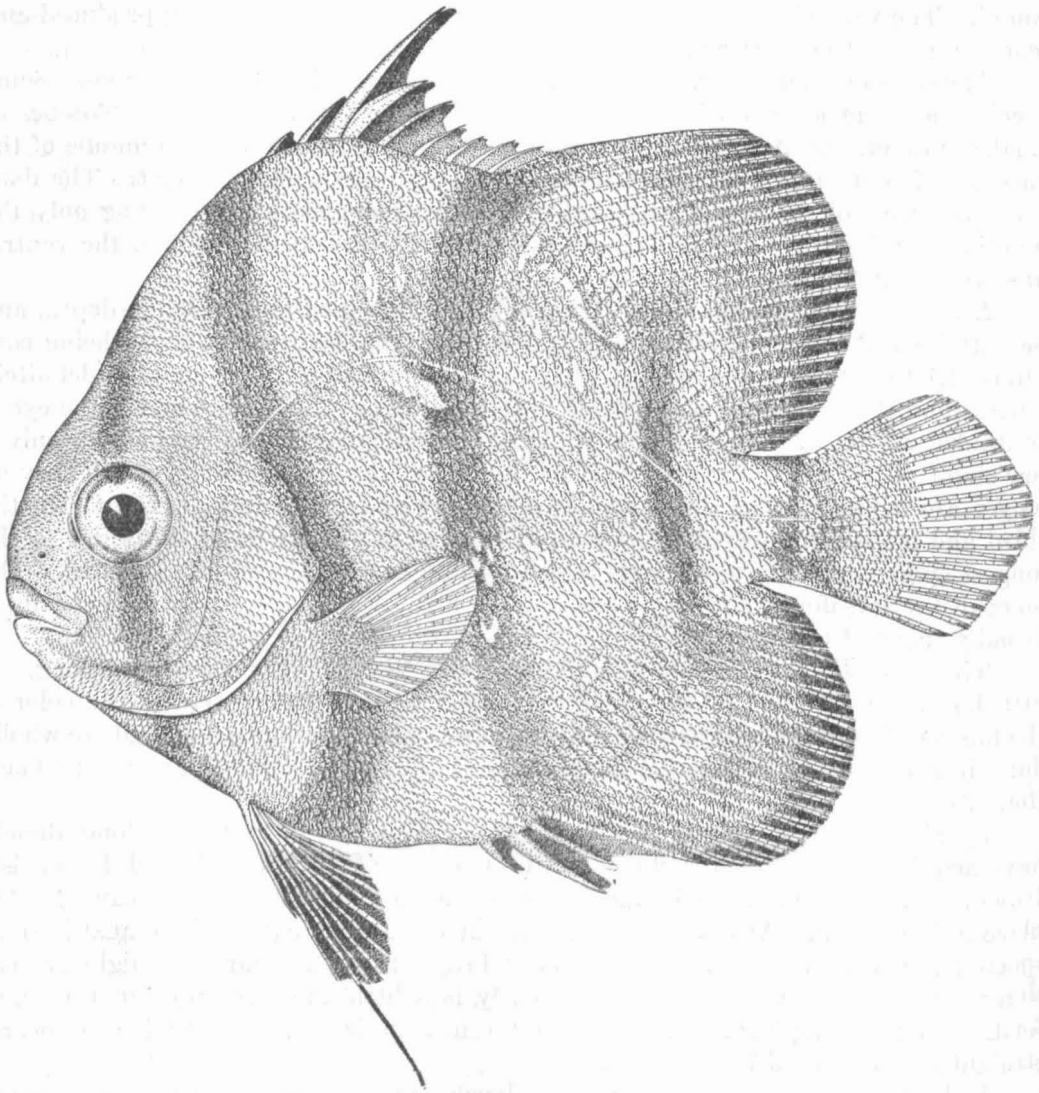

FIGURE 29.—*Chaetodipterus faber*. From a specimen 50 mm long.

The preserved specimens vary greatly in color, ranging from pale silvery to dark brown. Although the species is described as having four to six black bars, all the mature individuals at hand have five, except one old one (262 mm long) which has none. The caudal and pectorals are translucent except in fish upward of 110 mm in length wherein they are brownish. The ventrals remain black or at least dark throughout life.

DISTRIBUTION OF THE YOUNG

Too few early young were taken to cast much light on their distribution. The three smallest specimens at hand, having a length of 2.5, 4.25, and 9.0 mm were all taken at sea, the smallest one about 6 miles off Beaufort Inlet, the intermediate one somewhere off Southport (N. C.), and the largest a short distance west of Beaufort Inlet. It is not known whether the intermediate specimen was taken at the surface or bottom, but the other two were caught in bottom towings. The larger specimens were taken in inside waters in the immediate vicinity of Beaufort either with seines or with otter trawls. Other specimens, ranging upward of 11 mm in length, from the Gulf coast, principally from Louisiana and Texas, which have been studied, presumably were nearly all taken in shallow water with seines.

GROWTH

The literature contains little information on the rate of growth of the spadefish, and insufficient specimens were measured during the recent investigation at Beaufort for definite determination. Smith (1907, p. 335) stated, "In the latter part of August fish about 3 inches (75 mm) long may be seined in Beaufort Harbor." Hildebrand and Schroeder (1928, p. 307) reported the capture of small spadefish in Chesapeake Bay, which they believed were in their first summer, as follows: 1 fish, 55 mm long in September; and 35 fish, ranging in length from 65 to 100 mm in October.

Young spadefish evidently in their first summer were taken on the coast of North Carolina during the recent investigation as follows: 3 fish, respectively 2.5, 4.5, and 9.0 mm long, in July; 12 fish, ranging in length from 49 to 80 mm (average length 56.6 mm) in August; 21 fish, ranging in length from 57 to 86 mm (average length 72.1 mm) in September; and 2 fish, 72 and 74 mm long in October.

The data presented suggest that the young fish may reach a length of about 55 to 100 mm during their first summer on the coast of North Carolina and in Chesapeake Bay. As a fully mature, ripening female 135 mm (5.4 inches) long was seen, it seems probable that at least some of the fish reach that length during their second summer and that they may spawn when 2 years old.

FAMILY GOBIIDAE. GOBIES

Nine species of gobies with united ventral fins are recorded from the coast of North Carolina in this paper. These gobies are assigned to four genera, namely, Gobiosoma (two species), Microgobius (two species), Gobionellus (four species), and Gobius (one species). Three species of the genus Gobionellus appear to be new to the fauna of North Carolina, as stated elsewhere (p. 564). The single species of Gobius, namely, *glaucofraenum*, is known from North Carolina (Cape Lookout) from one specimen (Gudger, 1913, p. 165), which has not been seen by us. This species will receive no further mention in this paper. It appears to differ from all the other local species in having larger scales, about 23 transverse series on the side, and in the shorter second dorsal and anal fins, each fin having 10 rays.

In the present study we did not succeed in collecting eggs of gobies in their native environment. However, those of *Gobiosoma bosci* and *Gobionellus boleosoma* were secured through artificial means. The eggs of the other species dealt with in this paper remain unknown. Small larvae, usually under about 8 to 10 mm in length, were collected principally with 1-meter tow nets. The larger young, that is, fish from 8 to 10 mm and upward in length, were caught principally with especially adapted otter trawls, although some were taken with beam trawls and with bobbinet seines.

The comparative abundance at Beaufort of the young gobies discussed in this paper indicates that the adults are more numerous than the number taken in net collections suggests. It is probable that the adults adhere to the bottom or to objects on the bottom by means of the ventral disk, permitting nets to pass over them. Gobiosoma was able to escape nets quite successfully when confined in a large tank, as explained elsewhere. (See. p. 549). This propensity of escaping nets probably is exercised in nature by most species of gobies.

The original drawings of young and adult fish published in this paper are based upon preserved specimens. The illustrations showing the development of eggs are after Kuntz (1916) and were drawn from living material.

The main differences among the young of the three genera, with which this paper deals principally, are shown in a parallel comparison of characters appearing herewith. The adults of the local species differ from each other rather markedly. In Gobiosoma the body is naked, or at most only two scales are present on the base of the caudal. In Microgobius and Gobionellus, on the other hand, the body is nearly or quite fully covered with scales. Microgobius is distinguished from Gobionellus in having a deeper and more compressed body. Furthermore, the mouth is large and strongly oblique, the maxillary reaching nearly opposite the middle of eye in Microgobius, while in Gobionellus the mouth is scarcely oblique and the maxillary reaches only below the anterior margin of the eye. The dorsal spines are 7 in number and are about equally spaced in Microgobius, whereas Gobionellus has 6 dorsal spines, with the last 2 notably farther apart than the others; and Microgobius has a larger second dorsal and anal fin, each fin being composed of 16 or 17 rays, while Gobionellus has only 11 to about 15 rays in each fin.

The eggs of the gobies of North Carolina, as already indicated, have not been found in nature. Those of *Gobiosoma bosci* and *Gobionellus boleosoma* were secured by Kuntz (1916) by stripping the ripe fish. The eggs of the first-mentioned species also were secured recently by us. The eggs of all the other species remain unknown. Kuntz (loc. cit.) found that the eggs of *Gobiosoma bosci* and *Ctenogobius stigmaticus* (=*Gobionellus boleosoma*) each had a bundle of adhesive threads attached to the egg membrane. These threads no doubt serve the purpose in nature of attaching the eggs to submerged objects.

Ehrenbaum (1905), dealing with European species, stated that the eggs of *Gobius niger* are attached to plants, shells, ascidians, and stones; *G. flavescens* are attached to plants; and those of *G. minutus* to molluskan shells. Hefford (1910) found the eggs, with an adult fish (sex not stated), of *Gobius paganellus* "on a stone between tide marks on the shore" at Plymouth, England. It is not stated that the adult fish guarded the eggs. Clark (1913) stated that the eggs, with males, of *Crystallogobius nilssoni* were found in abundance in the waters at Plymouth, England, attached to the inside of empty tubes of Chaetopterus. Petersen (1917) figured the eggs of four species occurring on the coast of Denmark, namely, *Gobius niger*, *G. ruthensparri*, *G. minutus*, and *G. microps*, showing that the eggs of each species possess an adhesive foot. Lebour (1919) said of *Gobius paganellus:* "From early spring to late summer the males may be seen guarding their eggs, which are attached to the under surface of stones in masses." Lebour (1919) isolated several adults of *Gobius ruthensparri* in a tank and one deposited eggs on the inside of an empty oyster shell. It was not stated that the eggs were guarded by a male. Lebour (1920), who illustrated the eggs of *Gobius minutus*, *G. microps*, and *G. pictus* with adhesive organs, stated that those of the first-mentioned species were laid on an oyster shell, and those of the second one

on the valve of a Pectan. The eggs of the last-named species apparently were not found in nature, but were deposited in the aquarium on a molluskan shell.

It would seem quite certain from the knowledge gained from the study of some American and European gobies, as shown in the preceding paragraphs, that these little fish generally, if indeed not always, attach their eggs to submerged objects, where they probably are guarded by the males. In these respects the spawning habits of the gobies agree in a large measure with the blennies, as shown in another part of this paper.

Gobiosoma bosci and *Gobionellus boleosoma* are landlocked, except during extremely high storm tides, in the Mullet Pond on Shackleford Banks near Beaufort. The water in this pond ranges from brackish to nearly fresh. In fact, it becomes fresh enough, at times, to support such fresh water plants as Potamogeton and filamentous fresh water algae. Here the two species named evidently carry out their reproductive processes, as ripe adults and young fish, less than 10 mm in length, have been collected. The bottom of the pond is quite muddy. In places luxurious growths of plants are present, and oyster shells, as well as live oysters, are found over some parts of the bottom. It would seem necessary for the gobies to attach their eggs either to plants or to oyster shells in this pond, as few other submerged objects are present.

DISTINGUISHING CHARACTERS OF THE YOUNG OF THE GENERA GOBIOSOMA, MICROGOBIUS, AND GOBIONELLUS.

The young of the three genera, Gobiosoma, Microgobius, and Gobionellus, discussed in the following pages are quite similar, especially when very small. The following comparison is offered with the hope that it may be found useful. Myomere and vertebrae counts in the three genera are almost identical, the range of vertebrae for the three genera (of Gobionellus only *boleosoma* was examined) being 11 or 12+15 to 17 and cannot be used in separating them and, therefore, are omitted.

Length 2.0 to 3.5 mm

GOBIOSOMA	MICROGOBIUS	GOBIONELLUS
Body rather deep; depth just posterior to vent about equal to head.	Body as in Gobiosoma.	Body extremely slender; depth of body posterior to vent notably less than length of head.
Vent typically well behind midbody length.	Vent typically at midbody length.	Vent notably behind midbody length.
Eye small.	Eye slightly larger.	Eye small, bulging.
Ventral outline of body usually with a few dark spots.	Ventral outline usually with more numerous black spots, and a double row behind vent.	Pigment spots as in Gobiosoma or more usually wanting.

Length 4.0 to 5.5 mm

Soft dorsal and anal bases short, the rays developed in some specimens, each fin with 11 to 14 rays.	Soft dorsal and anal bases long, longer than in Gobiosoma, the rays partly undeveloped.	Soft dorsal and anal bases short, the rays partly undeveloped.

The differences listed for smaller specimens, exclusive of the position of the vent which has changed, apply to fish 4.0 to 5.5 mm long. The two rows of dark spots behind the vent in Microgobius, now lying along the opposite sides of the anal base, have become very definite and serve as ready recognition marks.

Length 6.0 to 7.5 mm

Soft dorsal and anal each with 11 to 14 rays.	Soft dorsal and anal each with 16 or 17 rays.	Soft dorsal and anal each with 11 to 13 rays.
A dark sheath present above air bladder, not crescent-shaped.	A dark sheath over air bladder as in Gobiosoma.	A distinct crescent-shaped dark area over air bladder.

The differences listed in the shape of the body for smaller specimens apply to fish 6.0 to 7.5 mm long.

Length 8.0 to 12 mm

Body anteriorly rather robust somewhat rounded; head slightly depressed, as broad as deep.	Body and head compressed, rather deep.	Body more or less round and very slender.
Mouth rather small; maxillary reaching about opposite anterior margin of eye.	Mouth large, maxillary reaching opposite anterior margin of pupil.	Mouth small; maxillary scarcely reaching opposite anterior margin of eye.

The differential color markings mentioned for smaller fish remain as described in specimens 6.0 to 7.5 mm long.

Length 13 to 16 mm

Body anteriorly quite robust; head notably depressed.	Head and body compressed throughout.	Body extremely slender, remaining round.
Mouth only slightly oblique, terminal; maxillary reaching only slightly beyond anterior margin of eye.	Mouth large, strongly oblique, terminal to slightly superior; maxillary reaching nearly opposite middle of eye.	Mouth moderately oblique, small, terminal; maxillary scarcely reaching opposite anterior margin of eye.
Dorsal spines all about equally spaced.	Dorsal spines as in Gobiosoma.	Last two dorsal spines much farther apart than the others.

A COMPARISON OF THE EGGS AND THE YOUNG OF SOME AMERICAN AND EUROPEAN GOBIES

It has been shown in the preceding paragraphs that the eggs of all the American and European gobies that have been studied have adhesive threads or an adhesive foot by which the eggs become attached to submerged objects. A further comparison of the eggs, and the young, of the American and European species shows other similarities. The eggs of all the gobies, so far as they are known, are rather small. A dozen eggs of *Gobiosoma bosci* measured by us several hours after fertilization, when they had had time to expand, had a length of 1.2 to 1.37 mm, and their greatest width was 0.52 to 0.59 mm. The eggs of *Ctenogobius stigmaticus* (= *Gobionellus boleosoma*), according to Kuntz (1916), are extremely small, having an average diameter of only 0.3 mm. The eggs of European species, too, are rather small. Ehrenbaum (1905) gave the following lengths of the eggs for the European species named: *Gobius ruthensparri*, 0.7 mm; *G. paganellus*, 1.8 to 1.9 mm; *G. pictus*, 0.8 mm.; and *G. niger*, 1.5 mm. Lebour (1920) gave the length of the eggs of *G. microps* and *G. minutus* respectively as 0.85 to 1.0 and 1.08 to 1.4 mm.

The eggs of *Gobiosoma bosci* when first spawned, as stated by Kuntz (loc. cit.) and verified by us, are nearly spherical. After fertilization they expand and become eliptical, the greater axis becoming nearly twice as long as the lesser one. The adhesive foot, consisting of a bundle of threads, remains attached to one pole of the longer axis. The eggs of *Ctenogobius stigmaticus* (=*Gobionellus boleosoma*) according to Kuntz (loc. cit.) are more or less irregular or variable in shape, and they remain so throughout the incubation period.

All the eggs of the European gobies that have been described or figured, so far as the present writers are familiar with the literature, are more or less elongate. According to Petersen's figures (1917) the eggs of *Gobius niger* are very elongate, the greater axis being about four times as long as the lesser one, and one end of the egg is larger than the other one. The adhesive foot is attached to the smaller end. The eggs of *Gobius ruthensparri*, as figured by Petersen (loc. cit.) and by Lebour (1919), are more or less pear-shaped, and the greater axis is less than 2 times as long as the lesser one. The adhesive foot is attached to the larger end of the egg. The eggs of *Gobius microps* according to Petersen's figures (loc. cit.) are very similar to those of *G. ruthensparri*. However, the upper end of the egg is rather less pointed and the lower end has a slight pedicel to which the adhesive foot is attached. Lebour (1920) stated that the eggs of *Gobius pictus* are very similar to those of *G. microps*. The eggs of *Gobius minutus*, as figured by Petersen (loc. cit.) and also by Lebour (1920) are similar in shape to those of *G. microps*, being more elongate, however, as the greater axis is nearly two times as long as the lesser one. The adhesive foot is attached to a slight pedicel. The eggs of *Gobius paganellus*, as figured by Lebour (1919), are eliptical and very similar in shape to those of the American species, *Gobiosoma bosci*. The greater axis is rather more than two times as long as the lesser one, and the adhesive strands are attached to one pole of the longer axis.

A rather remarkable similarity exists among the young of the American and European gobies, that have been studied, as shown principally by the works of Kuntz (1916), Petersen (1917), and Lebour (1919 and 1920), and by the present paper. The newly hatched larvae are of a small to a moderate size. Kuntz (loc. cit.) gave the length of the newly hatched larvae of the American species, *Gobiosoma bosci* and *Gobionellus boleosoma*, respectively as 2.0 and 1.2 mm; Lebour (1919) stated that the newly hatched larvae of the European species, *Gobius paganellus* and *G. ruthensparri*, are respectively 4.0 and 3.1 mm long and (1920) that those of *G. microps* and *G. pictus* are respectively 3.0 and 2.7 to 3.0 millimeters in length; and Petersen (loc. cit.) gave the length of the newly hatched young of two other European species, *Gobius niger* and *G. minutus* as 2.6 millimeters each.

In general the body of the larvae is quite elongate and slender, varying somewhat among the species. The caudal portion is especially slender and tapers gradually to a point. The vent is placed somewhere near midbody length; generally, however, rather nearer the tip of the tail (without the finfold) than the end of the snout. At hatching the head is rather rounded and the mouth tends to be horizontal and inferior. Very soon the mouth becomes rather oblique. However, as the adult stage is reached the mouth, in at least several species, tends to assume again more nearly the position occupied at hatching. When the caudal fin is first developed it either has a straight or a slightly rounded margin. As development of the fish progresses this fin tends to become more or less concave. Even in *Gobionellus boleosoma*, which has a moderately long and more or less pointed caudal fin in the adult, this fin is concave in the young that are around 8 mm long. In some species as in those of Gobiosoma, reported upon in this paper, the caudal fin does not become round, as in mature fish, until virtually all the adult characters are developed at a length of about 15 mm. The spinous dorsal usually develops somewhat later than the other fins in teleosts. In the gobies this fin develops especially late, or not until all the other fins are quite fully formed.

The body in larval gobies generally is quite transparent and often the notochord or vertebrae are visible in part. The plainly visible air bladder, commonly with a crescent-shaped black area over it, is characteristic. Usually a few pigment spots are present at hatching and others soon appear. General pigmentation, however,

takes place at a rather advanced stage, that is, after virtually all the adult characters are developed.

It is evident from the foregoing discussion that both American and European gobies generally have rather small eggs, which are variable in shape and somewhat in size among the species, and are equipped with an adhesive organ by which they become attached to submerged objects. The larvae as a rule are slender, quite transparent, and have at least a few pigment spots. Interesting phases in their development are the changes in the position of the mouth and in the shape of the caudal fin. In separating the species the myomere and vertebra counts sometimes are useful (although not in the American species discussed in this paper), the fin ray counts, as soon as they can be made, are extremely helpful, and the pigment spots are always important for identification purposes.

GOBIOSOMA BOSCI (LACÉPÈDE) AND GOBIOSOMA GINSBURGI, HILDEBRAND AND SCHROEDER. NAKED GOBIES

Two species of Gobiosoma, namely *bosci* and *ginsburgi*, occur in the waters at Beaufort. The last-mentioned species was described recently from Chesapeake Bay (Hildebrand and Schroeder, 1928, p. 324), Ginsburg (1933 p. 40) made a thorough study of the genus Gobiosoma, and found specimens of *G. ginsburgi* in collections from as far north as Cape Cod and southward to South Carolina, and of *G. bosci* from Long Island to Tampico, Mexico.

Specimens of adult *G. bosci* are much more numerous in the collection from Beaufort than those of *G. ginsburgi*. However, the reverse is true with respect to the young. In Chesapeake Bay (Hildebrand and Schroeder, 1928, p. 325) *bosci* was taken in shallow water only, whereas *ginsburgi* was taken principally in rather deep water and rarely in shallow water. A similar vertical distribution of the species is indicated for Beaufort, since all adult *bosci* from this vicinity were taken in very shallow water along the shores, whereas all specimens of adult *ginsburgi*, except one, were taken in water from a few to several fathoms in depth. The young that are recognizable as to species (10 mm and upward in length) have a vertical distribution identical with that of the adults.

KEY TO THE ADULTS OF THE LOCAL SPECIES

a. Body rather robust, its depth 3.95 to 4.8 in its length without caudal fin; second dorsal normally with 13 rays, infrequently with 12 or 14; ventral disk short, reaching about half the distance from its base to the vent; no scales on base of caudal ..... *bosci.*

aa. Body more slender, its depth 6 to 7.15 in its length without caudal fin; second dorsal normally with 12 rays, infrequently with 11 or 13; ventral disk long, reaching two-thirds the distance from its base to the vent; two large scales on base of caudal, situated respectively on the base of the upper and lower rays of the fin ..... *ginsburgi.*

Although the characters mentioned in the foregoing key readily separate the adults when two or more of the characters are taken into consideration, they cannot be used successfully in separating the young under about 10 mm in length, because the characters either are entirely undeveloped at that size or so imperfectly developed that they are useless. Neither have we succeeded in finding other distinguishing characters. Therefore, the young (under about 10 mm in length) cannot be discussed separately with respect to distribution, habitat, growth, etc. (figs. 30 and 31).

Young Gobiosoma are rather generally distributed throughout the local waters and are very abundant, as shown elsewhere (p. 558). Their relative abundance, in fact, suggests that the adults are more common than indicated by the number

of grown fish generally secured in collecting nets. From the difficulty experienced in recapturing adult fish placed in a rather large tank table in the laboratory, it is evident that nets are not very efficient for capturing the fish, because they attach themselves, by means of the sucking disk, to the bottom or to objects in the water, or they hide under objects, thereby making it very easy for a net to slide over them. They no doubt escape the net in a similar way in nature. All of this is a further indication that the fish probably are more numerous than shown by the number of adults captured.

No evidence indicating that any one individual produces an excessively large number of eggs was secured. A female 25 mm long with a greatly distended abdomen, for example, contained only 249 eggs. Furthermore, the eggs in the ovaries in several specimens examined were all of uniform size, indicating that a single spawn-

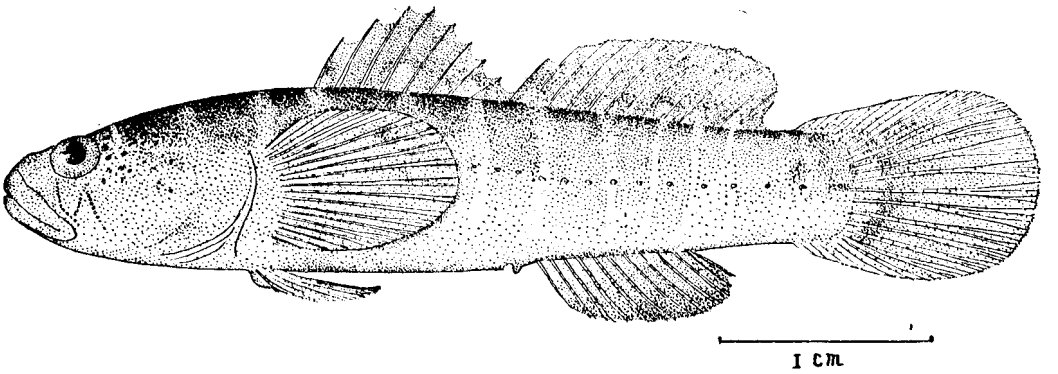

FIGURE 30.—*Gobiosoma bosci*. From adult 50 mm long. (Drawn by Louise Nash.)

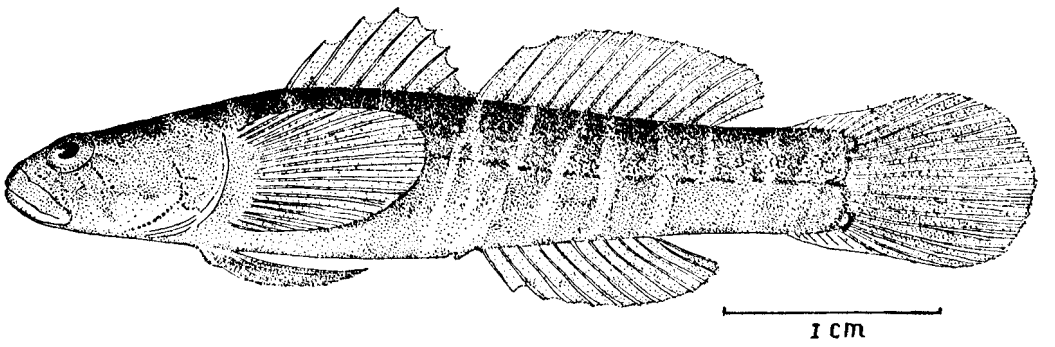

FIGURE 31.—*Gobiosoma ginsburgi*. From adult 45 mm long. (Drawn by Louise Nash.)

ing takes place during a season. The great abundance of the young—in several instances a hundred or more and in a few instances probably nearly a thousand specimens were taken in a single tow-net haul—then, would appear to be due to the presence of many adults.

The local species of Gobiosoma, which rarely exceeded a length of 2 inches, obviously are too small to be of direct commercial value, yet they probably are of some importance as forage for commercial species.

Nothing is known concerning the winter home of Gobiosoma. We have taken no specimens during the colder months of the year, or from early December to early May. It seems probable that these fish imbed themselves in mud during the winter. This probability is suggested by the abundance of gobies in seine hauls made in the Mullet Pond throughout the warmer months, in places where none were taken

during the winter. This pond is connected with the adjacent sound only during exceptionally high tides, which occur generally only a few times during a year, and seldom near or in the winter months. It seems rather certain, therefore, that the gobies are present during cold weather but are not in open water where they can be caught with seines. Several species of Fundulus and *Cyprinodon varigatus* which also inhabit the Mullet Pond, are known to imbed themselves in mud during cold weather. Therefore, it seems probable that the gobies also enter the muddy bottom during the winter.

No external structural characters by means of which the sexes may be distinguished have been found. In general, the males range larger in size and are darker in color. However, specimens intermediate, both with respect to size and color, are nearly always present in collections, making a complete separation of the sexes from external characters impossible. In gravid fish the anal papilla, although present in both sexes, appears to be larger in the female than in the male.

SPAWNING

The information about spawning in Gobiosoma was derived mostly from the study of large collections of young. It has not been possible, however, as explained elsewhere, to separate definitely the young (less than about 10 mm in length) into two groups, representing the two local species, *bosci* and *ginsburgi*. Therefore, it is not known positively, although it is highly probable, that both species are represented among the fry. Neither is it known definitely whether much of the information derived from the study of the collections is applicable to one or both forms. The data based on the study of the collections of young give no evidence of two predominating spawning periods. Therefore, if two species are represented among the fry, the spawning seasons probably occur simultaneously or overlap so fully that no distinction may be made either from the size of the young nor from their abundance.

Collections of young Gobiosoma were made from 1927 to 1931. The larvae first appeared in the tow in May (the earliest date being May 11, 1929), and throughout the summer and fall until December (the latest date being Dec. 6, 1929). The larvae were common to abundant from June to September each year but most numerous during July and August. During October, November, and December only a few scattered ones were secured.

Among the females in the relatively large collections of adults made in the Mullet Pond during August (1930), principally small individuals were in spawning condition, the larger ones evidently having spawned out. This condition suggests that the principal spawning season was past, and is in general agreement with the situation suggested by the data based on the collections of young. Although the fry were abundant in the towings during August it may be assumed, that many of those taken, particularly the larger ones, were hatched during July. Furthermore, in September there occurred a pronounced drop in the number of young. The evidence, therefore, is that spawning begins early in May or possibly during the latter part of April, that it occurs most abundantly during July and ends except for an occasional late spawner, in September.

The larvae of Gobiosoma were taken over a wide variety of conditions and over a comparatively large area, as explained under that section of this paper dealing with distribution (p. 558). Since the eggs become attached and do not drift as already shown, spawning probably takes place over a large portion of this area and over a wide variety of conditions.

Nothing definite can be said concerning the spawning places of the two species of Gobiosoma represented locally, first, because the young under 10 mm in length could not be separated, and second, because ripe *G. ginsburgi* were not taken. Ripe *G. bosci* were taken only in the Mullet Pond where they no doubt spawn, as the larvae were present in the same places where the adults were taken. It seems probable, therefore, that spawning takes place in the general habitat of the adults. If that were the case, then it would follow that *G. bosci* would spawn only in shallow water along the shores, whereas *G. ginsburgi* would spawn principally in somewhat deeper water (see p. 548).

DESCRIPTIONS OF THE EGGS AND YOUNG

Eggs.—The eggs stripped from ripe fish taken in the Mullet Pond were first described by Kuntz (1916, p. 423). Since the present investigators have found only *G. bosci* in that pond, it seems probable that the eggs described were of this species. The eggs were secured again by the present investigators in August 1930 from fish taken in the Mullet Pond. The description of the eggs given by Kuntz is essentially correct. The ova when expressed from the female adhere in clumps unless immediately separated. The eggs when seen in a mass with the unaided eye are yellowish in color and quite opaque. Under the microscope a "bundle" of gelatinous threads with small branches are seen to be joined to the egg membrane at a certain point. These threads cause the eggs to adhere. Their function no doubt is that of attaching the eggs to vegetation or other objects in the water. The eggs are slightly heavier than sea water and when placed in a dish of water they sink gradually.

The mature unfertilized eggs, as observed by us, generally, are slightly elongate, but sometimes nearly spherical. The variation in the major axis of five selected eggs ranged from 0.637 to 0.675 mm and for the minor axis in the same eggs it was 0.52 to 0.6 mm. As soon as fertilization had taken place the eggs began to expand and became elliptical in shape. In the process of expansion the minor axis retained about its former length, for in 10 eggs measured during various cleavage stages it ranged from 0.573 to 0.592 mm. The major axis, however, becomes much longer, for its range in length in the same eggs ranged from 1.147 to 1.369 mm. Expansion appears to be fully completed by the time the first cleavage takes place and thereafter, according to our observations, the egg changes little or not at all in shape. According to Kuntz's figures, eggs with large embryos are more pronouncedly elliptical than those in the early cleavage stages (fig. 32).

When the egg is fully expanded a relatively large perivitelline space is present, for the yolk mass occupies somewhat less than half the space within the egg membrane. The position of the yolk varies greatly. Generally it lies toward one pole of the major axis of the egg and most frequently opposite the pole at which the gelatinous adhesive strands are attached. Occasionally, however, it is much nearer the opposite pole of the major axis, or it may occupy an intermediate position (fig. 33).

The yolk mass of the egg when seen under magnification has a greenish-yellow cast and it contains many minute oil globules. Due to the opaqueness of the yolk, many of the phases in the development either cannot be seen at all or are obscure. The processes in the development of the egg are well described and accurately figured by Kuntz (1916, pp. 423 to 426, figs. 43 to 50).

The cells in the early cleavage stages stand out very prominently as round elevations. As cleavage advances the fissures become less pronounced and gradually the blastoderm becomes circular in outline and sharply differentiated from the yolk (figs. 34 and 35).

The development is rapid at first. Eggs fertilized at 10:30 o'clock in the morning and held at a temperature close to 27° C., for example, reached the 2-cell stage in

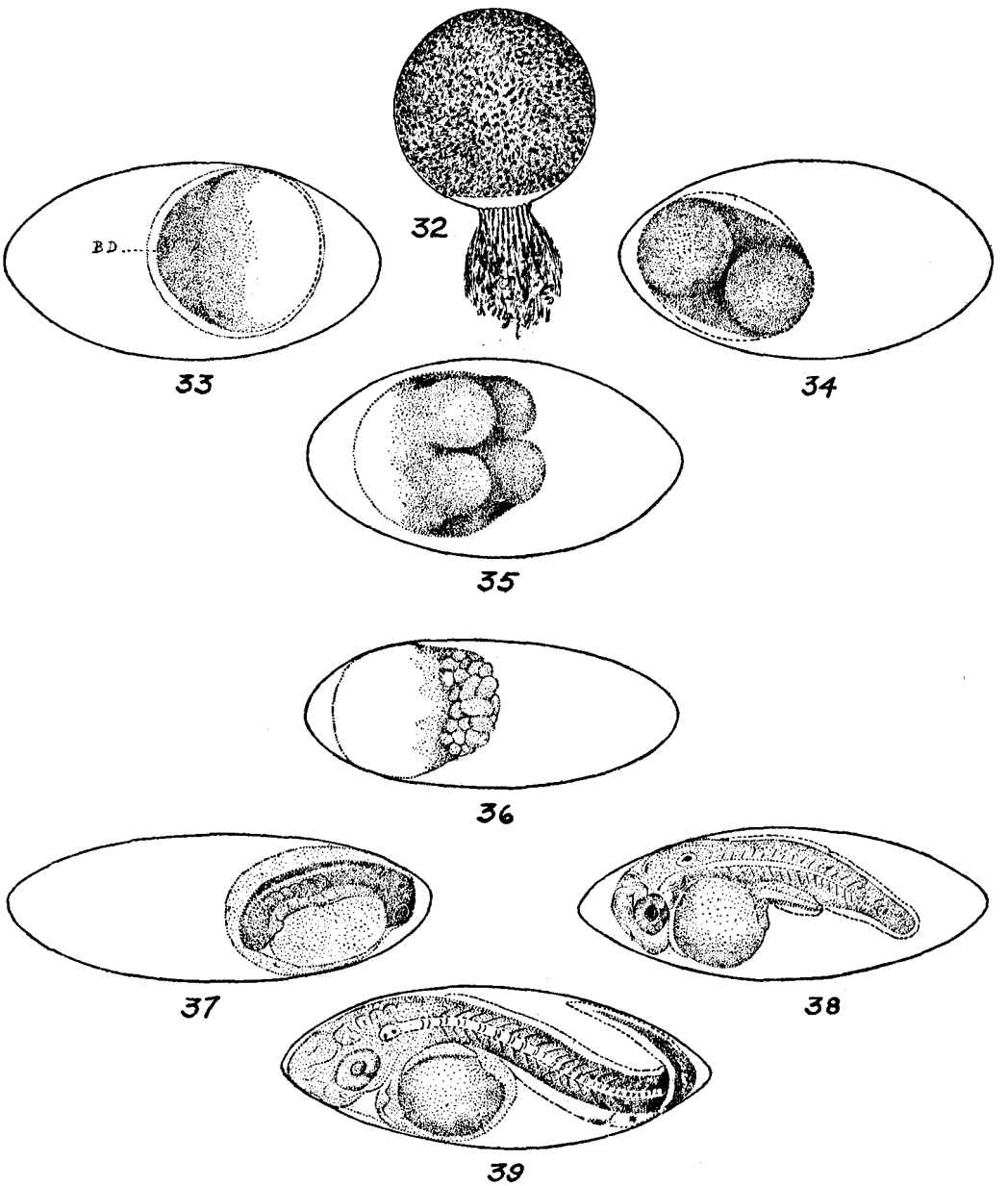

FIGURE 32.—*Gobiosoma bosci.* From mature unfertilized egg. (Drawn by Effie B. Decker. After Kuntz.)
FIGURE 33.—*Gobiosoma bosci.* From egg with fully developed blastodisc, BD. (Drawn by Effie B. Decker. After Kuntz.)
FIGURE 34.—*Gobiosoma bosci.* From egg with blastoderm of 2 cells. (Drawn by Effie B. Decker. After Kuntz.)
FIGURE 35.—*Gobiosoma bosci.* From egg with blastoderm of 4 cells. (Drawn by Effie B. Decker. After Kuntz.)
FIGURE 36.—*Gobiosoma bosci.* From egg with blastoderm of many cells. (Drawn by Effie B. Decker. After Kuntz.)
FIGURE 37.—*Gobiosoma bosci.* From egg with recently differentiated embryo. (Drawn by Effie B. Decker. After Kuntz.)
FIGURE 38.—*Gobiosoma bosci.* From egg with well-formed embryo. (Drawn by Effie B. Decker. After Kuntz.)
FIGURE 39.—*Gobiosoma bosci.* From egg with large embryo. (Drawn by Effie B. Decker. After Kuntz.)

1¼ hours, the 4-cell stage in 1¾ hours, and the 8- and 16-cell stages (for there were some eggs in each stage) were reached in about 2¾ hours. In about 22 hours, at a temperature varying from 26° to 27° C., the embryo had become well formed. There-

after development progressed less rapidly, and hatching took place in about 4 days at a water temperature varying from about 26° to 28° C. (figs. 36, 37, and 38).

Although the yolk mass, after the expansion of the egg is completed, occupies less than half the area within the eggs, as stated elsewhere, nearly the entire space is utilized later by the advanced embryo which becomes bent back on itself, with the tail pointed in the general direction of the head. The position of the embryo within the egg is not always the same. In most instances the head is pointed toward the pole of the major axis at which the adhesive threads are inserted, but occasionally it is directed toward the opposite pole. This fact is not brought out by Kuntz (loc. cit.) (fig. 39).

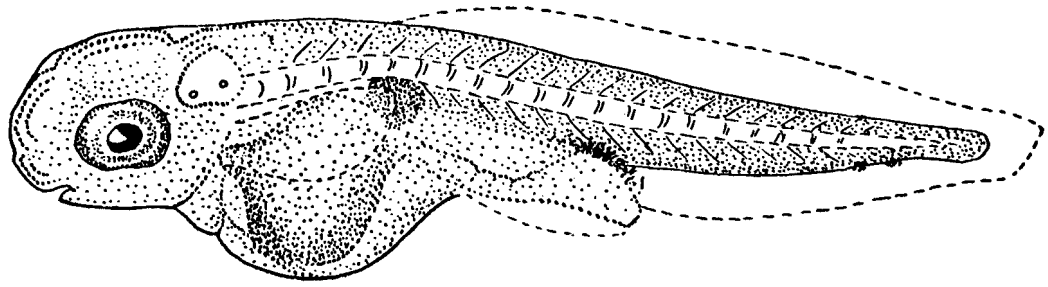

FIGURE 40.—*Gobiosoma bosci*. From a newly hatched fish about 2 mm long. (Drawn by Effie B. Decker. After Kuntz.)

Newly hatched young, 2.0 mm long.—The incubation period occupies about 5 days at the usual summer temperatures (around 24° to 27° C.) prevailing in the laboratory at Beaufort. The newly hatched fish is approximately 2.0 mm long and almost transparent. The air bladder is visible at the posteriodorsal aspect of the yolk mass. The vent is situated nearer the tip of the tail than the end of the snout. The mouth is inferior, although somewhat later it becomes strongly oblique, as shown subsequently. A few small pigment spots occur just over the vent and at the base of the ventral finfold posterior to the vent (fig. 40).

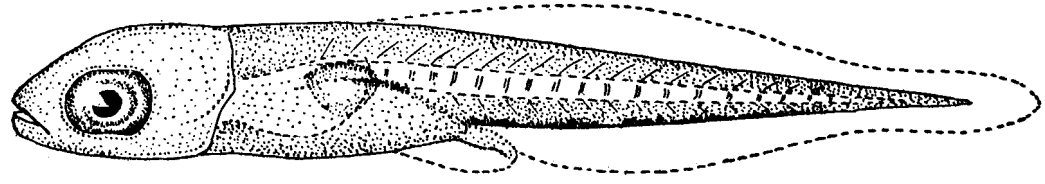

FIGURE 41.—*Gobiosoma bosci*. From a fish hatched in the laboratory, a few days old, and about 3 mm long. (Drawn by Effie B. Decker. After Kuntz.)

Kuntz (1916) was able to keep the fish hatched in the laboratory alive until a length of about 3.0 mm was attained. The mouth in the meantime, according to the illustration presented had moved forward and had become terminal and somewhat oblique. The line of pigment spots at the ventral outline of the tail had become somewhat more conspicuous than in the newly hatched fish (fig. 41).

The eggs and young hatched in the laboratory, upon which the foregoing descriptions are based, are known definitely to belong to *G. bosci*. The young up to 10 mm in length, upon which the descriptions that follow are based, were taken in the tow and probably include both local species, as already explained.

Kuntz did not have sufficient material for the preparation of descriptions and illustrations of all the stages in the development of the young. This information is supplied in the following pages.[4]

Specimens 1.8 mm long.—The smallest individuals in the collection of preserved specimens, which we assign with some doubt to this genus because of their similarity to Microgobius, are only about 1.8 mm in length. Such specimens are farther developed than a fresh or live larval fish 3.0 mm in length (fig. 13), which indicates that considerable contraction probably has taken place during preservation. The body is rather slender and somewhat compressed. The yolk is completely absorbed and the abdominal mass is quite small. The air bladder is plainly visible through the abdominal wall, lying dorsally of the abdominal mass. The intestine is free or at most loosely attached posteriorly and the vent is far behind midbody length. The finfold remains continuous but has slight indications of rays where it surrounds the pointed tail. The eye is excessively large, being equal to about three-fourths the depth of the head. The mouth is almost vertical and the snout is turned up slightly at the tip. The color consists of a few dark chromatophores on the median line of the abdomen and on the ventral surface of the tail, that is, at the base of the ventral finfold (fig. 42).

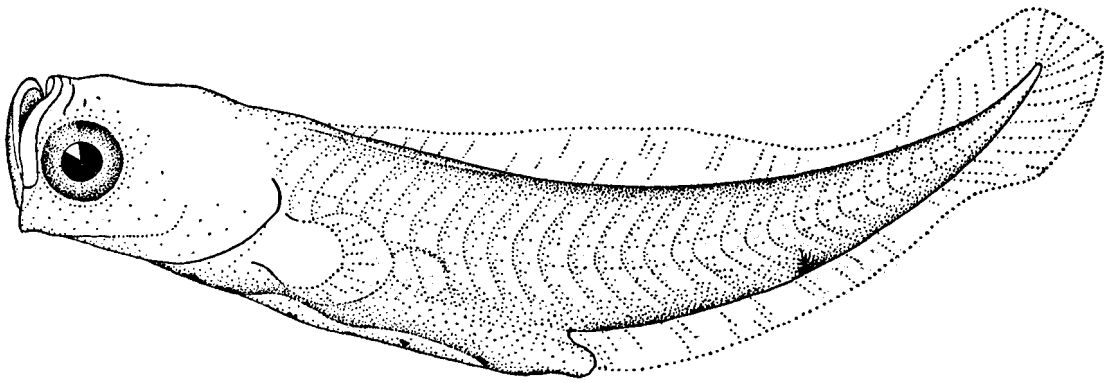

FIGURE 42.—*Gobiosoma sp.* From a specimen 1.8 mm long.

The position of the mouth in our specimens differs sharply from that shown in Kuntz's (loc. cit.) illustrations (figs. 40 and 41). Figure 40, based on a newly hatched fish, shows an inferior mouth, and figure 13, based on a fresh fish 3.0 mm long, represents the mouth as terminal and only slightly oblique, and shaped very much as in the adult. A sudden and a pronounced change in its position must take place since the specimens here described cannot be much older, as already indicated, than the 3.0 mm fish shown in figure 41. Illustrations, in various works, of the development of European gobies, too, show that the mouth in newly hatched larvae is inferior and that it tends to become oblique very early in life.

Specimens 4.0 mm long.—The body is moderately slender and notably compressed. The caudal portion of the body which is much more slender than the trunk in smaller individuals has become much deeper and at this size the depth just posterior to the vent is nearly as great as it is in advance of it. The air bladder remains visible, microscopically, through the abdominal walls, but the intestine which is partly free posteriorly in smaller specimens is now quite fully invaginated.

[4] Shropshire (1932, pp. 28 and 29, figs. 1 to 4) described four stages of young gobies under the name *Gobiosoma molestrum*, which is a synonym of *G. bosci* according to Ginsburgh (1933, p. 32). The two smaller stages are so different in the shape and position of the mouth from our series that they undoubtedly represent a different species. The two larger specimens figured could conceivably be identical with those of our series.

The finfold no longer remains continuous, as the caudal fin is fairly well developed and the bases of the dorsal and anal fins have become indefinitely outlined and some of the rays have become differentiated. Pectoral fins, too, are evident, but the ventrals remain undeveloped. The notochord is curved upward posteriorly, giving the tail a heterocercal appearance. The mouth remains nearly vertical as in younger fish. The body is unpigmented, except for a few dark chromatophores on the median ventral outline of the body and tail, the last one of these dark spots, situated near the end of the anal base, being the largest (fig. 43).

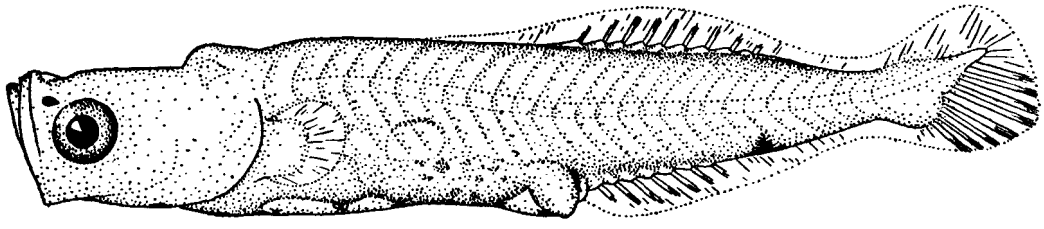

FIGURE 43.—*Gobiosoma sp.* From a specimen 4 mm long.

Specimens 5.0 mm long.—The shape of the body is essentially as in specimens 4.0 mm long. The mouth, however, is not quite as nearly vertical as in the smaller fish. The development of fins has progressed rather rapidly, the caudal, soft dorsal and anal being sufficiently developed to show the rays rather definitely and it is now possible to enumerate the rays of the second dorsal and the anal quite definitely which is a great help in identification. The first, or spinous dorsal, is partly developed in some specimens, but it is impossible to count the spines accurately. The pectoral fins are plainly evident but without distinct rays. The ventral fins, however, are still undeveloped. The air bladder remains slightly visible, microscopically, through the abdominal walls as an area which is slightly more transparent than the abdomen is elsewhere. The notochord is still turned upward posteriorly and pigmentation remains essentially as in 4.0 mm specimens (fig. 44).

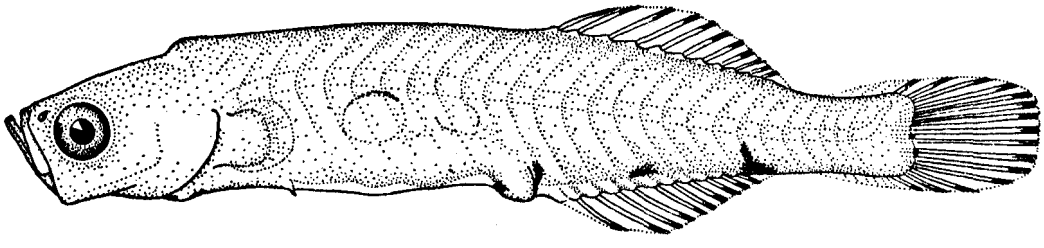

FIGURE 44.—*Gobiosoma sp.* From a specimen 5 mm long.

Specimens 7.5 mm long.—The body remains shaped essentially as in 5.0-mm specimens, that is, compressed and slender, the depth being contained in the length to base of caudal fin about 6.25 times. The fish has a somewhat different appearance, however, at this size, mainly because of the rather pointed snout; for the mouth, although still superior, has become rather oblique with a somewhat pointed projecting mandible, as seen in a lateral view. The muscular rings on the body remain rather distinct, but the heterocercal character of the tail generally has disappeared. The air bladder remains visible, microscopically, through the body wall as a somewhat lighter area. The development of the fins has progressed slowly. The spinous dorsal is not yet evident, but the ventrals now appear as a short tuft of membrane

without evident rays. The caudal fin seems to have a nearly straight to a somewhat concave posterior margin. In life the body remains highly transparent and the fish are almost invisible when caught in a net, except for the dark eyes. Pigmentation on the body consists of two short dark lines situated on the median ventral line, the anterior one being under the posterior part of the head and the second one on the chest; a dark chromatophore appears just in advance of the vent; and usually a series of indefinite dark markings extends from the origin of the anal to the base of the caudal, the last spot of the series being on the base of the lower caudal rays and generally slightly vertically elongate. These markings are different from those in related species of gobies occurring locally and serve as a recognition mark (fig. 45).

Specimens 10 mm long.—The two local species of Gobiosoma are rather definitely separable at a length of 10 mm. In both species the body has become more robust since a length of about 7.5 mm was attained and generally it is somewhat rounded anteriorly. The greatest depth of the body in *bosci* is contained in the length to the base of the caudal about 5.3 times, whereas *ginsburgi* generally is more slender, the depth being contained in the length about 6 times. In *bosci* the head is nearly

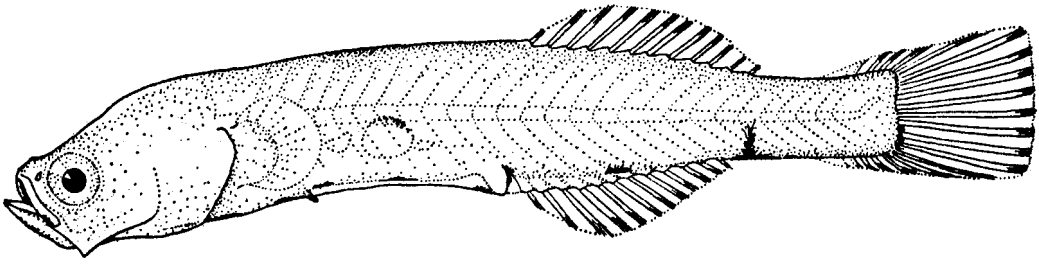

FIGURE 45.—*Gobiosoma sp.* From a specimen 7.5 mm long.

as broad as deep, the eyes have become slightly superior, the snout is comparatively round and blunt, and the mouth is moderately oblique and terminal. In *ginsburgi* the development in all these respects is rather less pronounced. The ventral fins are quite fully developed as a sucking disk in both species (reaching its greatest development in *bosci* at this size and becoming proportionately shorter later in life), and the first dorsal is present, although the spines are very weak and slender. The margin of the caudal fin remains straight to slightly concave. Variation in the progress of pigmentation is evident among specimens of the same species. However, the development generally is further advanced in *bosci* than in *ginsburgi*. In the latter no general pigmentation has taken place and the markings remain virtually as described for the 7.5-mm fish. The posterior one of the two short dark lines on the median line of the chest is now situated at the base of the ventral disk. The dark markings along the base of the anal and on the ventral outline behind the anal clearly are short hyphen-shaped lines when viewed ventrally and are rather more distinct than in smaller fish. In the most profusely pigmented individuals of *bosci* indefinite cross bars are present on the upper part of the sides and back. Also, an oblique bar reaches from the eye to the mouth and another bar occupies the base of the caudal fin (fig. 46; based on a rather unusually well developed specimen for its size).

A difference among specimens in the robustness of the body is present, as already shown. That the slender individuals generally are referable to *ginsburgi* is evident

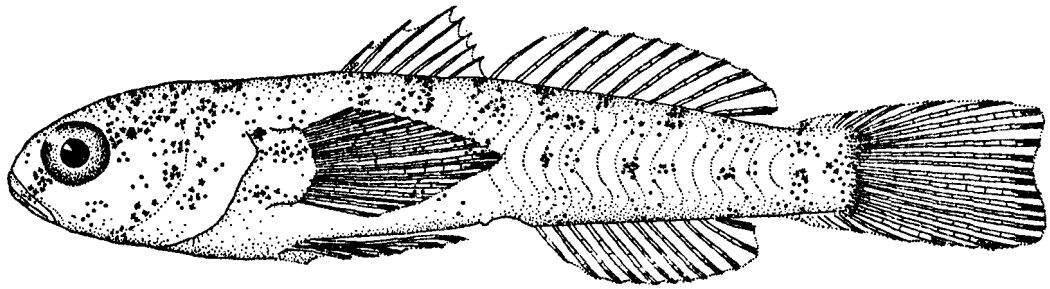

FIGURE 46.—*Gobiosoma bosci*.—From a specimen 10 mm long.

from the presence of two scales on the base of the caudal fin, previously described (p. 548), which *bosci* does not possess (fig. 47).

The development of adult characters at a larger size in *ginsburgi* than in *bosci* suggests that the first-mentioned species might reach a larger size. Judging from the adults taken this is not the case, for on the contrary the largest specimens in the collection are *bosci*.

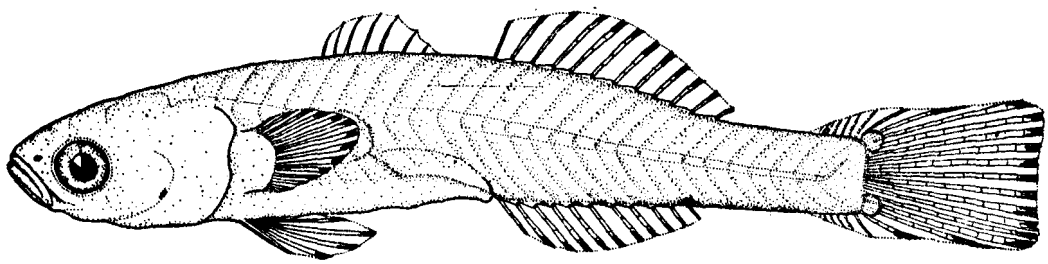

FIGURE 47.—*Gobiosoma ginsburgi*. From a specimen 11 mm long.

Specimens 15 mm long.—At this size *bosci* is robust anteriorly, the depth being contained about 5.3 times in the length to base of caudal fin; the head is depressed and quite as broad as deep; the snout is blunt; the eyes are directed slightly upward; the mouth is small, gently oblique, and terminal to slightly inferior; the maxillary reaches a little past anterior margin of eye; the fins are all fully developed, the margin of the caudal fin now being slightly rounded; and the body is fully pigmented. It is evident, therefore, that fish of this size have acquired nearly all the characters of the adult and are readily identifiable with the grown fish (fig. 48).

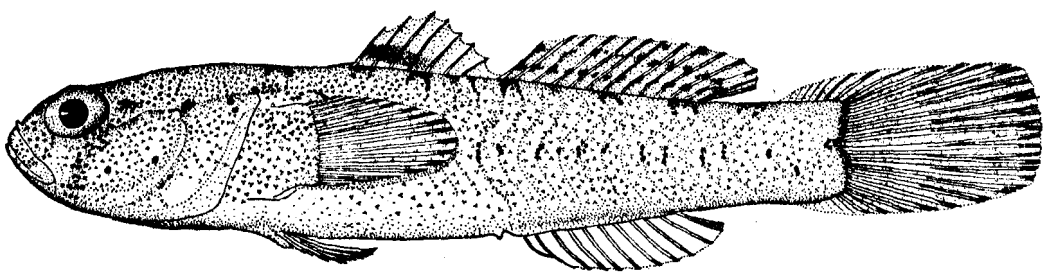

FIGURE 48.—*Gobiosoma bosci*. From a specimen 15 mm long.

It is possible to identify the young at a length of about 15 mm as to species with a reasonable degree of certainty. *G. ginsburgi*, at this size, is notably more slender, the depth being contained in the total length about 6.1 times. The greater length of the ventral disk, which (having attained its highest state of development at about this

size, becoming proportionately shorter later in life) reaches nearly to or even past the vent in some specimens, also is evident. The interorbital space, too, is narrower, being equal to only about half the width of the pupil, whereas in *bosci* it is fully equal to the width of the pupil. Furthermore, *ginsburgi* has two scales on the base of the caudal fin which the other species does not possess. Pigmentation in *ginsburgi* in the specimens at hand has not progressed as far as in *bosci* of the same size. However, a considerable degree of variation in color development appears to exist among both species and the degree of pigmentation may be of no specific importance (fig. 49).

General characteristics of the young.—In general young Gobiosoma, even before fin rays are developed, may be recognized by the rather deep body, by the vertical mouth, by the air bladder which is visible as a clear area through the body wall, and, perhaps most important of all, by the pigment spots present, which remain about the same throughout the larval stages, or until pigmentation becomes general. These spots are black and consist of a single row occupying the median ventral line of the body. Two elongate spots (short lines) are situated under the head and chest, one or two immediately in advance of the vent and several behind the vent, or along the base

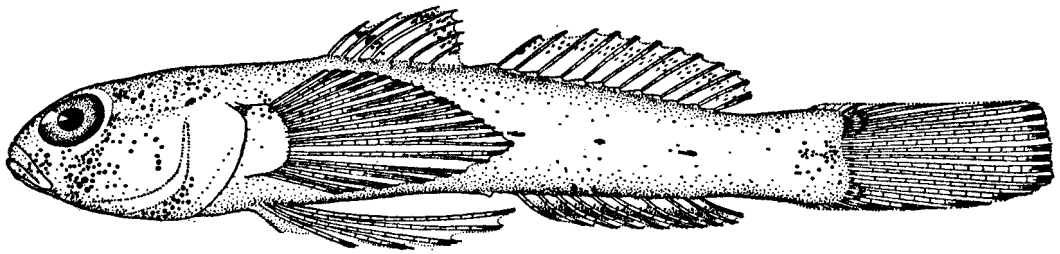

FIGURE 49.—*Gobiosoma ginsburgi*. From a specimen 15 mm long.

of the anal when that member becomes developed, the last spot of the series being at the base of the caudal when that fin becomes differentiated. When the dorsal and anal fins become developed, at a length of about 5.0 mm, the rather low number (generally 11 to 13) of rays in each fin is of much help in identification. At about this size the body becomes quite robust, the head rather broad, the caudal peduncle is short and deep, and the mouth is less nearly vertical than previously. Identification now is much simplified.

DISTRIBUTION OF THE YOUNG

Young Gobiosoma were taken in tow nets and seines in many places and over a wide variety of conditions, ranging from brackish water creeks and ponds, through salt and brackish estuaries, in Beaufort Harbor, along Bogue and Shackleford Banks (both shores) and at sea as far as approximately 15 miles offshore in 10 to 12 fathoms of water. The great majority of the hundreds of specimens collected were taken on the bottom, although occasionally a few appeared in the surface tow. The indications are, then, that the young, like the adults, dwell principally on the bottom. Since the larvae (under about 10 mm in length) could not be separated as to species, the distribution cannot be given separately for each species. Among the young fish that are recognizable, *bosci* was taken only in shallow water and only once at an outside station, that is, about 1 mile off Bogue Banks in a few fathoms of water. *G. ginsburgi*, on the other hand, was taken in both shallow and rather deep water and frequently at offshore stations.

As to time, the larvae are distributed over the entire summer, appearing first in May and a few stragglers as late as December, but they were common to abundant only from June to September.

GROWTH

Growth in Gobiosoma probably progresses moderately fast. It is not always an easy matter, however, to distinguish between those of the 0-class and the older ones, as the sizes intergrade during late summer. Specimens 18 mm long, taken in August, are recognizable as young of the current season and may be among the largest of their year class. Larger examples of the current year, if present, apparently could not be recognized, for they are as fully developed as the adults. Since the spawning season may be said to end, except for an occasional late spawner, by the end of August, it seems unlikely that the largest young become mature during their first summer. However, sexual maturity is reached at a very small size, for we have seen a few gravid females only 23 mm long and many gravid ones from 25 to 30 mm in length. Therefore, the authors are not prepared to state positively that none of the young become mature during their first summer, but they regard it as quite unlikely. It seems highly probable, however, that sexual maturity is reached during their second summer.

MICROGOBIUS HOLMESI SMITH. HOLMES GOBY

Two very closely related species of *Microgobius*, namely *eulepis* and *holmesi*, are recognized from North Carolina. As understood by us *eulepis* has a somewhat more slender and less strongly compressed body than *holmesi*, the depth in the former in the two specimens at hand is contained respectively 6.5 and 7.0 in the standard length, whereas in eight specimens of the latter the depth goes into the length 4.7 to 5.75 times. The mouth in *eulepis* appears to be rather more nearly vertical and the ventral disk is shorter, failing to reach the vent, whereas in *holmesi* the disk usually reaches to or beyond the vent. It is possible that *holmesi* may grow somewhat larger. However, it seems probable that a further study based on a larger number of specimens than is now available may show that the two nominal species intergrade, and in fact are identical. As now understood *eulepis* is very rare at Beaufort, whereas *holmesi* is moderately common. The known range of the two species is coterminous extending from Chesapeake Bay to North Carolina.[5]

The sexes are readily separable in *M. holmesi*, as the male has a row of prominent black spots on the interradial membranes of the anal just below the pale margin of the fin. These spots are entirely missing in the female, in which, as contrasted to the male, the membranes between the longest dorsal spines is jet black distally. In general, the males also have higher fins. The ventral disk, for example, usually reaches the origin of the anal in adult males, whereas it frequently reaches only to the vent in adult females. Furthermore, the females, at least during the breeding season, have a larger anal papilla. Whether similar sexual differences exist in *eulepis* cannot be stated at this time. The two specimens in the present collection in general agree in color with the females of *holmesi*.[6]

It is not surprising that the larval and young Microgobius do not appear to be separable into two species (if indeed more than one species is represented) since the adults of the local representatives are very closely related. Since *M. holmesi* is com-

[5] Since the preparation of this manuscript Isaac Ginsburg, who has made a special study of the American gobies, concluded (Copeia, No. 1, 1934, p. 35) that *M. holmesi* and *M. eulepis* are identical and that both are synonyms of *M. thalassinus*.

[6] Smith (1907, p. 367) presents a very satisfactory illustration of an adult male *Microgobius holmesi*.

paratively common, whereas, *M. eulepis* is very rare, as previously stated, it seems logical to refer all the young, at least tentatively, to *holmesi*.

The locally represented species of Microgobius reach a length of only about 2 inches and they probably are of only slight economic value even as forage fish, because of their comparative scarcity. The rather large number of young taken suggests, however, that the fish may be somewhat more common than is indicated by the scarcity of adults in the collections.

Neither adults nor young were taken from December to February, inclusive. It seems probable, therefore, that these fish leave the local waters during the winter, or that they possibly seek shelter in the mud or sand like Fundulus and probably other minnows.

SPAWNING

The eggs of Microgobius have not been studied. *M. holmesi* with large roe were taken only during the first half of July. That the spawning period of this species is not limited to the month of July is evident, however, from the collection of larvae at hand, as shown subsequently. Smith (1907, p. 368) reported that a female *M. eulepis* distended with nearly ripe eggs was taken at Beaufort on May 18 (1905). No gravid fish of the last mentioned species were seen during the present investigation.

A few young Microgobius, only about 3.0 to 4.0 mm long, were taken as early as March 11 (1929), and a few equally as small were taken as late as November 21 (1927). The larvae were numerous, however, only during July, August, and September. The collection of young Microgobius indicates, therefore, that some spawning takes place as early as March, that it continues throughout the summer, probably extending into the month of November, and that the principal spawning season occurs during July, August, and September.

Larval Microgobius were taken over the entire area in which tow-net collections were made, including Beaufort Harbor, the adjacent sounds and estuaries, and off Beaufort Inlet to Cape Lookout and as far as 12 to 13 miles offshore. It seems reasonable to expect Microgobius to produce eggs which become attached like those of Gobiosoma and Gobionellus, and like those of the various European species that have been studied. If that be true the eggs do not drift and the recently hatched young should be expected to occur somewhere near the place where the eggs were spawned. It seems probable, therefore, that spawning takes place over much of the area in which the larvae were taken.

DESCRIPTIONS OF THE YOUNG

Specimens 1.6 to 4.0 mm long.—Specimens of Microgobius 4.0 mm and less in length generally are difficult to separate from Gobiosoma (figs. 50 and 51). A careful study has revealed no outstanding structural differences in these small larvae, and color marking in preserved specimens, except in rather rare instances, are not of much help until a length of about 4.0 mm is attained. In general, the vent in Microgobius is slightly more anterior in position than it is in Gobiosoma. This difference is evident only when specimens of even size are compared, and it is not readily shown in a table of measurements, because few specimens are straight enough for an accurate measurement and, furthermore, the position of the vent evidently changes with growth. The quotients derived from dividing the caudal portion of the body into the total length to the tip of the notochord, even in specimens varying less than a millimeter in length, do not show a constant difference. An average difference, however, is evident, for in 12 specimens measured of each genus, the caudal portion of the body averages 2.15

times in the length in Microgobius (with a range of 2.02 to 2.3) and 2.24 times in Gobiosoma (with a range of 2.13 to 2.33). Microgobius also has a slightly larger eye. However, the difference is so slight and the size of the eye changes so rapidly with growth that the difference cannot be shown easily in a table of measurements. Furthermore, the size of the eye in the delicate larvae of this size appears to have been affected by the strength of the preservative used which varied considerably with the different lots in the present collection.

The first concrete difference observed between specimens of Microgobius and Gobiosoma are color markings which generally are fairly well developed at a length of 4.0 mm, frequently at 3.0 mm, and occasionally at a somewhat smaller size. Gobiosoma, as explained elsewhere (p. 555), has only a few dark markings on the ventral outline, consisting generally of about two elongate spots on the median ventral line under the head and on the chest, a larger spot or blotch at the vent and a few posterior to the vent, including one (situated at the last rays of the anal fin when that member becomes developed) that is notably larger than the others. Microgobius, on the other hand, has more numerous dark spots on the ventral outline and a double row of rather

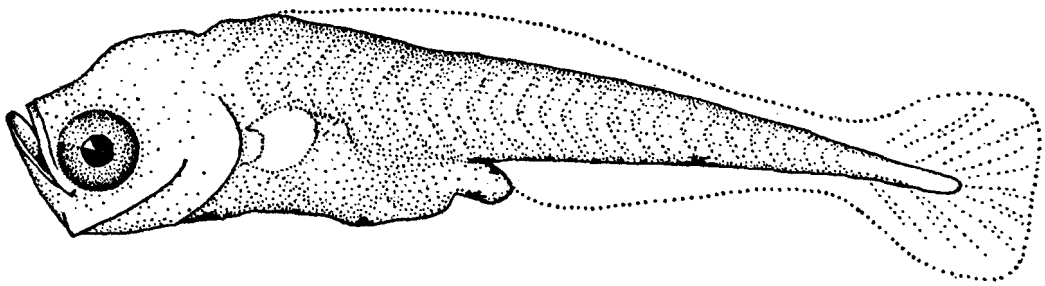

FIGURE 50.—*Microgobius sp.* From a specimen 1.68 mm long.

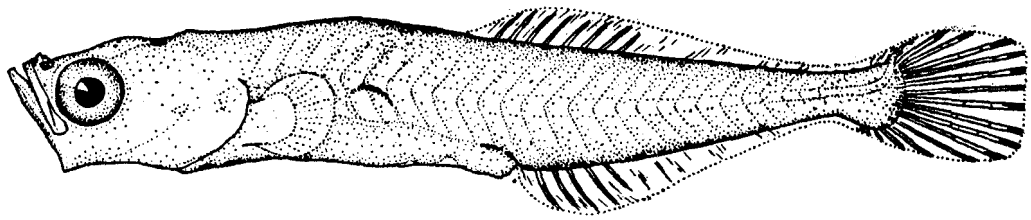

FIGURE 51.—*Microgobius sp.* From a specimen 4.5 mm long.

well outlined dots extending from the vent to near the end of the tail, or nearly to the base of the caudal fin when that member becomes developed. The dark spot at the vent typically forms a short black line lying parallel with the upper margin of the loosely attached hind gut. Occasionally the larvae of Microgobius, only a few millimeters long, have a few dark spots at the nape and two more or less definite rows of minute black dots on the dorsal surface of the caudal portion of the body (fig. 51). No markings of any kind have been noticed on the dorsal outline in the larvae of Gobiosoma.

Specimens 5.0 mm long.—At a length of about 5.0 mm the second dorsal and anal fins usually are sufficiently developed (although some of the posterior rays generally are undifferentiated) to admit of a count accurate enough to establish the fact that these fins are too long for Gobiosoma which has only 11 or 12 rays in each fin. The slightly larger eye in Microgobius remains equally as evident at this size as in the smaller individuals previously described. Differences in color markings

between Microgobius and Gobiosoma which generally become established when the fish reach a length of about 4.0 mm, remain essentially as described in the preceding paragraph (fig. 51).

Specimens 7.5 mm long.—The general shape of the body, as well as the head and mouth remain very similar in Microgobius and Gobiosoma. The slightly larger eye in the first-mentioned genus, noticed in the very smallest larvae at hand, remains evident. The second dorsal and anal fins are quite fully developed and a fairly accurate fin-ray count is obtainable. In addition to the higher fin-ray count (second dorsal and anal each with about 16 or 17 rays) in Microgobius, it is evident now that the caudal peduncle also is shorter. The color markings in Microgobius remain largely as when they first appeared, except that no dark markings are present on the back in any of the specimens examined. The two rows of dark spots along either side of the base of the anal fin are more distinct and each spot is now horizontally slightly elongate (fig. 52).

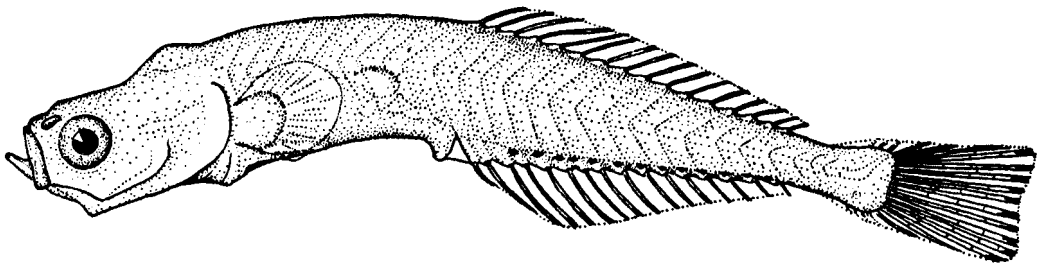

FIGURE 52.—*Microgobius sp.* From a specimen 7.6 mm long.

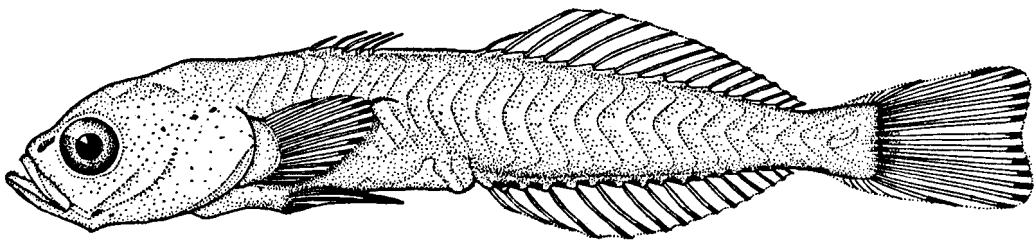

FIGURE 53.—*Microgobius sp.* From a specimen 10 mm long.

Specimens 10 mm long.—A difference in the shape of the body between specimens of Microgobius and Gobiosoma is plainly evident in examples about 10 mm long. In Microgobius the body remains nearly as strongly compressed as in smaller fry, but in Gobiosoma it has become notably more robust anteriorly and the head is broader with a wider interorbital space. Although the mouth remains about equally oblique in the representatives of each genus, it is evident now that the gape in Microgobius is somewhat larger, the maxillary reaching about below the anterior margin of the pupil, whereas it ends slightly in advance of this point in Gobiosoma. All the fins, exclusive of the first dorsal, are now quite fully developed. The ventral disk is long and slender. The caudal fin is shorter than the head and its margin remains straight to slightly concave. The spinous dorsal usually consists of four very slender spines, with two or three of the posterior ones still missing. Pigmentation has advanced only slightly. In addition to the pigment spots described in smaller fish, at least some specimens now have a few dark markings about the mouth, a few on the side of the head and an indication of a slight dark bar at the base of the caudal. Some specimens also have some black dots along the bases of the dorsal fins (fig. 53).

Specimens 15.0 mm long.—The body has become more robust but remains compressed throughout. The eyes are lateral in position; the mouth is large, terminal to slightly superior and nearly or quite as oblique as in 10-mm fish; and the maxillary reaches nearly opposite middle of eye. The fins, including the spinous dorsal, are all well developed. The caudal is strongly rounded to pointed and fully as long as the head; the long ventral disk usually reaches nearly to or even beyond the origin of the anal; the dorsal spines are rather long and slender, the longest ones being equal to or slightly longer than the eye and snout; and the posterior rays of the second dorsal and anal frequently reach the base of the caudal when deflected. Pigmentation has progressed considerably, for nearly the entire body is covered with minute dark points. The color markings along the ventral and dorsal outlines, described for smaller fish, in most specimens have become somewhat less pronounced (fig. 54).

It is evident from the foregoing description that nearly all the structural characters of the adult, exclusive of scales, are developed at a length of 15.0 mm and identification is comparatively easy. The scales first appear when the fish is about 18 mm long and they become evident on the caudal peduncle first, and from there squamation proceeds forward until it is virtually completed when the fish reaches a length of about 23 mm.

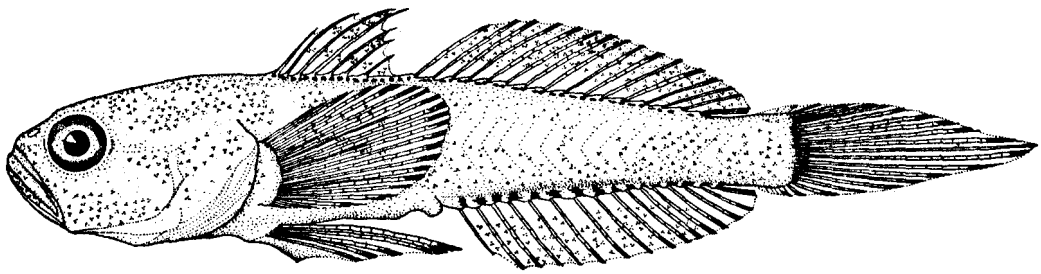

FIGURE 54.—*Microgobius sp.* From a specimen 15 mm long.

It is interesting that in specimens from about 16 to 25 mm long the ventral disk is proportionately longer than in larger fish, generally reaching to or a little beyond the origin of the anal at this size.

Microgobius and Gobiosoma, at a length of about 15 mm, differ strongly. Microgobius now has a more compressed body; a much narrower and deeper head with the eyes fully lateral; the mouth is much larger, more strongly oblique, and terminal to slightly, superior; and the fins are much higher than those in Gobiosoma.

DISTRIBUTION OF THE YOUNG

It already has been stated under the section of this paper dealing with spawning that the larvae of Microgobius were taken virtually over the entire area in which tow net collections were made. This area includes Beaufort Harbor, the adjacent sounds and estuaries, and at sea, 13 to 15 miles offshore. The variation in depth over this area ranges from a few feet to 12 fathoms.

The larvae were taken in inside waters 37 times and offshore 20 times. The inside catches, besides being more numerous, generally contained a larger number of fish per catch. A total of about 90 larvae was taken outside, whereas a total of about 760 larvae was taken inside. Although a somewhat greater number of hauls probably was made in the inside waters, that difference would not offset the great difference between the number of larvae taken in inside and outside waters. It may be con-

cluded, therefore, that young Microgobius are decidedly more numerous in Beaufort Harbor and adjacent sounds and estuaries than they are off Beaufort Inlet.

In about an equal number of surface and bottom hauls Microgobius was taken at the surface 13 times and on the bottom 45 times. Young Microgobius, like the adults, therefore, are primarily bottom dwelling. With respect to distribution over time, a few young appeared in the catches in March, April, and May, they become rather numerous in June, and abundant in July, August, and September; only a few were taken in October and November, and none from December to February.

GROWTH

The largest young of the season were caught in September and had reached a length of 32 mm. It seems quite certain that such individuals will reach an adult size of 40 to 50 mm, and sexual maturity, during their second summer. However, some of the young taken with the large ones mentioned are only about 5.0 mm long. It seems doubtful that such individuals will attain an adult size and sexual maturity before their third summer. It may be concluded, therefore, that some of the larger and faster-growing individuals certainly reach an adult size and sexual maturity during their second summer when about a year old. Others almost certainly are not full grown, nor sexually mature, before their third summer.

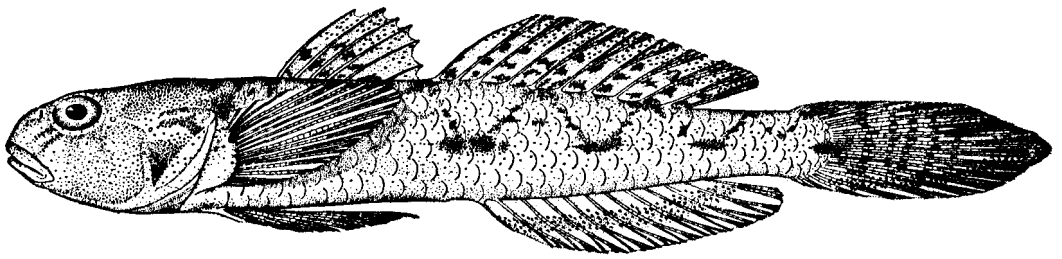

FIGURE 55.—*Gobionellus boleosoma.* From an adult 34 mm long.

LOCAL SPECIES OF GOBIONELLUS

A single species of Gobionellus, namely, *boleosoma*, heretofore has been recorded from the coast of North Carolina. This fish was assigned to *Ctenogobius stigmaticus* by Smith in "The Fishes of North Carolina" (1907, p. 365). However, Ginsburg (1932, p. 23) in an exhaustive study of extensive collections in the Bureau of Fisheries and the National Museum failed to find *stigmaticus* north of Florida This investigator assigned the common Atlantic coast species of scaled goby (which ranges from North Carolina at least as far south as Panama) to *boleosoma* and places it in the genus Gobionellus. Mr. Ginsburg's nomenclature has been adopted by the present writers. Attention is called to the fact that Smith's illustration (loc. cit., fig. 167) is not correct for *boleosoma*. The figure probably represents an entirely different species. Accordingly, a drawing of an adult based on a specimen from Beaufort has been prepared (fig. 55).

A few representatives of a second species of Gobionellus, namely, *shufeldti*, recently were taken in fresh water in Newport River. *G. shufeldti* according to Ginsburg (1932, p. 14) differs from *boleosoma:* (*a*) In having one or more rows of scales on the median line of the back in advance of the first dorsal (in one specimen from Beaufort, assigned to this species, however, the median line of the back is naked as in *boleosoma*); (*b*) in having a slightly higher average number of rays in the dorsal and anal

fins, the typical number being dorsal 12, anal 13, as compared with dorsal 11, anal 12 in *boleosoma;* (*c*) in having no definite dark shoulder spot, nor V-shaped dark markings along the sides whereas these color markings generally are quite evident in *boleosoma;* (*d*) in reaching a larger size (according to the few specimens at hand from North Carolina the maximum size attained by *shufeldti* is about 70 mm, while the largest specimen of *boleosoma*, of which many specimens have been collected, is only 55 mm long); (*e*) in inhabiting fresh and slightly brackish water, whereas *boleosoma* ranges from salt to brackish water. If the young of *shufeldti* are present in the collection, they are confused with *boleosoma.*

Two other species of gobies which Mr. Ginsburg (loc. cit.) also places in the genus Gobionellus, not as yet recorded from Beaufort, have been taken there recently, namely, *oceanicus* and *hastatus.* These species both differ from the other local Gobionellus in the more numerous rays in the dorsal and anal fins, the usual number in the dorsal being 14 and in the anal 14 or 15. The two species differ from each other largely in the number of scales in a lateral series, *hastatus*, according to 10 specimens from Beaufort, has 81 to 89, and *oceanicus*, according to 3 specimens from Beaufort, has 61 to 68 scales. The counts agree with those made by Ginsburg (1932, p. 39) based on specimens from Panama, Puerto Rico, Cuba, Florida, and Louisiana. The young of at least one of these species apparently also are included in the present collection.

GOBIONELLUS BOLEOSOMA (JORDAN AND GILBERT). SCALLOP FISH

The young of Gobionellus are much less numerous in the collection than those of Gobiosoma and Microgobius, but they are not rare, as 177 larvae are at hand. Adults of *Gobionellus boleosoma* have been taken more frequently locally than those of Microgobius, but much less often than Gobiosoma. The local distribution of adult *G. boleosoma* seems to be rather general. They were taken most frequently with seines in shallow water and on muddy bottom, both in salt and slightly brackish water, including in one instance a small drainage ditch. In somewhat deeper water they were secured only twice, once in the channel of Newport River, a few miles north of the laboratory, and again at sea off Bogue Banks.

Many variations or differences have been noticed among adults from Beaufort. In some specimens the body is more slender than in others. Also, the size of the mouth, the teeth, and the eyes varies. The median portion of the abdomen is variously scaled or naked and in some specimens the caudal fin is much longer than in others. Most of these differences certainly are associated with sex. In general, large males are more slender than females, and they have larger eyes, more prominent teeth, and a longer and more pointed caudal fin.

The maximum size attained by this goby is about 55 mm. It no doubt is preyed upon by larger predatory fishes, but it evidently is not abundant enough to be of much importance as a forage fish. Therefore, its economic value must be very slight locally.

Gobionellus boleosoma is present in the vicinity of Beaufort throughout the year, as both adults and young have been taken occasionally during the winter months as well as during the summer. Therefore, it evidently does not migrate, and no evidence indicating that it seeks protection from the cold by burying itself in mud or sand has been secured.

SPAWNING

Ripe or nearly ripe fish have been taken locally during July and August. Very small larvae (2.5 to 5.0 mm long), however, were taken as early as May 15 (1929),

and as late as November 3 (1928). The young were not abundant at any time. The largest number of specimens was secured during July and August, which may represent the principal spawning period.

It is not definitely known where this goby spawns. The eggs are demersal and bear adhesive threads, which suggests that spawning probably takes place where there are sufficient objects in the water for the attachment of the eggs. Small larvae, only a few to several millimeters long, were taken virtually over the entire area in which towings were made. This area includes Beaufort Harbor, and the neighboring sounds and estuaries, as well as the waters off Beaufort Inlet, extending 12 to 15 miles offshore. It seems probable, therefore, that spawning takes place both in the inside protected waters and along the outside shores.

DESCRIPTIONS OF THE EGGS AND YOUNG

Eggs.—The eggs were described by Kuntz (1916, pp. 426–428) on the basis of samples stripped from fish taken and identified by the present senior author as *Ctenogobius stigmaticus*, following Smith (1907, p. 365). The following descriptions of the eggs and their development is a condensed account, based on Kuntz's paper. The illustrations of the development of the egg and the figure of the newly hatched fish are also from Kuntz.

The eggs are yellow in color, highly translucent, somewhat irregular in shape and have a diameter of about 0.3 mm. Their specific gravity is only slightly greater than sea water. The egg membrane is thin and delicate and usually drawn out into a blunt apex at the insertion of the "peduncle", that is, at the insertion of the gelatinous threads. The egg contains a relatively enormous amount of protoplasm and very little yolk (fig. 56).

The fully developed blastodisc covers about half the area of the surface of the yolk. The first cleavage act, at ordinary summer laboratory temperature, takes place in about 30 minutes and the successive cleavages occur in rapid succession. The first cleavage plane cuts deep into the blastodisc and the first cells usually, although not always, are quite symmetrical. Until the 16-cell stage is reached the cells are in a single row. Thereafter they become heaped up on one side of the yolk (figs. 57, 58, and 59).

As cleavage advances the blastoderm becomes more distinctly dome-shaped and it soon becomes thickest at the periphery. The peripheral growth of the blastoderm advances and the yolk becomes entirely engulfed, the blastopore closing within 6 hours after fertilization (figs. 60 and 61).

Soon after the closing of the blastopore a distinct linear thickening of the blastoderm, representing the axis of the future embryo, grows anteriorly from the blastopore. As the differentiation of the embryonic axis advances the anterior region of the differentiated area of the blastoderm becomes distinctly broader than the posterior region. That is, the differentiation of the embryo begins in the anterior or head region and advances posteriorly (fig. 62).

The subsequent growth of the embryo advances rapidly. Within 11 hours after fertilization the embryo is well formed and it shows 10 to 12 somites. An hour later the embryo almost completely encircles the egg and the posterior region of the body is already free from the greatly reduced yolk mass. The embryo, although highly transparent, is marked by small areas of delicate pigment. It now more than encircles the periphery of the egg membrane, and the entire period of incubation at laboratory temperature occupies not over 18 hours (figs. 63 and 64).

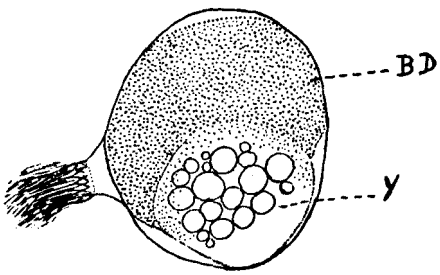

FIGURE 56.—*Gobionellus boleosoma*. From egg with undivided blastodisc, BD; yolk, Y. (Drawn by Effie B. Decker. After Kuntz.)

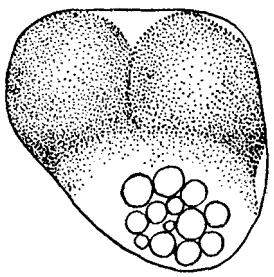

FIGURE 57.—*Gobionellus boleosoma*. From egg with 2-cell blastoderm. (Drawn by Effie B. Decker. After Kuntz.)

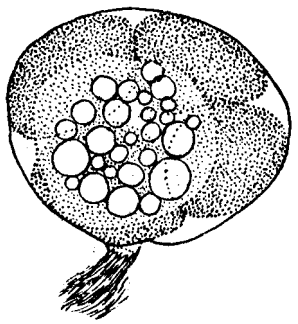

FIGURE 58.—*Gobionellus boleosoma*. From egg with a 4-cell blastoderm. (Drawn by Effie B. Decker. After Kuntz.)

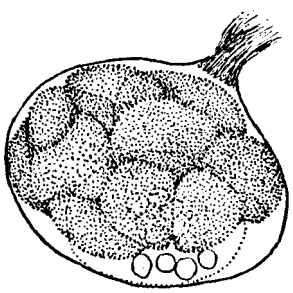

FIGURE 59.—*Gobionellus boleosoma*. From egg with a 16-cell blastoderm. (Drawn by Effie B. Decker. After Kuntz.)

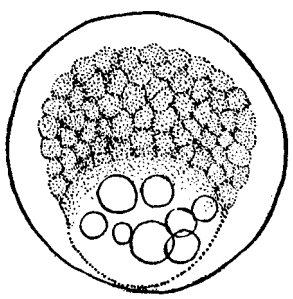

FIGURE 60.—*Gobionellus boleosoma*. From egg with blastoderm of many cells. (Drawn by Effie B. Decker. After Kuntz.)

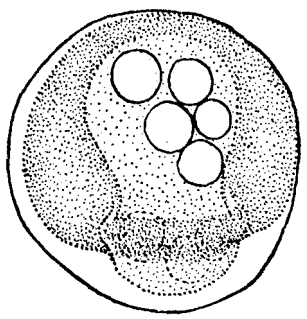

FIGURE 61.—*Gobionellus boleosoma*. From egg with blastoderm growing around yolk shortly before closing. (Drawn by Effie B. Decker. After Kuntz.)

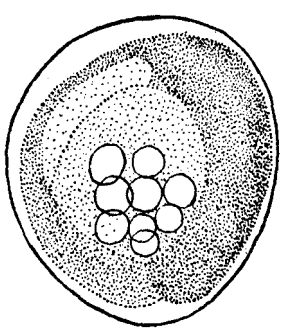

FIGURE 62.—*Gobionellus boleosoma*. From egg showing an early stage in the differentiation of the embryo. (Drawn by Effie B. Decker. After Kuntz.)

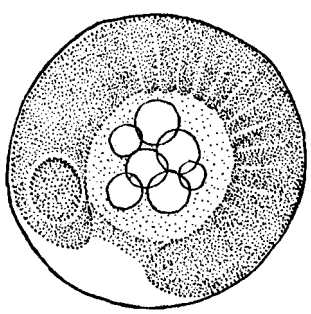

FIGURE 63.—*Gobionellus boleosoma*. From egg with well-differentiated embryo. (Drawn by Effie B. Decker. After Kuntz.)

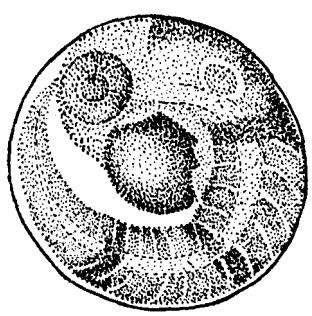

FIGURE 64.—*Gobionellus boleosoma*. From egg with large embryo, just before hatching. (Drawn by Effie B. Decker. After Kuntz.)

The newly hatched fish, 1.2 mm long.—The following account of the newly hatched fish has been compiled from Kuntz's description (loc. cit.) based on a fresh specimen: It is exceedingly delicate, and only about 1.2 mm long. It is highly transparent and marked by small areas of delicate yellow pigment on the dorsal surface of the head, over the vent and with a vertical band about half way from the vent to the tip of the tail. The vent is located slightly in advance of midbody length. The dorsal and ventral finfolds are continuous and the depth of each fold is equal to or greater than the depth of the body posterior to the vent (fig. 65).

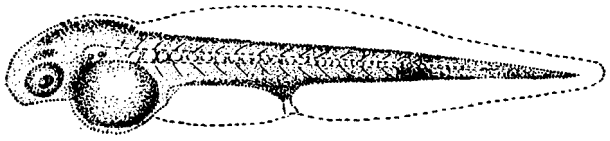

FIGURE 65.—*Gobionellus boleosoma.* From newly hatched fish, length 1.2 mm. (Drawn by Effie B. Decker. After Kuntz.)

Kuntz was able to keep the delicate larvae alive in the laboratory only a few hours, and he did not have any advanced larval stages. Descriptions and illustrations of the subsequent development of the young are based on preserved specimens contained in the collection studied by the present writers.

Specimens 2.5 mm long.—The larvae of this genus are extremely slender and this character generally distinguishes them from those of Gobiosoma and Microgobius. The caudal portion of the body is especially slender and at this size notably longer than the rest of the body. The head is rather broad, its width being nearly as great as its depth; the mouth is almost vertical and very close in front of the moderately large protruding eyes. The air bladder is plainly visible as a round or slightly elongate clear area within the abdominal cavity; dorsally of the air bladder the dark peritoneum is visible (and at a slightly larger size the black peritoneum at this point becomes very pronounced and forms a recognition mark). Fins are undeveloped, except for a slight indication of rays in the fin fold around the tip of the notochord (fig. 66).

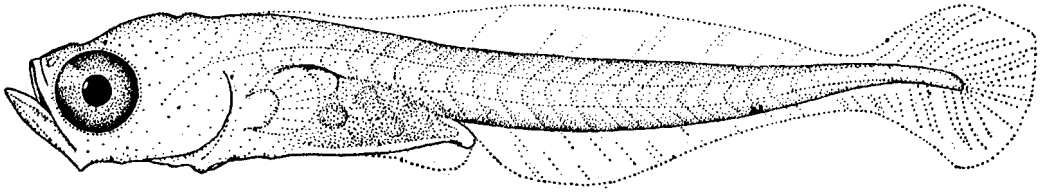

FIGURE 66.—*Gobionellus boleosoma.* From a specimen 2.5 mm long.

Specimens 3.5 mm long.—The fish has become only slightly more robust than it was at a length of 2.5 mm. The mouth remains very close to the eyes, but has become slightly less vertical. Pectoral fins have appeared as tufts of membrane without rays. The notochord remains straight, with indications of rays around its tip. The soft dorsal and anal bases are in part evident, but no definite rays have developed. On some specimens a few very small dark spots are present along the ventral outline of the body and tail. The black peritoneum over the air bladder is moderately distinct and has acquired a crescent shape which is characteristic of the young of this species (fig. 67).

Specimens 5.0 mm long.—Little change has taken place in the shape of the head and body since a length of 3.5 mm was attained. The mouth has become slightly

less strongly oblique, but remains superior, and the gape is proportionately further removed from the eye. The notochord is bent upward sharply at the tip, giving the tail a heterocercal appearance. The caudal fin is fully formed, with definite rays, and has a nearly straight posterior margin. The soft dorsal and anal contain some well-developed rays, but a definite fin ray count is not yet obtainable. The pectorals remain as tufts of membrane, and the ventral fins (disk) are not yet evident. Pigmentation has made little progress. It now consists of two or three short, narrow, dark lines on the chest, a very small dark spot at the vent and a slightly larger one at or near the end of the anal base. The crescent-shaped dark area over the air bladder, visible through the abdominal wall, is prominent and serves as a ready recognition mark (fig. 68).

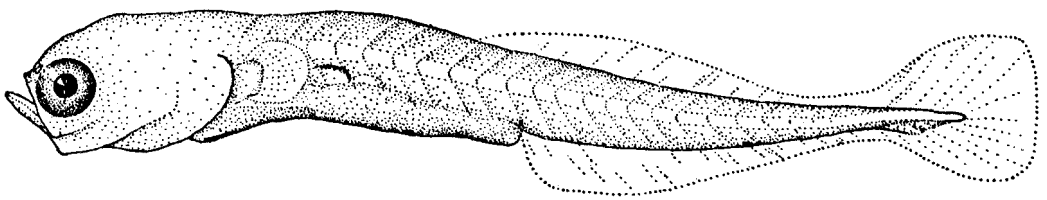

FIGURE 67.—*Gobionellus boleosoma.* From a specimen 3.7 mm long.

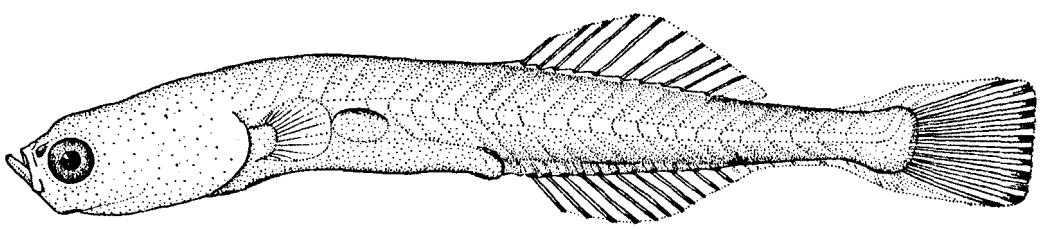

FIGURE 68.—*Gobionellus boleosoma.* From a specimen 5.1 mm long.

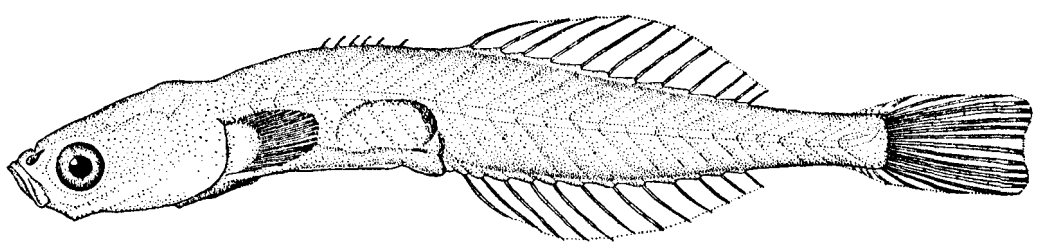

FIGURE 69.—*Gobionellus boleosoma.* From a specimen 7.5 mm long.

Specimens 7.5 mm long.—The body has increased somewhat in depth but remains comparatively very slender, the depth being contained in the length to the base of the caudal about 7.5 to 8.0 times. Some progress in the development of the fins has been made. It is now possible, in at least some specimens, to make a fairly accurate count of the soft dorsal and anal rays, each fin having 11 to 13 rays. The caudal fin is well developed and its margin is straight to slightly concave. The pectoral fins have indications of rays and the base of the ventral disk is just becoming evident. The spinous dorsal is undeveloped, or in some specimens just becoming evident. The notochord, sharply bent upward at its tip, remains visible. A crescent-shaped dark area over the air bladder is quite distinct. This dark area is visible with the unaided eye in somewhat larger specimens and is a definite aid in identification. Pigmentation on the body remains virtually as in 5.0 mm fish (fig. 69).

Specimens 10 mm long.—The body remains much more slender than in other local genera of gobies, and fully as slender as in 7.5-mm fish, the depth being contained in the length to base of caudal about 6.5 to 8.0 times. The mouth is still quite oblique, nearly terminal and small, the maxillary scarcely reaching opposite anterior margin of eye. The fins are all developed. However, the spines of the first dorsal usually remain short and slender. The ventral disk is fully developed and long, reaching about three-fourths of the distance from its base to the vent. The pectoral fins, too, are rather long but do not reach quite as far back as the ventral disk. The margin of the caudal fin is straight to rounded. The crescent-shaped dark area over the air bladder has become quite pronounced and in some specimens is clearly evident with the unaided eye. Pigmentation has made no definite advancement (fig. 70).

Specimens 13 mm long.—The body remains extremely slender, the depth being contained in the length to base of caudal about 10 times. The head has become slightly broader and somewhat depressed. The mouth is small, oblique, and terminal, and the maxillary scarcely reaches the vertical from the anterior margin of eye. The air bladder is visible microscopically, but the crescent-shaped black area above it (that is, the dark peritoneum), very evident in somewhat smaller fish, is quite indistinct and somewhat changed in shape. The spinous dorsal now is fully developed and it is plain that the last two spines are much further apart than the others, which appears to be characteristic of the local species of the genus. The pectorals and ventral disk are long, but do not extend as far back on the body as in somewhat smaller fish.

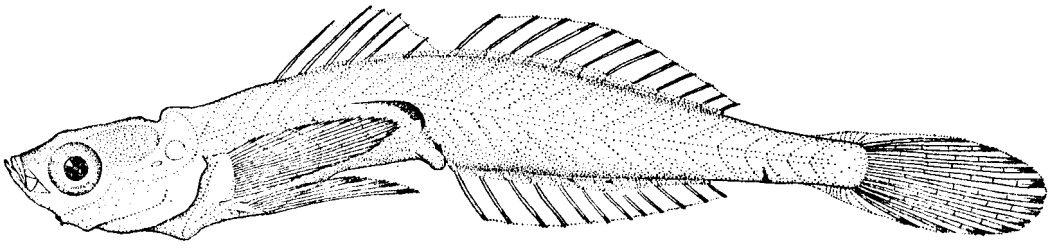

FIGURE 70.—*Gobionellus boleosoma*. From a specimen 10 mm long.

However, there appears to be some variation in this respect among individuals. The caudal fin is about as long as the head and its margin is slightly convex. Progress in pigmentation varies greatly. In a 13-mm specimen it has progressed little further than in the 10-mm fish, described in the foregoing paragraph. However, there is at hand one specimen 11 and another 12 mm long which have some dark markings on the head, including indications of a dark oblique bar between the eye and the mouth (characteristic of the adult); scattered dark dots on the back and along the ventral edge of the abdomen, a more definite series of black spots on the base of the anal, and with indications of wavy dusky bars on the caudal fin, as in the adult.

No perfect specimens from Beaufort suitable for drawing are at hand. Furthermore, the differences between fish 10 mm and 13 mm long are slight, as pointed out in the description. For these reasons no illustration of the size described in the foregoing paragraph is offered.

Unfortunately specimens between 13 and 22 mm in length (the latter being adults) are not at hand. The fish described in the foregoing paragraph are quite immature, yet sufficient adult characters are developed to make identification fairly easy and certain. The characters that are especially helpful in the identification of specimens of the size described in the foregoing paragraph are: (*a*) The fin-ray counts (dorsal and anal each having 11 to 13 rays), which may be made accurately, (*b*) the

greater distance between the last two dorsal spines than between the others, (*c*) the long pectoral fins and ventral disk (reaching about two-thirds the distance from their bases to vent), (*d*) the general shape of the head and the small mouth (the maxillary scarcely reaching the eye). The head is still somewhat less strongly depressed than in the adult, the snout more pointed and the mouth more oblique, (*e*) the elongate body, which remains more slender than in the adult (depth in the length to base of caudal in the adult about 5.0 to 6.25 times, in 13 mm young about 10.0 times), and (*f*) the characteristic color developed on some specimens, especially the oblique bar between the eye and the mouth and the wavy dusky bars on the caudal fin. However, a series of about five slightly elongate dark spots along the middle of the side, the last one being situated on the base of the caudal, which are quite characteristic of the adult, are undeveloped in the 13 mm specimens at hand.

Gobionellus boleosoma, at about 13 mm in length, differs from *Gobiosoma bosci* and *ginsburgi*, and *Microgobius holmesi*, of similar length, very prominently in the much more slender body, as well as in the smaller mouth, and in the long space between the last two dorsal spines.

DISTRIBUTION OF THE YOUNG

The young were taken in tow nets over nearly the entire area in which collections were made, including Beaufort Harbor, the adjoining sounds and estuaries, and off Beaufort Inlet to Cape Lookout and at stations as far as 13 to 15 miles offshore. They were taken 22 times at offshore stations and 17 times in the inside waters. The young appeared in surface hauls only 6 times and in bottom hauls 33 times, indicating that the young, like the adults, dwell chiefly on the bottom. We also have many specimens taken by the United States Fisheries schooner *Grampus* in 1917 from Florida to Texas.

The distribution of the young as to time differs from that of the other common gobies at Beaufort in that some individuals, 13 mm and less in length, were taken throughout the year, while the other species are not present in collections made during the winter months. Very small larvae, under 5.0 mm in length, were taken from May to November.

GROWTH

The scarcity of the species and the long spawning season resulted in capturing comparatively few young, which vary widely in size. It is consequently impossible from the few specimens taken to determine definitely the rate of growth. The presence in the tow of larvae only about 8.0 mm in length during March and April, which evidently were hatched the previous summer or fall, suggests a slow rate of growth, at least during the winter months. Sexual maturity apparently is reached at a length of about 25 to 30 mm, but it is not known how old a fish is when it attains that length.

GOBIONELLUS OCEANICUS (PALLAS). OCEAN GOBY

In addition to the young of *G. boleosoma* described in the forgoing pages, at least one other species is represented. Most of the specimens of the second group are large enough to permit a fairly accurate count of the dorsal and anal rays which is about the same for each fin, namely, 14 or 15 (rarely 13). This number of rays suggests that the specimens either are *oceanicus* or *hastatus*. The adults of these species are separable by the difference in the number of scales in a lateral series (see p. 565). However, no scales are developed in the young at hand. Therefore, the specimens cannot be definitely identified at this time and are only tentatively referred to *oceanicus*.

The specimens of the second group of Gobionellus differ from the first one, furthermore, in having a more slender body and in the somewhat more retarded

development. For example, in specimens of *boleosoma* 10 mm long the spinous dorsal is equally as well or even better developed than in specimens of *oceanicus* (?) 15 mm long. Specimens of this group of Gobionellus, with the very slender body, range in length from 9.0 to 18 mm. If smaller ones are contained in the collection they were not recognized as different from *boleosoma*. Only 15 specimens were collected in the vicinity of Beaufort. In addition 23 specimens, taken by the United States Fisheries schooner *Grampus* off the eastern coast of Florida and in the Gulf of Mexico, are at hand.

SPAWNING

The time and place of spawning remain largely undetermined, as the eggs and very small larvae have not been taken. Since two of the common local species of gobies (*Gobiosoma bosci* and *Gobionellus boleosoma*) are known to spawn in the usual habitat occupied by the adults, it seems reasonable to expect this species to do likewise. However, the number of adults taken locally is too small to admit of a definite statement in regard to their habitat. The examples at hand were taken on rather muddy bottom, two in Newport River and one along the shores of Pivers Island. The young were collected at Beaufort over such a long period of time that it is impossible to judge definitely when spawning takes place, the specimens having been taken in February, April, August, September, October, November, and December. Since these young generally were taken with those of *G. boleosoma*, a species known to spawn throughout the summer, it seems probable that the spawning period of *G. oceanicus* may extend over the same period of time.

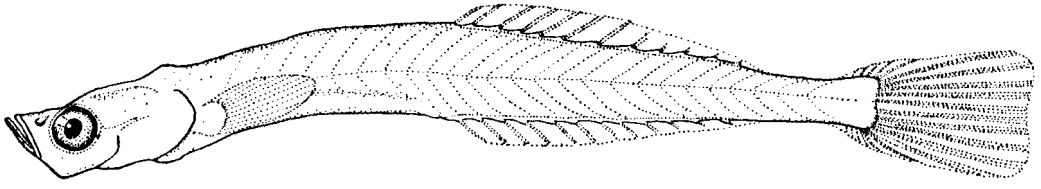

FIGURE 71.—*Gobionellus oceanicus*. From a specimen 9 mm long.

DESCRIPTIONS OF THE YOUNG

Specimen 9.0 mm long.—Only one specimen of this, the smallest size recognized, is at hand. It was taken by the *Grampus* at latitude 27°39′, longitude 83°36′ on January 24, 1917. This fish differs from *boleosoma* of the same size in the extremely slender body, the depth being contained in the standard length about 9.7 times (as compared with 7.3 times in *boleosoma*). The bases of the dorsal and anal rays are visible in part, but the rays themselves are almost wholly undeveloped. Twelve or 13 fulcra can be counted in each fin, the posterior ones being feebly and very probably in part undeveloped, whereas in *boleosoma* the rays are quite well formed at this size. Pectoral fins are evident, although without definitely formed rays. The ventral disk, already well formed in *boleosoma* of this size, is not evident (fig. 71).

Specimens 14 mm long.—The body remains very slender, the depth being contained in the standard length about 9.0 times. The soft rays of the dorsal and anal are now well developed and easily enumerated, each fin having 14 or 15 rays. However, generally only two or three spines have become visible in the first dorsal, this fin being scarcely as well developed at this size as it is in specimens of *boleosoma* only 10 mm long. The pectoral fins are well developed and have definite rays, but the ventral disk is rudimentary, whereas it is long and prominent in specimens of *boleosoma* when only 10 mm long (fig. 72).

Specimen 18 mm long.—Only one specimen of this size is at hand, which is the largest post larva in the collection. Development has progressed rather slowly and is about in the same stage as a *boleosoma* of a length of 10 to 12 mm. The body has become rather more robust, the depth being contained in the length to base of caudal about 8.0 times. The spinous dorsal is partly developed, five slender spines being present, whereas in the fully developed individuals the normal number is six. The ventral disk is quite well formed and reaches about half the distance from its base to the vent. This specimen, like the smaller ones, is void of color. The transparent air bladder with the dark membrane over it remains visible through the abdominal wall (fig. 73).

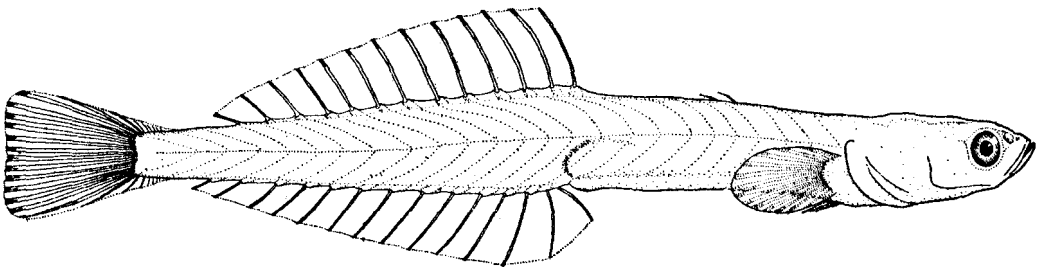

FIGURE 72.—*Gobionellus oceanicus.* From a specimen 14 mm long.

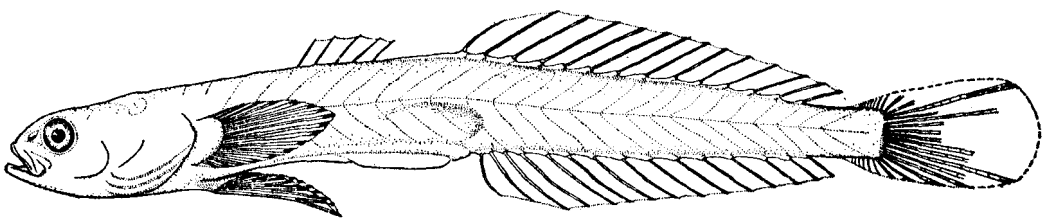

FIGURE 73.—*Gobionellus oceanicus.* From a specimen 18 mm long.

DISTRIBUTION OF THE YOUNG

The number of specimens taken is entirely too small to permit drawing a conclusion in regard to the distribution of the young of this species. Eight of the 14 specimens from Beaufort were collected off Beaufort Inlet, while the others were taken in the harbor and a neighboring estuary. The 23 specimens collected by the *Grampus* were all taken offshore. The young, therefore, may be expected along the outer shores, as well as in inside waters.

Only two specimens were taken in surface towings at Beaufort, all the others appearing in bottom hauls. Of the 23 specimens collected by the *Grampus* 21 were taken on the bottom. This information is missing for the other specimens. It seems probable, therefore, that the young may occur at any depth in the water inhabited, but that they are most commonly on the bottom. Nothing can be reported at this time concerning the rate of growth.

FAMILY BLENNIIDAE. THE BLENNIES

Three species of blenny, namely *Hypsoblennius hentz*, *Hypleurochilus geminatus*, and *Chasmodes bosquianus* are common on the coast of North Carolina. The development of the eggs of all these species has been studied, and also the development of the young of the first two named. The young of *C. bosquianus*, a species less common

at Beaufort than the other two, remain unknown. A fourth species, *Blennius stearnsi*, was recorded from Beaufort by Radcliffe (1914) without comment. This species was not seen by us.

The adults are not especially difficult to identify, yet care is required as the species superficially are not strikingly different. This is true especially of young adults. Accordingly the following key, embodying characters thought to be readily usable and dependable, is offered.

KEY TO THE GENERA AND SPECIES

a. Head short, deep; *forehead very steep* (nearly vertical); snout scarcely projecting. Mouth small; maxillary scarcely reaching middle of eye. *Canine teeth wanting.* P. 14, rarely 13 or 15; D. XII, 14 or 15; A. II, 16 ..... *Hypsoblennius hentz*

aa. Head somewhat longer, not quite as deep; forehead not very steep, strongly convex; snout projecting moderately. Mouth small; maxillary reaching only slightly past anterior margin of eye. *Each jaw with a strong canine tooth posteriorly, near angle of mouth.* P. 14; D. XI to XIII, 14 or 15; A. II, 16 or 17 ..... *Hypleurochilus geminatus.*

aaa. Head notably longer and not as deep; forehead not steep, rather gently convex; snout strongly projecting, very pointed. *Mouth large; maxillary reaching to or past posterior margin of eye.* Canine teeth wanting. P. 12, rarely 11; D. XI or XII, 18; A. II, 17 or 18 ..... *Chasmodes bosquianus.*

THE CHARACTERS OF THE EGGS AND NEWLY HATCHED YOUNG

The eggs of the three species of blennies discussed in this report are not difficult to recognize. That is not true for the young, however, which are very similar in appearance. The distinguishing characters of the eggs and newly hatched larvae are shown in the parallel comparison which follows. The distinguishing characters of young *Hypsoblennius hentz* and *Hypleurochilus geminatus* taken in the tow are described in the text. Since young *Chasmodes bosquianus* were not taken in collections made in nature, our present knowledge of its development ends with the newly hatched larvae.

DISTINGUISHING CHARACTERS

EGGS

Hypsoblennius hentz	*Hypleurochilus geminatus*	*Chasmodes bosquianus*
Moderately small, about 0.77 mm in diameter. Eggs with violet or old rose colored bodies (disappearing in advanced stage of development) and yellow oil globules in yolk.	Small, about 0.69 mm in diameter. Eggs with purple spots (disappearing in advanced stage of development) and bright golden yellow to orange oil globules in yolk.	Large, about 1.04 mm in diameter. Eggs with pale yellow oil globules, never with violet or purple bodies in yolk.

NEWLY HATCHED YOUNG

Larvae moderately small, average length about 2.7 mm. Myomeres behind vent about 23.	Larvae small, average length about 2.4 mm. Myomeres behind vent about 24.	Larvae large, average length about 3.66 mm. Myomeres behind vent about 28.
Black markings on abdomen (yolksac) generally scattered, usually not especially concentrated at upper edge of abdominal mass.	Black markings mostly concentrated at upper margin of abdominal mass.	Black markings mostly concentrated at upper margin of abdominal mass.
Lower two-thirds or so of inner surface of pectoral fin membranes with black chromatophores.	Pectoral fin membranes at most with only a few black chromatophores at base.	Lower two-thirds or so of pectoral fin membranes with black chromatophores.
An elongate branching black spot under auditory vesicle.	An elongate branching black spot under auditory vesicle.	No black under auditory vesicle.

A COMPARISON OF THE EGGS AND YOUNG OF SOME AMERICAN AND EUROPEAN BLENNIES

The eggs of the three species of blennies from North Carolina, forming the basis for the present report, all have an adhesive disk or foot by which they become firmly attached to objects in the water at the time they are laid, remaining attached throughout the period of incubation. The eggs of the European blennies, *Blennius pholis*, *B. ocellaris*, and *B. gattorugine*, all have similar organs of attachment (Lebour, 1927). In all these species, both American and European, the eggs are laid in a single layer. The adhesive organs generally, if not always, have a greater diameter than the eggs and keep them from touching each other. In another European blenny, *B. montagui*, the eggs are described (Guitel, 1893) as having a number of glutinous threads which attach them to the under side of stones. The eggs are said to press against each other, although presumably laid in a single layer.

Such distantly related forms as *Pholis gunnellus* (Ehrenbaum, 1909), *Anoplarchus purpurescens* (Schultz and De Lacy, 1932) and *Heterostichus rostratus* (Barnhart, 1932), formerly assigned to the family Blenniidae, but now referred to separate and distinct families, also have eggs which adhere. The adhesive organ, if any, for the first mentioned species are not described, it merely being stated that the eggs adhere in clusters. The egg of the third species has a number of adhesive threads like the one of *Blennius galerita*. The eggs of the two last-mentioned species, therefore, resemble those of the silversides (Menidia) in the structure of their adhesive organs.

The eggs may be attached to mollusk shells, particularly to the inner surface of the valves of empty oyster shells, as in *Hypsoblennius hentz*, *Chasmodes bosquianus*, and *Blennius ocellaris*. Or they may be attached to rocks in crevices or to the under side of overhanging rocks, as in *B. pholis*, *B. gattorugine*, and *B. galerita*. Again, they may be laid in such places as the hollow of an ox bone or bottle, as in *B. ocellaris*, or in clusters loosely attached to stones, as in the distantly related *Anoplarchus purpurescens* of the Pacific coast. The eggs in one "nest", if laid in a single layer, often cover several square inches of surface. The male was observed guarding the nest in most of the species studied by various investigators, as in *H. hentz*, *C. bosquianus*, *B. pholis*, *B. ocellaris*, *B. sphinx*, *B. gattorugine*, *B. montagui*, and *Clinus argentus*. Gudger (1927) reported that both sexes guard the eggs of *Pholis gunnellus*. Finally Shultz and De Lacy (1932) reported that the female guards the eggs of the Pacific coast blenny *A. purpurescens*.

The eggs of the three species of blenny from North Carolina, constituting the subject of a part of this paper, are all slightly flattened at the place of attachment, as stated in the descriptions of the eggs in the text. The eggs of two European species, namely, *Blennius pholis* and *B. gattorugine*, are described as decidedly flattened, the egg of the first-mentioned species being a little more than three-fourths of a sphere, and that of the other one only slightly more than half a sphere. The eggs of another European species, *B. ocellaris*, having a smaller adhesive organ, is described as nearly spherical.

It is pointed out in the text (pp. 579 and 592) that the eggs of two species of blennies from North Carolina have yolk containing brightly colored bodies. The eggs of *Hypleurochilus geminatus* have yolk with purple bodies, and those of *Hypsoblennius hentz* violet to old-rose colored ones when first spawned. The colored bodies gradually lose their outline as development of the egg progresses, and the color becomes diffuse, generally disappearing before hatching. Bright colors in the yolk seem to be usual in the eggs of European blennies also. The egg of *Blennius ocellaris*, *B. gattorugine*, and *B. pholis* are all said to have pink, red, or purple yolk, though no

definite spots or bodies are mentioned. *Chasmodes bosquiannus* seems to be the only true blenny (family Blenniidae according to Jordan 1923) studied to date which has eggs containing yolk without pink, red, or purple color.

The eggs of the North Carolina blennies all contain many oil globules. The oil spheres are yellow, being especially bright golden yellow in *Hypleurochilus geminatus*. In the European species oil globules are mentioned only in the eggs of *Blennius ocellaris*.

The newly hatched fish of the European species *Blennius ocellaris*, *B. gattorugine*, and *B. pholis* are respectively 4.4, 4.9, and 5.4 mm long, and therefore larger than those of the American species, *Hypsoblennius hentz*, *Hypleurochilus geminatus*, and *Chasmodes bosquianus*, which are respectively 2.7, 2.4, and 3.6 mm long. Somewhat larger young would be expected as the eggs of the European species are larger than those of the American ones. The greater axis of the eggs of the European species, in the order named, are 1.2, 1.6, and 2.0 mm, whereas those of the American species, respectively, are only 0.77, 0.69, and 1.04 mm. Furthermore, the European species grow larger than the American ones. The former, in the order named, reach a length of about 175, 225 and 150 mm, whereas the latter attain a length, respectively, of only about 100, 75, and 90 mm. It is understood, of course, that the size of a fish is no criterion relative to the size of the egg it produces. However, in this instance the larger European species evidently do produce larger eggs than the smaller American ones.

Although the newly hatched young of the European species are larger than those of the American ones, as pointed out in the preceding paragraph, they are all strikingly similar in general appearance throughout the larval stages. The newly hatched larvae are fairly stocky anteriorly and have rather long slender tails, the vent being situated far in advance of midbody length. The pectoral fin membranes are comparatively large and generally more or less spotted with black. Usually black is present also on the abdomen which most often is concentrated on the side of the fish along the upper edge of the abdominal mass. Short black cross lines on the ventral edge of the tail may be present on only a few to several myomeres or on all the caudal segments.

In the older larvae the tail becomes proportionately shorter and heavier and the black on the sides and on the pectorals tends to become more prominent. In the postlarval stages the pectoral fins generally are proportionately much longer than in adults, and the caudal fin, which is round in the adult, tends to be slightly concave. Such a development of the caudal fin must be considered rather unusual, though a similar evolution has been observed in the gobies. (For descriptions and figures of the eggs and the young of the European blennies, *Blennius ocellaris*, *B. gattorugine*, and *B. pholis*, see Cunningham, 1889; Ford, 1922; and Lebour, 1927.)

HYPSOBLENNIUS HENTZ (LeSUEUR). SPOTTED SEAWEED FISH

Hypsoblennius hentz is common, but not abundant at Beaufort, N. C., and is known to range from Chesapeake Bay to Florida. It is recognized chiefly by its very steep forehead; small, horizontal mouth, the maxillary scarcely reaching under the middle of the eye; by the absence of canine teeth; the small gill opening; the broad pectoral, with 14, rarely 13 or 15 rays; and the moderately long and low dorsal and anal fins, the former consisting of 12 spines and 14 or 15 soft rays and the latter of 2 spines and 16 soft rays.

The males appear to grow larger than the females (largest male at hand 104 and the largest female 84 mm long) and the males have a much longer tentacle over

the eye. Although the tentacle is variable in length among individuals of the same sex, it is rarely as long as the eye in adult females, whereas it always exceeds the length of the eye in adult males. Males differ from the females in external structure, furthermore, in having fleshy expansions or hoods, opening forward, attached to the two anal spines, and the fin itself is preceded by a low elliptical membranous hood, opening backward. Females have a distinct genital papilla, at least during the breeding season, which is not evident in the males (fig. 74).

The shallow water areas with rather hard, often somewhat shelly, bottom supporting growths of plants, sponges, ascidians, hydroids, etc., are the common summer habitat of the adults. The shallow areas are deserted during the winter when specimens occasionally are taken in the deeper channels and in holes, where the species also occurs sparingly during the summer.

It is a game little fish and like its relative, *Chasmodes bosquianus*, it fights when handled. It will seize the skin (its mouth being too small to catch more than the skin) of a man's hand and hold on bulldog fashion, allowing itself to be lifted by its grasp. However, its jaws are not strong enough to inflict a wound.

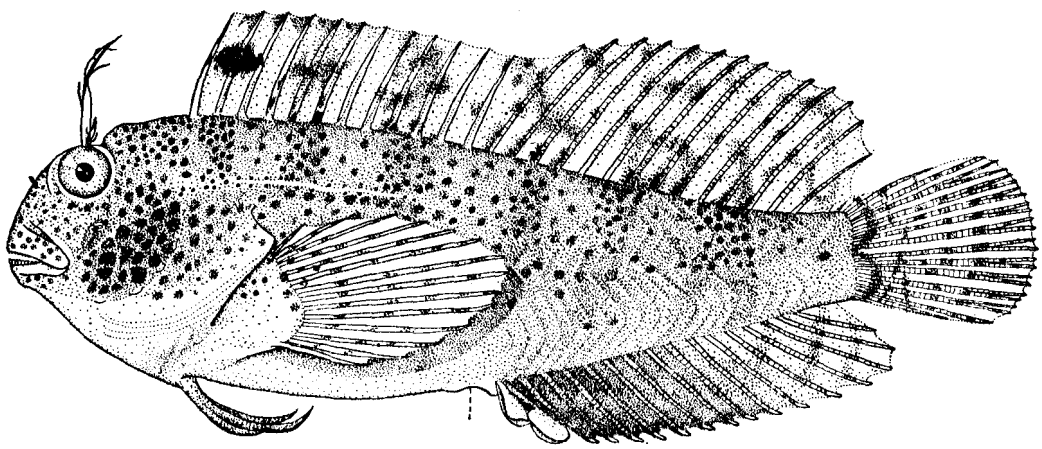

FIGURE 74.—*Hypsoblennius hentz*. Adult male 96 mm long. Note membranous expansions attached to the anal spines.

Color assimilation is well developed in this blenny. It is hardy, stands handling, and endures confinement in small aquaria very well and, therefore, it constitutes a fairly favorable subject for the study of its reactions to various color stimuli.

The species no doubt is preyed upon to a limited extent by various predatory fishes. It is not abundant enough locally to be of much importance even as a forage fish, and of course it is too small to be of direct commercial use, as 100 mm (4 inches) is near the maximum size attained.

The figures of the developing egg and the newly hatched larva are based on living material. The other illustrations were prepared from preserved specimens.

SPAWNING

Eggs of several sizes are present in the ovary at one time, just as in the other local species of blenny, suggesting a long spawning season, as well as repeated spawning. This expectation is substantiated by the presence of fry less than 5.0 mm in length in the tow from May 13 (1930) to September 13 (1927). The young of this species were never as abundant in collections as those of *Hypleurochilus geminatus*. They were taken in fair numbers, however, from about the middle of May to the end

of August. It may be concluded, therefore, that the spawning period extends from May to August.

The eggs were seen first on August 25, 1927, when a female held in a battery jar spawned. Since no male was at hand the eggs could not be fertilized. Several "nests", each containing many eggs, were taken from May 31 to June 27, 1932. From this material it was possible to study the embryology in detail.

This blenny does not make a nest in the true sense of the word. However, it uses empty oyster shells (possibly also clam and scallop shells) with the hinge intact, from which the oysters probably have not been removed very long and which are still clean and white within. Therein the eggs are deposited, and they become firmly attached by means of an adhesive disk. In several instances, nearly the entire inner surface of both valves of the oyster shell was covered with eggs. Occasionally only a part of each valve was occupied by the eggs. It seems probable that in these last mentioned instances the nests were not completed, and that more eggs would have been deposited. Nests were found only on a natural oyster reef at the west end of Pivers Island, at or near the usual low tide line.

It is evident from the difference in the development of the eggs in a nest that they are not all spawned at the same time. The difference in development may range from an early cleavage stage to an advanced embryonic stage, suggesting that the eggs are laid over a period of several days. In general, the eggs near the hinge of the oyster shell are furtherest advanced, whereas those most distant from the hinge of each valve show the least development.

The eggs are in a single layer in the nest, not always in definite rows, and are well separated by the adhesive disks which have a greater diameter than the eggs. It is estimated that some of the larger nests found contained as many as 3,750 eggs. The eggs are so firmly attached that they can be removed without injury only by cutting the adhesive disk close to the oyster shell with a sharp instrument.

It is not known whether all the eggs in one nest are the product of one female, although this seems quite possible since all the eggs within an ovary evidentally do not mature at one time, as already stated. It is possible, therefore, that a female may go to the same nest several days in succession to spawn.[7]

The eggs probably always are guarded by a male. The foregoing statement is made notwithstanding the fact that a few nests were found with which no males were seen. On the other hand, a fish was seen to escape from a nest in a few instances, and several nests were taken with the male within the valves of the oyster shell constituting the nest. It is assumed in those instances when no males were seen that they escaped unnoticed.

The male stays within the oyster shell in taking care of the eggs. In case the shell is shorter than the fish it bends the tail forward to get within the shell, for it allows only the snout and eyes to protrude. A decided difference in the temperament of different males was noticed. It already has been shown that some males fled when someone approached. Others stayed with the nest and allowed themselves to be picked up (by hand) with the oyster shell containing the eggs. Only one male, upon being transferred from its native habitat to the aquarium, reoccupied his nest almost immediately, although others, after being in confinement for some time would even occupy empty shells. In a few instances males failed to return to their nests in

[7] Guitel (1893) has reported that among specimens of *Blennius montagui=B. galerita*, from the coasts of France, kept in a tank made of a small boat, in which their natural habitat was reproduced as nearly as possible, several females laid eggs in one nest situated on the under side of an overhanging stone. The eggs were all fertilized and guarded by the same male. It cannot be stated of course, that this procedure would obtain in nature.

nature after being disturbed. One male transferred to the aquarium devoured the eggs, instead of taking care of them. The single male which reoccupied his nest in the aquarium not only stayed in the oyster shell until the eggs were hatched (notwithstanding frequent disturbances during the incubation period for removing eggs for study), but also for several weeks afterwards or until removed from the tank. During the incubation period, as well as afterwards, he came out only to feed on bits of oyster and fish that were supplied, and even retreated between bites.

The male undoubtedly drives away intruders, for it was noticed that the eggs in nests deserted by the parent fish were destroyed very soon. The chief enemy noticed was the flat mud crab, *Eurypanopeus depressus* (Smith).[8] Specimens of this crab were taken with three deserted nests. The male, however, appears to have another function, namely that of keeping the eggs clean and in healthy condition. Just how this is accomplished is not evident. It was not noticed that he fanned the eggs especially, for he seemed to lie quietly within the oyster shell.[9] Yet, the eggs in a nest cared for by a male, and held in a tank with running water almost all hatched, whereas the eggs treated identically, but without a male attendant all died in advanced embyronic stages. A very small number of eggs in one deserted nest was hatched by providing special treatment. That is, in addition to keeping the nest in a tank with running water, the eggs were washed vigorously once or twice each day by playing a jet of water directly on the eggs, and by rushing the nest through water rapidly. A few eggs removed from a nest were hatched in standing water (changed twice daily) in a glass bowl. Eggs in deserted nests in tanks became infested with hydroids and copepods, which caused death before hatching. No infestations were noticed in eggs guarded by the male fish.

Spawning apparently takes place early in the morning. This conclusion is arrived at from the fact that eggs in early cell division stages were present only in nests taken before 9 o'clock in the morning. All eggs collected even as late as 11 o'clock in the morning already had passed the early cell division stages and those taken during the afternoon had progressed correspondingly further in development.

DESCRIPTIONS OF THE EGGS AND YOUNG

Description of the eggs.—The eggs of *Hypsoblennius hentz* are slightly flattened next to the adhesive disk or foot which attaches them to oyster shells, as already explained. The foot and the slight depression in the contour of the egg at the place of attachment are shown in only two of the accompanying drawings (figs. 77 and 83). The greater axis in 11 eggs measured varied from 0.72 to 0.8 mm, the average being 0.769 mm. The smaller axis which is difficult to measure accurately because the opaque foot obscures the outline of the egg, varied in four specimens from about 0.64 to 0.68 mm.

The eggs, as seen with the unaided eye, if still in rather early developmental stages, are pinkish in color. Under magnification it becomes evident that the color is within the yolk and in the form of spherical or more or less elongate bodies. The longest diameter of the latter apparently is always perpendicular to the plane to which the egg adheres. These bodies, as seen under magnification, are violet to old rose in color. They are variable in size within the same egg, as well as in shape and number in different eggs. They lie at various depths within the yolk, and therefore it is necessary to refocus the microscope to see all of them. The variation in number in different

[8] The writer is indebted to Dr. Mary J. Rathbun of the U. S. National Museum for the identification.

[9] Guitel (1893) stated that the male of *Blennius montagui*=*B. galerita*, a European species, does fan the eggs and that he will remove with his mouth any foreign object which may enter the nest.

eggs apparently ranges from about 12 to 24. During development these colored bodies become less and less definite in outline, and in advanced embryonic stages the color becomes paler and diffuse, often disappearing entirely several days before the egg hatches.

Golden yellow oil globules are also present. These spheres are equally as variable in size within an egg and in number in different eggs as the old-rose colored bodies. In general they are somewhat concentrated near the blastoderm. The oil globules persist in part at least until the egg hatches or even in the small yolksac attached to the newly hatched fish. In the accompanying drawings the old rose colored bodies are shaded, while the oil globules are unshaded. Some of the variations in the shape of the colored bodies are shown in the illustrations. The total number of colored bodies and oil globules is not shown. Those indicated are the ones which came into focus under the microscope at one level.

The egg, furthermore, has a large central body, apparently denser in texture than the rest of the egg, grayish in color like the adhesive disk, and quite opaque. This body disappears in the advanced embryonic stage. A similar central opaque body is present also in the eggs of the other two species of blenny discussed elsewhere in this paper.

The entire egg is moderately opaque, becoming more so as development proceeds. Fair perception is obtainable, however, in recently spawned eggs if viewed in a plane parallel with the surface to which they are attached. In the opposite direction the dirty-gray opaque adhesive foot, which cannot be detached without injury to the egg, and the opaque central body obscure vision. The yolk is granular in appearance. The egg membrane has deep lines and elevations, suggesting rugged eroded land. This sculpture on the egg case is not shown in the accompanying illustrations.

Segmentation and the development of the embryo.—The eggs forming the bases for the present account were taken in nature. The exact time of fertilization is not known. Therefore, the length of the period intervening between fertilization and the beginning of cell cleavage cannot be stated definitely. The earliest cell division stage found, namely four cells, occurred in two nests taken at 8:30 o'clock in the morning. These eggs probably had been laid 2 hours or so before the nests were found. This tentative conclusion is based on the results obtained with *Hypleurochilus geminatus* (p. 593). In that species segmentation started about 2 hours after fertilization. It seems reasonable to expect that the intervening time in these related species would be about equal at the nearly identical temperatures which prevailed (26° to 28° C.).

The blastodisc is apparently always situated next to the adhesive disk. This position of the blastodisc makes it difficult to observe cell division, as the opaque adhesive disk below and the opaque central body above it obscure vision. Fortunately, eggs in the early stages are more transparent than those in the more advanced stages. Consequently, it was possible to see the cells, even though dimly, through the mass of the egg (fig. 75). In a lateral view the cells could be seen more definitely. The first blastomeres apparently are about equal in size and the second cleavage cuts the blastodisc at right angles to the first. The perivitelline space is comparatively large at the positive pole and very small or wanting at the negative one (fig. 76).

Segmentation proceeds rapidly, the 8- and the 16-cell stages (figs. 76 and 77) following the 4-cell one at intervals of about 30 minutes each at a water temperature of about 26° C. As development proceeds the egg becomes more granular, and it becomes more and more difficult to see exactly what is taking place. While the blastoderm no doubt is dome-shaped, as usual in teleosts, it cannot be seen because of the opaqueness of the yolk (fig. 78). An advanced cleavage stage is reached in about

8 hours at a water temperature of 25° to 27° C. (fig. 79). In about 24 hours the germ ring becomes evident (fig. 80) and in 48 hours the embryo already is well differentiated. Generally only a part of it is visible from one viewpoint, as any part lying underneath

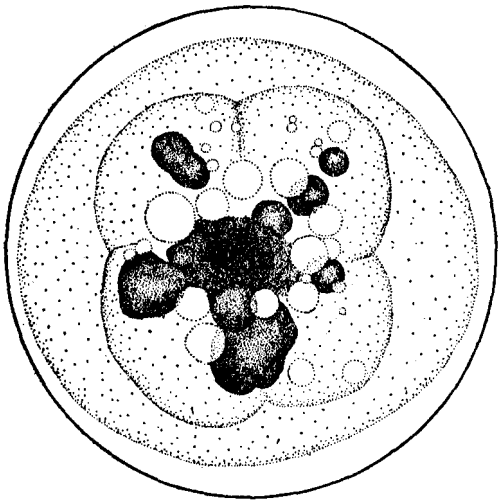

FIGURE 75.—*Hypsoblennius hentz.* From egg in 4-cell stage, about 2 to 3 hours after fertilization. (Drawn by Nell Henry.)

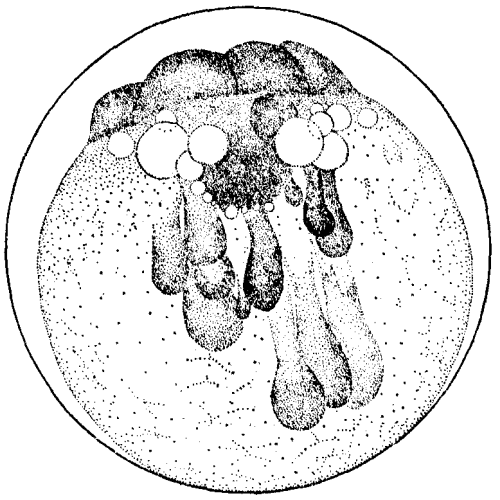

FIGURE 76.—*Hypsoblennius hentz.* From egg in 8-cell stage, lateral view about 3 hours after fertilization. A slight depression in the egg at place of attachment opposite the blastodisc is not shown. Note elongate shape of the shaded bodies. (Drawn by Nell Henry.)

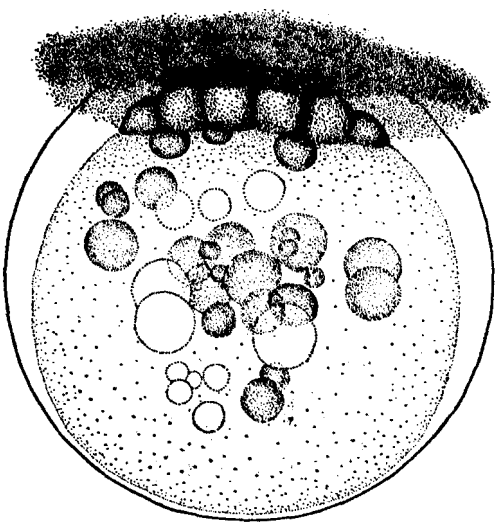

FIGURE 77.—*Hypsoblennius hentz.* From egg in about 16-cell stage, lateral view; about 3½ hours after fertilization. Adhesive disk shown at upper margin of egg. Note round form of shaded bodies in yolk. (Drawn by Nell Henry.)

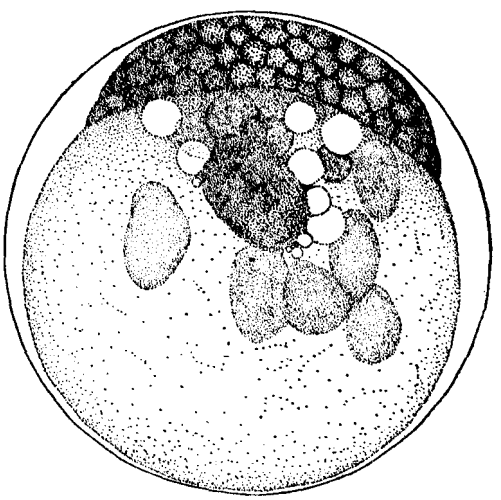

FIGURE 78.—*Hyposblennius hentz.* From egg in a moderately advanced cleavage stage; probably about 6 hours after fertilization. Only that part of the blastoderm projecting above the yolk is shown as the rest is obscured by the opaqueness of the egg. (Drawn by Nell Henry.)

the now very dense yolk cannot be seen (fig. 81). The tail was curved underneath the yolk where it could not be seen and for that reason was not shown in figure 81.

The development proceeds slowly for such a small egg after the embryo once is well formed. The embryo may be expected to extend three-fourths of the distance around the egg in about 3 days at a water temperature of 25° to 27° C. Somites are evident in at least a part of the body, the eyes are well formed and punctuated with

dark dots, and circulation is established, although the blood flows slowly. The heart is situated under the anterior tip of the head. A large artery courses through the ventral part of the embryo. It recurves rather sharply in the caudal portion where it leaves the embryo. This vessel then divides and several branches course over the yolk, reuniting just before reaching the heart. No return circulation is established in the embryo. Large dark blotches with irregular outlines, sometimes merely

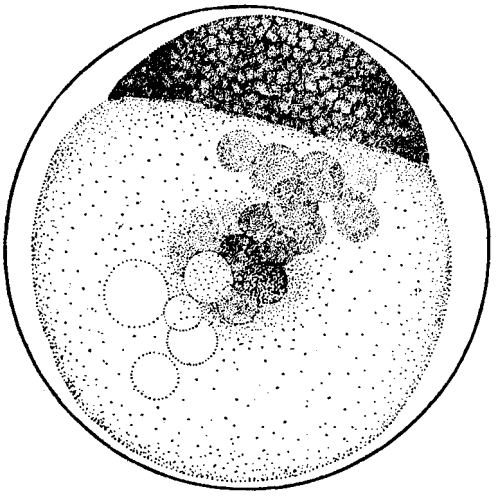

FIGURE 79.—*Hypsoblennius hentz.* From egg in an advanced cleavage stage; probably about 8 hours after fertilization. (Drawn by Nell Henry.)

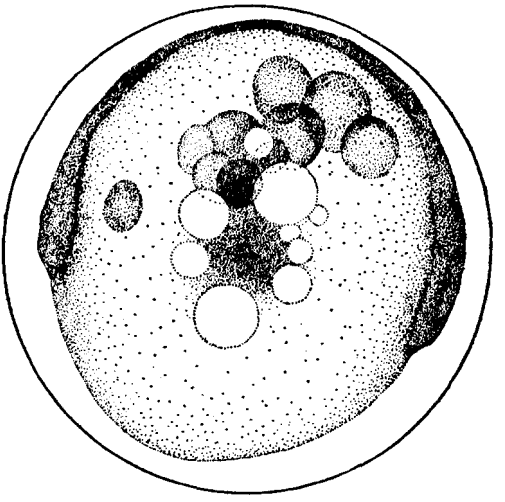

FIGURE 80.—*Hypsoblennius hentz.* From egg showing blastoderm growing around egg; about 1 day after fertilization. (Drawn by Nell Henry.)

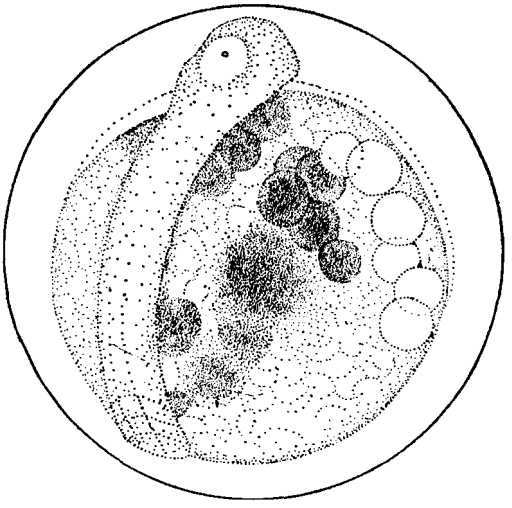

FIGURE 81.—*Hypsoblennius hentz.* From egg with an early embryo; tail underneath the opaque yolk; about 2 days after fertilization. (Drawn by Nell Henry.)

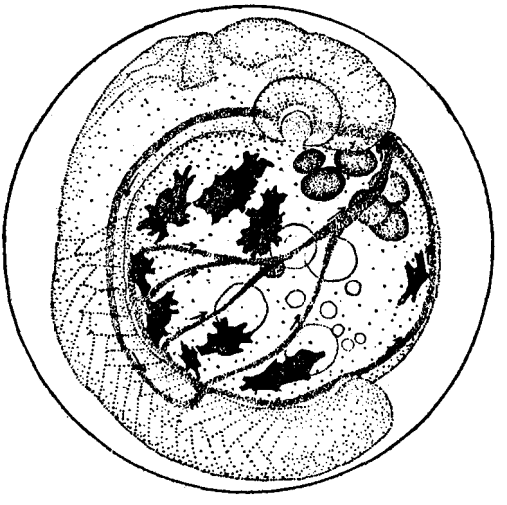

FIGURE 82.—*Hypsoblennius hentz.* From egg with well-formed embryo, showing blood vessels. Arrows indicate direction of flow of blood. About 3 days after fertilization. (Drawn by Nell Henry.)

branching blotches resembling crows feet, are now present on the surface of the yolk (fig. 82).

In about 6 days the embryo encircles the egg, the tip of the tail reaching to or past the head. The eyes are very large and black with a greenish sheen. Heart action is very brisk, the beats following each other so rapidly that it is difficult to enumerate them accurately. The number of beats probably is close to 200 per minute. A return circulation is now established in the embryo. Large vessels still course over the yolk

and these together with the large vein in the embryo all pour their contents into the heart which has somewhat the appearance of a pit. Corpuscles are plainly evident, and from their rapid progress it is obvious that circulation is brisk. The old-rose colored bodies previously present have disappeared. However, some eggs retain a diffuse pinkish cast in the yolk near the heart of the embryo. The embryo is capable of much movement. The tail is free and is switched frequently. The embryo is able to turn within the egg membrane, carrying the yolk with it in its movements. (fig. 83).

Progress in the development after about the sixth day of incubation seems particularly slow. The embryo increases little in length and the yolk is absorbed very slowly. Dark markings on the yolk, which tend to decrease in size after about the fourth or fifth day of incubation, generally disappear entirely a day or two before hatching. In the meantime black markings become evident on the embryo. A rather large branching blotch is present on the head between the eyes, numerous black chromatophores also appear on the comparatively large pectorals, and short branching cross lines mark the myomeres along the ventral surface of the caudal region of the embryo. Just before hatching the egg becomes somewhat distorted, the egg membrane being pushed out somewhat at the head of the embryo.

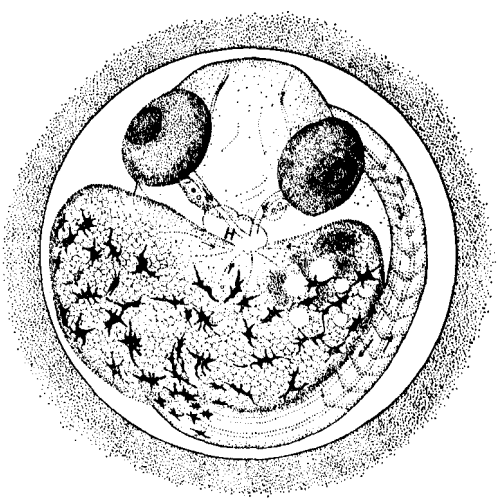

FIGURE 83.—*Hypsoblennius hentz.* From egg with large embryo: about 6 days after fertilization. H, heart. Arrows show direction of blood flow in the larger vessels. (Drawn by Nell Henry.)

Eggs taken on May 31, 1932, which were in several different stages of development, ranging at the time of collection from a rather advanced cleavage stage to a stage in which the embryo already was well differentiated, hatched from June 8 to 12. The temperature of the water during this time varied from about 25° to 27° C. The eggs in a nest taken June 16, 1932, which ranged in development about equally as much as those taken on May 31, hatched from June 24 to 26. The temperature of the water during this period varied from about 24.5° to 27° C. Assuming that the last eggs hatched in each nest were those which were in an advanced cleavage stage when taken, and that these eggs were laid on the day of collection (concerning which there can be little or no doubt), the incubation period has a duration, at the temperatures stated, of about 10 to 12 days. The incubation period in this species, therefore, is longer than in *Hypleurochilus geminatus* (see pp. 596 and 610), and about the same as in *Chasmodes bosquianus.*

Hatching, like spawning, apparently takes place early in the morning. At the time of hatching, the yolk was almost wholly absorbed and the young fish generally died by the evening of the day on which they were hatched. However, for 4 days in succession a new lot was present each morning. Several efforts were made to keep the fish alive and to induce them to feed and to grow. Some were kept in a tank with running water, others were transferred to shallow glass bowls with standing sea water. The lots in running water were not fed, those in standing water in part were offered towings and in part very finely minced oyster. However, none lived more than 2

days. The fish presumably did not feed, but it is quite unlikely that they died of starvation as a bit of the yolksac remained even in those individuals that lived longest.

Newly hatched fish.—The newly hatched fish range in length from about 2.6 to 2.8 mm. The yolk is nearly all absorbed at hatching. The fish are robust anteriorly, with a broad depressed head. The tail is long and slender, with the vent situated much in advance of midbody length; distance from snout to vent about 1.0 mm, from vent to tip of tail, without finfold, about 1.5 mm. The snout is short and very blunt; the eye is large, having a diameter of about a quarter of a millimeter; the mouth is large, the gape reaching to or past the middle of eye. Large pectorals with suggestions of rays are present. The body is fairly transparent. Consequently the outline of the brain and the circulation can be seen rather definitely. The aorta may be seen close to the notochord, turning upon itself about an eye's diameter from the tip of the tail to form the caudal vein. Heart action is too rapid to permit accurate enumeration of the beats. However, the number of beats probably is close to 230 per minute. About 28 to 30 myomeres may be enumerated, being indefinite in advance of the vent (only 3 or 4 visible) and again toward the tip of the tail. The vertebrae count in the adult is 33, there being 9 body and 24 caudal ones. The number of more or less definitely outlined myomeres in the newly hatched fish, therefore, is not far below the number of vertebrae in the adult.

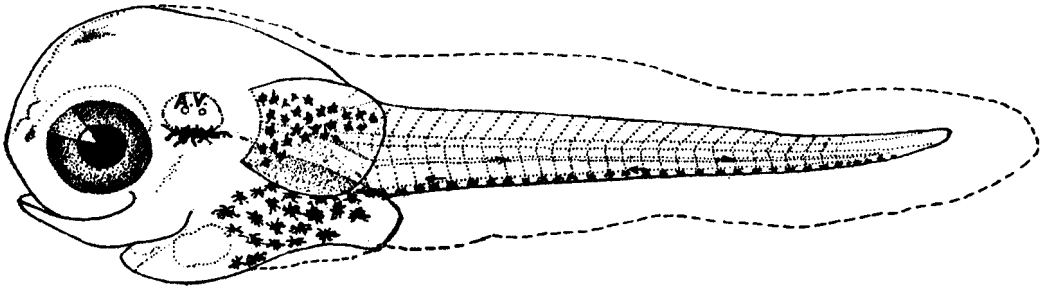

FIGURE 84.—*Hypsoblennius hentz.* From newly hatched fish. Length of live specimen 2.6 mm. AV, auditory vesicle. (Drawn by Nell Henry.)

Several dark markings are present on the newly hatched fish which correspond for the most part with those already present in the advanced embryo as described elsewhere. The eye is very dark with a greenish sheen above the pupil; an irregularly outlined dark spot is present on the head between the anterior part of the eyes, or in some specimens several black chromatophores are distributed over the snout to the interorbital; generally a blackish blotch with branches is present at the auditory vesicle; many black chromatophores (or in some specimens in part solid black) are present on the abdominal region; and the ventral side of the tail is marked by short black branching cross lines. The large pectorals are marked on the inner surface, with dark chromatophores. The dark markings often are present only on the basal two-thirds, although sometimes they may cover nearly the entire inner surface and extend to the margin of the fin (fig. 84).

Comparatively few of the numerous fish hatched lived as long as 2 days. At 2 days after hatching the fish apparently had become more slender and had increased in length only slightly, being 1.8 to 1.9 mm long. The yolksac was almost all absorbed. Only minor changes in color had taken place. The black chromatophores on the abdominal region had become more concentrated along the side near the upper boundary of the abdomen in the form of an indefinitely outlined oblique band extending from near the eye to the vent. Only a few separate black branched markings remained on the ventral surface of the abdomen (yolksac) where a shade of yellow

had appeared. Other color markings remained essentially as in the newly hatched larvae. The black color along the upper margin of the abdomen, described in the foregoing lines; the short black lines on the ventral surface of the tail, which remain as in the newly hatched fish; and the black chromatophores on the pectoral fins are very useful characters in identifying the larvae hatched in the laboratory with others taken in towing and described in the following pages.

Specimens 1.5 to 2.0 mm long.—Although the newly hatched fish when alive, or before preservation, were around 2.7 mm in length, the smallest specimens taken in the tow are only 1.5 to about 2.0 mm long. These small larvae quite surely belong to the species under discussion. Their size does not exclude them, as young tender fish generally shrink greatly when preserved in formalin and alcohol. Young hatched in the laboratory, preserved when less than a day old in 65 percent alcohol, for example, decreased in length from about 2.7 to 2.0 mm. The specimens taken in the tow were killed in formalin and later transferred to about 75 percent alcohol. Some of these specimens, although 2.0 mm and less in length, evidently are several days old, as shown by the more advanced development. The older fish are less robust anteriorly, the pectoral fins are more elongate and less broadly rounded, and suggestions of rays are present. Indications of rays also are appearing in the vertical finfold around the tip of the tail. The color on the abdomen has become more concentrated along the upper margin of the abdominal mass, the black spots on the inner surface of the pec-

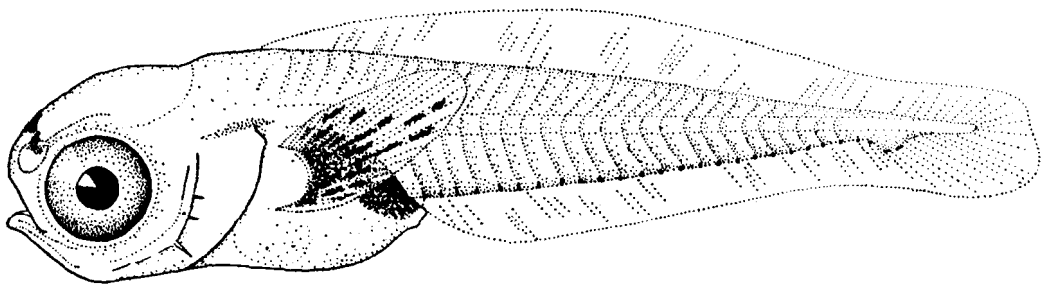

FIGURE 85.—*Hypsoblennius hentz.* From a preserved specimen 3.0 mm long.

torals are prominent, and the cross lines on the ventral edge of the caudal region remain as in younger fish.

Specimens 2.5 to 3.0 mm long.—The head and trunk are robust, the head being about two-thirds as broad as deep. The head and trunk have become longer in proportion to the tail, the distance from tip of snout to vent being contained about 2.4 times in the total length without the caudal finfold. The snout is very short and blunt, scarcely longer than the pupil, the forehead is very steep, and the mouth is slightly inferior, moderately oblique, with the tip of the lower jaw a little below the level of the middle of eye. Three minute preopercular spines are evident in some specimens. The vertical finfold remains continuous, with indications of rays posteriorly. The pectoral fins are long and rather narrow, with definite rays, and about three-fourths as long as the head. The most prominent color marking is an oblique black bar extending from the axile of the pectoral to the ventral outline just in front of the somewhat protruding hindgut. Several dark dots are present on the ventral surface in advance of the vent, a distinct dark bar crosses the forehead between the eyes, and generally several chromatophores are present on the upper surface of the head and nape. A row of small, vertically elongate, dark spots is situated on the ventral outline of the tail. The most important color markings for the purpose of identification are dark dots, covering most of the pectoral fins, which extend to the tips of at least some of the rays (fig. 85).

Specimens 4.0 to 4.5 mm long.—The head and trunk remain rather robust, although less so than in somewhat smaller specimens. The caudal portion of the body is moderately deep, strongly compressed, and scarcely longer than the head and trunk, the vent being situated at about midbody length, exclusive of the caudal fin. The head is deep and rather broad, the interorbital space being scarcely narrower than the eye. The snout is very short and round, projecting scarcely half the diameter of the orbit in front of the eye. The mouth is placed low, slightly inferior, oblique, the tip of the lower jaw being only a little above the level of the lower margin of the eye. The eye is placed low, that is, nearer to the ventral than the dorsal outline of the head. Fin rays are only partly developed in the dorsal and anal fins, but more fully in the caudal fin which is round in outline. The notochord is bent upward at the base of the fin, as usual in larval teleosts at about this stage of development. Ventral fins are not evident. The pectorals, however, are long and rather narrow, and scarcely shorter than the head. A few obscure dark markings generally are present on the ventral surface of the chest and abdomen; a dark band extends across the forehead between the eyes; the occipital surface of the head has one to several dark dots and a large median black spot is present at the nape. An oblique black band extends from the axile of the pectoral nearly to the vent; the long pectoral fin, exclusive of two or three of the upper rays, is densely dotted with black; and a row of very small black points begins a short distance behind the vent and extends to the base of the caudal fin (fig. 86).

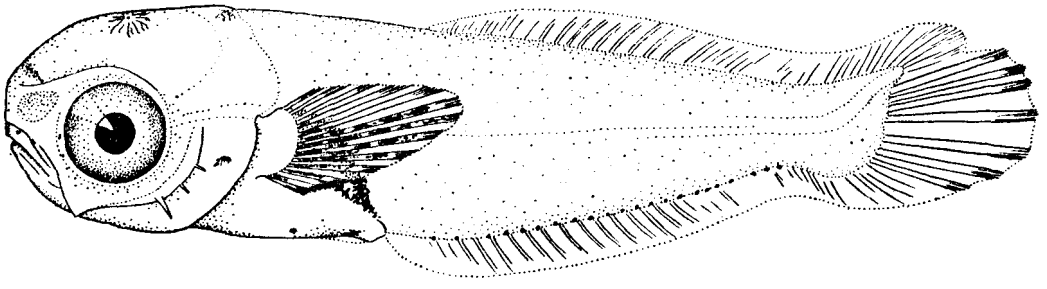

FIGURE 86.—*Hypsoblennius hentz.* From a young fish 4.45 mm long.

Specimens 5.0 to 6.0 mm long.—The body has continued to grow deeper and somewhat more compressed since a length of about 4.0 to 4.5 mm was attained. The head especially is deep and short; the snout remains very short and blunt, being scarcely more than half as long as the eye. A rather definite bony ridge is evident now over and in front of the orbit, making the interorbital space quite flat and fully as broad as the eye. The position of the mouth remains low and is slightly inferior, the tip of the lower jaw being only a little above the level of the lower margin of the eye. Five preopercular spines are now visible. Advancement in the development of rays in the dorsal and anal fins is not pronounced. The caudal fin, however, has grown proportionately longer and remains round. Ventral fins now are evident as mere tufts of membrane. The pectoral fins are fully equal to the length of the head and, exclusive of the upper rays, are dotted with black as in the younger fish, and the oblique, dark bar behind them remains as described in smaller specimens. A few indefinite dark spots occur on the chest and sides of the head, and several rather definite dark chromatophores usually are present on the occipital surface of the head and nape. A row of very small dark dots on the ventral outline of the tail, or base of the anal, described in smaller specimens, remains (fig. 87).

Specimens 8.0 to 10 mm long.—The body is rather deep and strongly compressed, the depth being contained about 3.4 to 4.0 times in the length without the caudal fin. The head is deep, the snout remains excessively short, as in smaller specimens, and the forehead is very steep. The snout projects in front of the orbit a distance scarcely equal to half the diameter of the eye. The mouth is small, placed very low, almost horizontal, and terminal to slightly inferior. The tip of the lower jaw is on, or a little below, the level of the lower margin of the eye, and the maxillary reaches to, or slightly past, the anterior margin of the pupil. The interorbital remains quite flat,

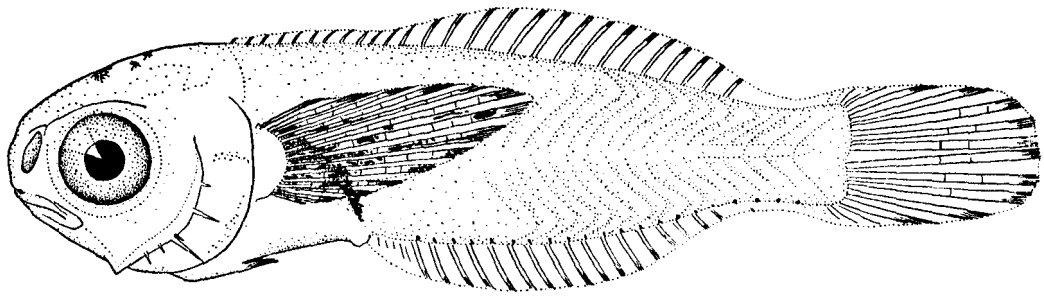

FIGURE 87.—*Hypsoblennius hentz.* From a young fish 6.2 mm long.

with a prominent bony ridge over and in front of the eye. The preopercular spines, while well developed in specimens 8.0 mm long, are proportionately longer in specimens 10 mm in length. The dorsal and anal fins are quite fully developed and a fairly accurate count of the rays can be made; the caudal fin has an almost straight margin and is about as long as the head; the ventral fins are well developed and are long and slender, being nearly as long as the head without the snout; and the pectoral fins are large, being nearly or quite as long as the head. The lower surface of the head and chest is variously dotted with black, generally with a few definite dark spots slightly behind the articulation of the lower jaw, also with a pair of dark spots a short distance

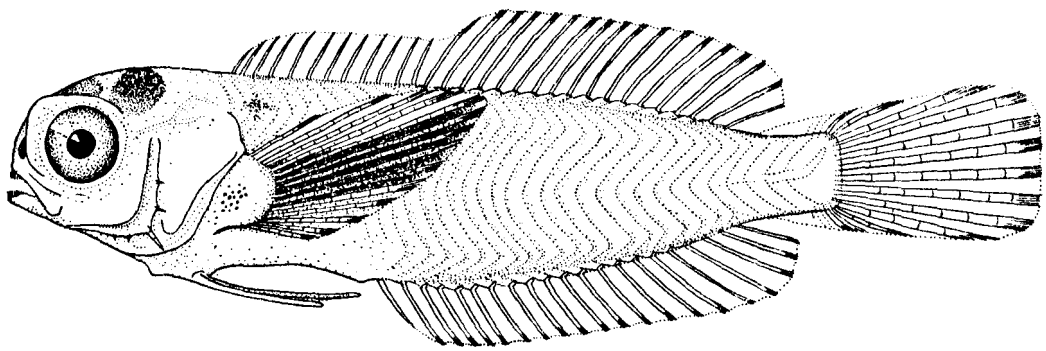

FIGURE 88.—*Hypsoblennius hentz.* From a young fish 9.8 mm long.

in advance of the ventral fins, and another pair in the axiles of the ventrals. The side of the head has a few indefinite spots or blotches and the upper surface of the head, that is from the interorbital backward, bears brownish spots with dark center and dark outline. The pectoral fin is almost wholly black in some specimens; in others two to four of the upper rays are pale, while the rest of the fin is black, and the oblique dark bar behind the pectoral, very prominent in smaller fish, has become quite obscure in 10-mm fish. A row of fine dark points along the base of the anal is present in some specimens, but not evident in others (fig. 88).

Specimens about 12 mm long.—The differences between fish 10 and 12 mm long are not pronounced. However, the body in the larger fish is considerably more robust, especially anteriorly, the depth as in the smaller specimens being contained 3.4 to 4.0 times in the length without the caudal fin. The bony ridge over and in advance of the eye is quite as prominent as in the smaller fish. The forehead remains very steep to vertical and projects slightly beyond the low, almost horizontal mouth. The gape of the mouth is now wholly below the level of the lower margin of the mouth as in the adult. The preopercular spines have continued to increase in proportionate length, the one situated at the lower posterior angle having become much larger than the other, being equal to the length of the eye in one specimen, but somewhat shorter in others. It is probable that the preopercular spines, which are not present in the adult, reach their greatest development at this stage and that they gradually decrease in size in larger fish. Specimens of the proper sizes for a study of the recession of these spines, however, are not at hand. A small fleshy tentacle is now visible over the eye for the first time. Although nearly or quite as long as the eye in the adult it is scarcely as long as the pupil in fish 12 mm long. A definite notch between the spinous and soft portions of the dorsal fin is present, as in the adult. No pronounced development in pigmentation has taken place since a length of 10 mm was attained. However, dark areas and spots about the head have increased somewhat in size and number in at least some specimens. A row of very small black dots still persists on the base of the anal. The dots are not evenly spaced and not definitely on each interradial membrane, although some variation in this respect exists (fig. 89).

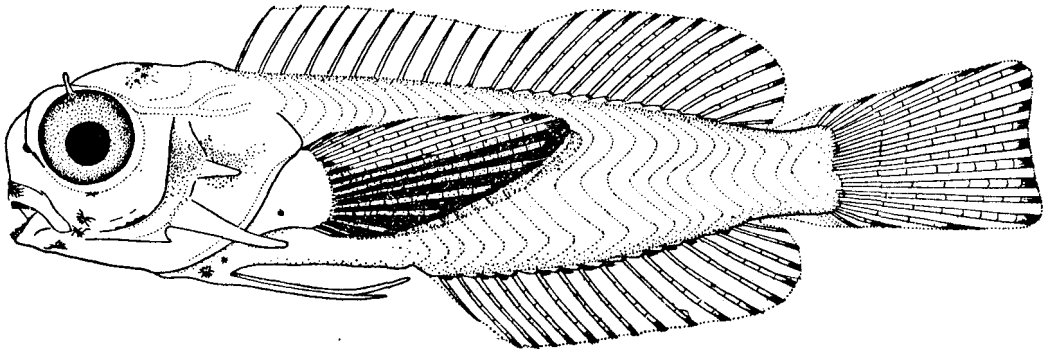

FIGURE 89.—*Hypsoblennius hentz.* From a young fish 12 mm long.

Unfortunately no specimens ranging from about 13 to 24 mm in length are at hand, and therefore, a complete picture of the development of the late juvenile stages cannot be given at this time. Specimens 25 mm long are "young adults" and have virtually all the characters of mature fish. In such specimens the prominent bony ridge over each eye, very characteristic of the young, has disappeared entirely; the fleshy tentacle over the eye is nearly or quite as long as the orbit, the preopercular spines no longer are evident; the caudal fin is round; and pigmentation is complete and similar to that of fully matured fish. Although the series is not complete, the largest young (12 mm long) at hand have developed sufficient adult characters to make identification certain. The extremely steep forehead in the young and the size, shape, and position of the mouth are quite characteristic of the adults and unlike the other local species of blennies. Furthermore, the fins are rather fully developed and the shape and number of their rays agree with those of the adult.

DISTRIBUTION OF THE YOUNG

The fry were taken in towings in outside waters 39 times and in inside waters 28 times. No definite record of the number of hauls made was kept. It is probable, however, that nearly an equal number of towings was made in the inside and outside waters. Therefore, the indications are that the fry are somewhat more common off Beaufort Inlet than in Beaufort Harbor and adjacent sounds and estuaries.

The fry were taken in surface towings 48 times and in bottom ones only 16 times. Although a considerably larger number of surface than bottom hauls was made, the discrepancy in the number of hauls certainly is not great enough to account entirely for the difference. Furthermore in 1927 and 1928 the number of surface and bottom hauls made was about equal and during those years the fry appeared 21 times in the surface nets, and only 11 times in the bottom ones. Since the bottom nets were not closed while they were lifted, it is entirely possible that some of the fry occurring in these nets were not actually taken on the bottom. The larger larvae, 5.0 to about 10 mm in length (after which they seldom appeared in the tow), occurred in the surface nets quite as frequently as the smaller ones. It may be concluded, therefore, that the young of this species, until they reach a length of at least 10 mm, occur in the open waters and are chiefly surface dwelling.

The size at which the young cease to be chiefly pelagic and begin to occupy the habitat of their parents (mainly shallow "grassy" areas) is not definitely known, as no specimens ranging from about 13 to 24 mm in length were taken. Fish 24 mm in length are "young adults" and may be taken with collecting seines in shallow water in the usual summer habitat of the adult, while the fish of the smaller size (13 mm) are still pelagic.

GROWTH

Insufficient specimens were taken to determine the rate of growth. Specimens 5.0 to 6.0 mm in length first occurred in towings early in June and several specimens 10 mm and one 12 mm long were taken in July. Therefore, the indications are that the larval stages are passed rather quickly, or within 2 or 3 months, and the earliest young of the season probably become "young adults" during their first summer. Specimens ranging from about 13 to 24 mm in length are lacking in the collection.

HYPLEUROCHILUS GEMINATUS (WOOD). BLENNY

The genus Hypleurochilus contains a single species, which is common at Beaufort, N. C., and from there it ranges southward to the coast of Texas. This blenny, in general, is recognized by its rather deep, compressed, naked body; short, blunt head; low horizontal mouth, with a strong canine tooth on the posterior part of each jaw; broad pectoral, with 14 rays; long, low, continuous dorsal fin, with 11 to 13 spines and 14 or 15 soft rays; and by a tentacle over the eye; which is much larger in the male than in the female. Adult males differ from the females, furthermore, in having fleshy bulbs, covered with folded or creased skin, on the two anal spines, and an eliptical membranous hood in advance of the anal fin and in the presence of folds of skin around the vent. Females have a very distinct genital papilla, at least during the breeding season, which is not evident in the other sex (fig. 90).

Males reach a larger size than the females, for the largest fish in the numerous catches invariably were males. Furthermore, the largest male seen was 72 mm long and many others nearly as large were present in the collections, whereas the largest female was only 58 mm in length.

The common habitat of this blenny locally is among marine growths attached to wharf and bridge piling and to rocks of breakwaters. The ripe fish used in the present investigations were secured from the marine growths (principally ascidians) attached to the wooden piling of a railroad bridge near the laboratory. The fish were caught with a scrape net, that is, a dip net with a flattened side, provided with a blunt cutting edge. With such a net the marine growths, in part, may be scraped from the piling and frequently a blenny is contained among them. Collecting is most conveniently and efficiently done on low tide. During July and August 1930, one man could catch from two to four dozen fish with a scrape net on the low stages of a single tide.

Hypleurochilus geminatus is very hardy and it lives well in an aquarium. Therefore, if captured specimens were not quite ripe, they could be retained several days until their sexual products matured.

This species occupies a habitat which is almost identical with that of the adult sheepshead (*Archosargus probatocephalus*), the gamest of the locally represented salt water fishes. Both species feed on attached marine growths and on free swimming forms (principally crustaceans) which also frequent these marine growths. However,

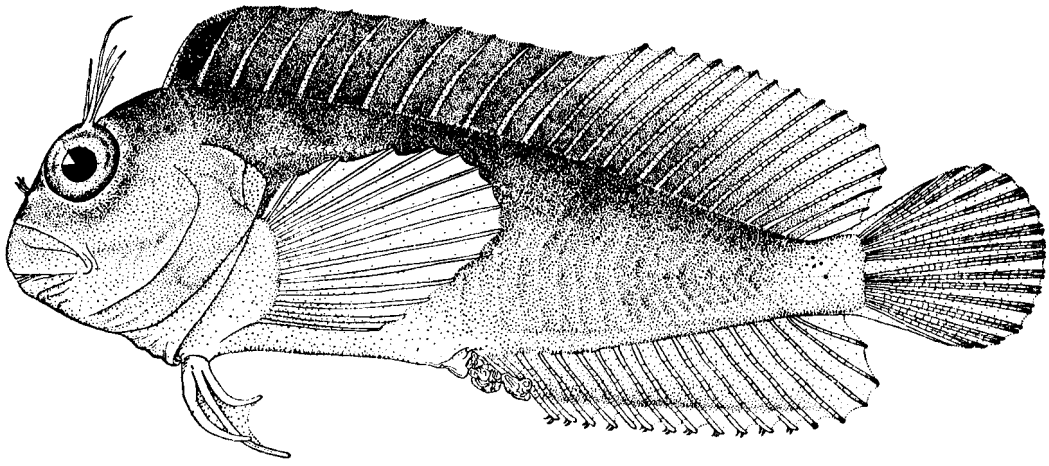

FIGURE 90.—*Hypleurochilus geminatus*. From adult male 55 mm long. Note plicate membranous bulbs attached to anal spines, covering the anterior one almost completely.

the competition probably is not great, as the blenny requires much smaller bits of food than the sheepshead. And young sheepsheads do not enter into the competition, because they have an entirely different habitat. (See p. 532.)

Hypleurochilus probably is preyed upon to a limited extent by predatory fishes, but its habitat is very restricted, as already shown, and of such a nature that it is not visited by many species. Neither is this blenny abundant enough to be of much importance as a forage fish. Therefore, its economic value locally must be very slight.

SPAWNING

The presence of eggs of several different sizes within the ovary at one time, as will be pointed out subsequently, suggests a long spawning season. That the period of reproduction is a long one is substantiated by the presence of small fry, under 5.0 mm in length, in the tow from spring to autumn, or to be exact, from May 11 (1929) to October 5 (1927). Such small young were common from the last half of May, through June, July, and August. In September they became less numerous. It seems evident, therefore, that the spawning period extends from May to September,

inclusive, or possibly into the early part of October, with the principal spawning activities taking place during May, June, July, and August.

Adult fish were examined for their spawning condition only during July and August when the egg development reported upon in the following pages was studied. Nearly all the adults taken during July contained ripe or nearly ripe roe. However, during August the percentage of spawned-out fish increased steadily, indicating that the end of the spawning season was approaching.

"Nests" containing the eggs of this blenny have been found from time to time for several years and were first reported by Dr. R. E. Coker (in Smith, 1907, p. 377), who found them attached to "rocks, ascidians, shells, etc." During the present investigation they have been taken on ascidians only. The ova are neatly arranged in rather regular series and in a single layer. They are placed close together, but do not touch, and one nest may cover an area of 2 to 3 square inches.

Although naturally spawned eggs were taken several times, the development could not be observed satisfactorily within the nests, and it was found impracticable to remove the eggs from their place of attachment without injury. Therefore, other means and methods for their study had to be devised.

On one occasion ripe fish were secured and artificially spawned in a glass dish. The eggs adhered equally as tightly to the glass as to the ascidians.

Ripe or nearly ripe fish were confined in 1930 in a small aquarium, the bottom of which had been covered with microscope slides. It was hoped that the slides would receive the eggs when cast and, if so, they could be placed under the microscope for the study of the development. Eggs apparently were cast, as shown by "marks" on the slides where they had been attached. However, they apparently had been eaten by the fish. Thereupon, ripe fish were secured and the eggs were expressed directly on microscope slides where they were fertilized and then placed into sediment dishes, containing sea water, for development. The slides with the eggs attached were removed from the water from time to time for study under the microscope. The eggs did not suffer injury by being exposed to the air for several minutes at a time. By adding water at frequent intervals in sufficient amounts to keep them moist, the observation could be carried on as long as desired.

The presence of several different sizes of eggs within the ovary and the comparatively small number that ripens at one time suggest that this blenny spawns several times during a breeding season. The eggs in the "nests" observed also were in several different stages of development, ranging from apparently recently laid eggs to others with large embryos, showing that they were not all deposited at the same time. It is not known, however, whether a nest is the product of a single female or whether it receives eggs from two or more individuals. Since all the ovaries examined contained eggs of several sizes, it seems possible that a nest may be the product of a single female and that it returns from time to time to deposit additional eggs as they become mature. (See footnote 7, p. 578).

No males were found from which milt could be expressed. To obtain fertilization, males were killed, the testes removed, placed on a slide or in a small dish, with several drops of sea water, and cut and mashed into a pulp with a scalpel. Then the liquid was drawn off with a pipette, distributed over the freshly expressed eggs, and allowed to remain there for about 5 minutes before the eggs were transferred to sea water. Fertilization resulted readily.

It was not observed that the nests of *Hypleurochilus geminatus* are protected by a parent fish like those of *Hypsoblennius hentz* and *Chasmodes bosquianus*, as stated elsewhere in this paper. Since the eggs of nearly all species of blennies, as far as

known, are guarded by a parent fish, it seems probable that they are similarly protected in the present species.

DESCRIPTIONS OF THE EGG AND YOUNG

Description of the eggs.—Mature eggs within the ovary, according to preserved material examined, are slightly flat on one side to which a sort of disk, or "foot", is attached. Immediately after spawning the eggs adhere firmly, by means of this disk, to objects (probably principally ascidians in nature) with which they come in contact. The disk as seen under the microscope in newly spawned eggs is granular, slightly irregular in shape, and a little greater in diameter than the egg. The eggs are relatively small, as the diameter of 25 ova secured from several different females (measured in the same plane as the surface to which they were attached) ranged from 0.6 to 0.75 mm, with an average of 0.694 mm.

The mature unfertilized egg is so opaque that its structure cannot be seen definitely. The center of the egg as seen with the microscope, using transmitted light, is somewhat paler in color and more densely opaque than the rest of the egg. The pale center is surrounded by purple and orange spots, or spheres, which vary among themselves

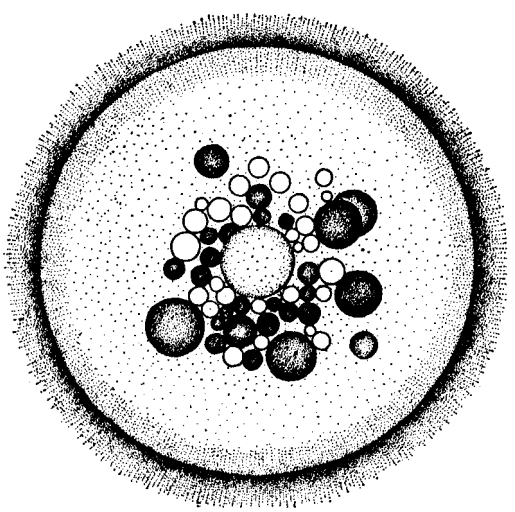

FIGURE 91.—*Hypleurochilus geminatus.* From egg before fertilization. The adhesive foot is shown extending beyond the outline of the egg.

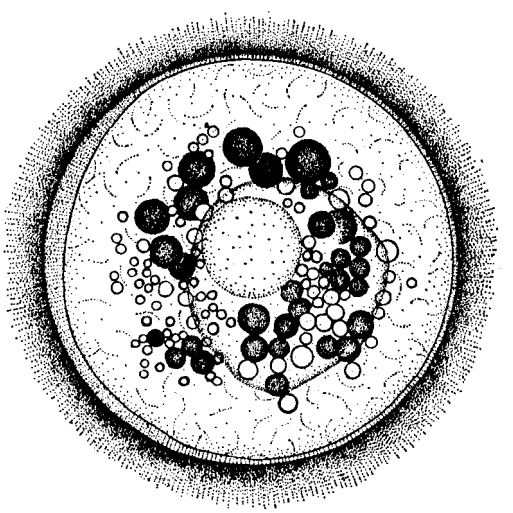

FIGURE 92.—*Hypleurochilus geminatus.* From egg with blastodisc, shortly before the first cleavage; about 25 minutes after fertilization.

in the intensity of their color. By changing the focus of the microscope a slight network of cellular structures, too, is evident on the surface of the egg. The perivitelline space is very small and the yolk is slightly granular (fig. 91).[10]

Segmentation and the development of the embryo.—Fertilization does not cause a change in the size and shape of the egg. The blastodisc becomes evident about 25 to 35 minutes after fertilization at a water temperature of about 28° C. It is not a perfect disc, however, as it is somewhat irregular in shape and generally slightly elongate. Neither does it occupy the center of the upper surface of the egg. Owing to the density of the egg its outline usually cannot be seen definitely (fig. 92).

The first cleavage occurs about 1¾ to 2 hours after fertilization at a water temperature of 27° to 28° C. The cells, while not plainly visible throughout, appear unequal in size. Some variation in this respect, however, is evident. Upon completion of

[10] Figures 89 to 102 were drawn from live material; those from 103 to 107 from preserved specimens.

the first cleavage some influence is exerted on the color markings within the egg (previously described as clustered rather closely around the opaque center), which suddenly, as through an explosion, become rather widely scattered within the egg (fig. 93).

The second cleavage plane generally follows the first very quickly. In fact some eggs reach the four-cell stage as quickly as the two-cell stage is attained in others. An irregularity in size and shape of the cells remains evident. It is obvious, also, that the purple and orange markings have increased somewhat in size (fig. 94).

The eight-cell stage may be expected about 2¼ to 3 hours after fertilization, when the water temperature ranges from 27° to 28° C. The cells, although not plainly evident throughout, appear even more irregular and unequal in size than in the earlier stages. The purple and orange spots, or spheres, have continued to increase in size,

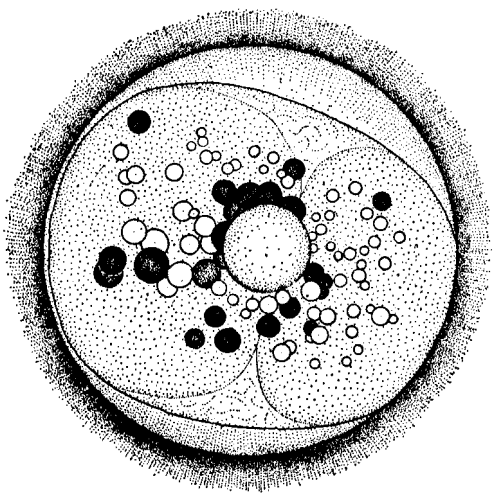

FIGURE 93.—*Hypleurochilus geminatus*. From egg in 2-cell stage; 1¾ hours after fertilization.

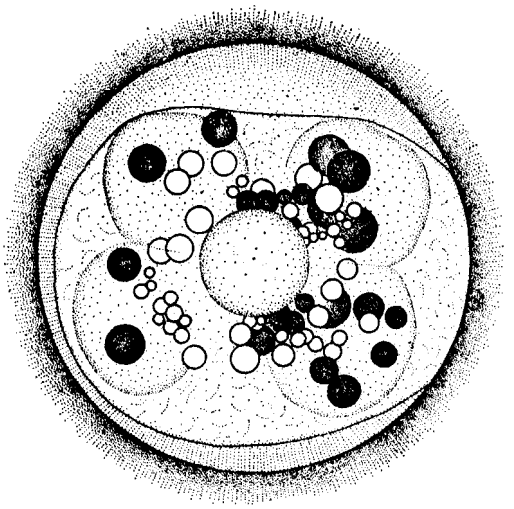

FIGURE 94.—*Hypleurochilus geminatus*. From egg in 4-cell stage; 1¾ hours after fertilization.

some of them being nearly twice as large as in the four-cell stage, and they cover most of the germinal disc, further obscuring vision of the segmental processes (fig. 95).

The eggs that failed to adhere to the slides by means of the foot, because of crowding or other causes, did not develop. It is important, therefore, that they become attached in the proper position. Judging from the neat and even arrangement of the eggs in the "nests", it would seem highly improbable that a loss from a similar source would occur in nature.

The 16-cell stage follows the 8-cell stage rather quickly and may be expected within about 2¾ to 3½ hours after fertilization at a water temperature of 27° to 28° C. The cells remain irregular in shape and unequal in size. The germinal disc now spreads over nearly the entire upper surface of the yolk (fig. 96).

Cell division continues to progress rapidly, the 32-cell stage following the 16-cell one very quickly. Owing to the opaqueness of the egg and the large color markings, segmentation is very obscure and it generally cannot be followed after the 32-cell stage is reached. The germinal disc now appears to cover the entire upper surface of the yolk. The large opaque center of the egg remains unchanged. In the advanced cell stages the purple spots, varying among themselves in intensity, have all become somewhat less brilliant in color and are irregularly distributed in the yolk. The

orange and yellow spots, too, are much scattered, but appear to remain unchanged in the intensity of color.

It has been stated that the development cannot be followed for some time after the early cleavage stages, owing to the opaqueness of the egg. As a result, the next phase in the process that is clearly evident is the appearance of a notch in the edge of the yolk which no doubt is occupied by the head of the newly formed embryo. This stage is reached in about 20 to 40 hours at a water temperature of 27° to 28° C. (fig. 97).

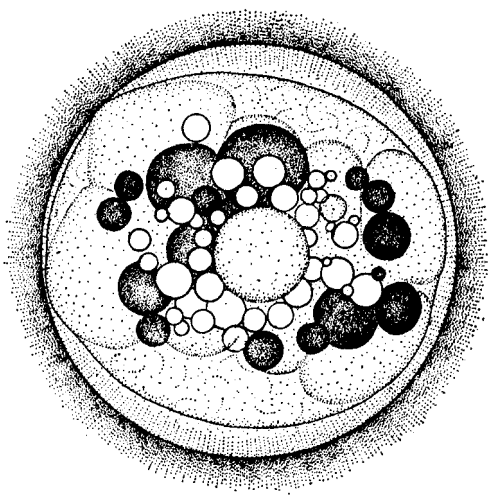

FIGURE 95.—*Hypleurochilus geminatus*. From egg in 8-cell stage; about 2¼ hours after fertilization.

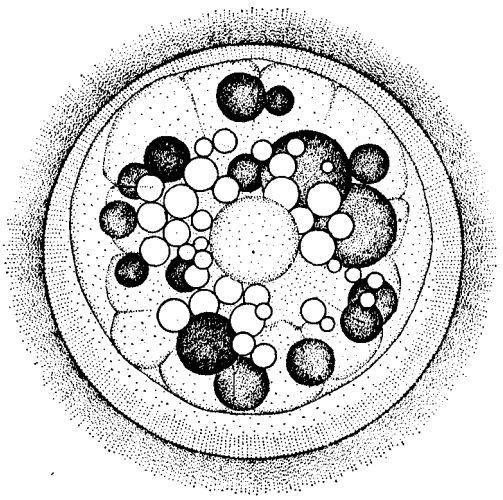

FIGURE 96.—*Hypleurochilus geminatus*. From egg in about 16-cell stage; 2¾ hours after fertilization.

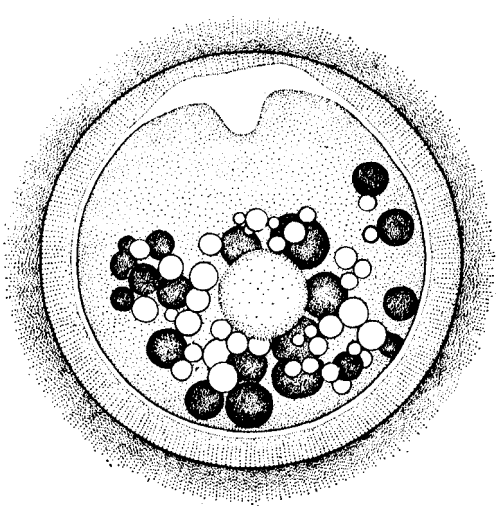

FIGURE 97.—*Hypleurochilus geminatus*. From egg showing early stage of differentiation of embryo, 21 hours after fertilization.

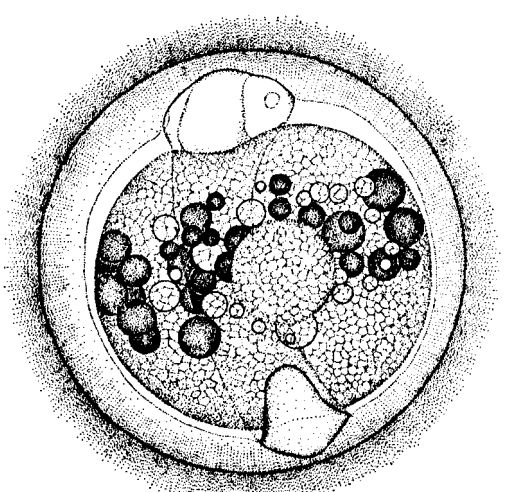

FIGURE 98.—*Hypleurochilus geminatus*. From egg with well-differentiated embryo; 26 hours after fertilization.

The outline of at least the head (with large eyes) and tail, which extend beyond the periphery of the opaque yolk, becomes distinctly visible about 25 to 27 hours after fertilization at a water temperature of 27° to 28° C. It is evident now that the embryos are not all in the same position. Some of them lie above the yolk, others curve underneath it, and still others occupy positions intermediate between the ones mentioned (fig. 98).

Very soon after the embryo becomes well differentiated the purple spots become quite diffuse and shortly disappear. The pale, densely opaque center and the yellow spheres persist somewhat longer. At about this stage two black wavy lines or bars become evident on the yolk. These bars usually meet at one end in the form of a U or a V, although occasionally they are separate. The cellular structures on the yolk of the egg, mentioned previously, have become smaller and much less definite.

About 48 hours (2 days) after fertilization at a water temperature of 26° to 28° C. the embryo has nearly encircled the egg. Several somites are visible, but a definite count cannot be made. Circulation is evident. The heart is located under the anterior part of the head, from which a large blood vessel rises and courses through the length of the embryo to near the tip of the tail and then runs across the yolk back to the heart. If other blood vessels are present, they cannot be seen. The embryo already is capable of some movement. The black bars on the yolk, previously mentioned, are now broad and distinct and show indications of breaking up into spots in some specimens. The opaque center of the egg has disappeared, and very rarely a few spots, previously purple but now changed to pink, remain. In some eggs yellow spots are still definitely present. In others they seem to have become diffuse, giving the yolk a yellowish tinge (fig. 99).

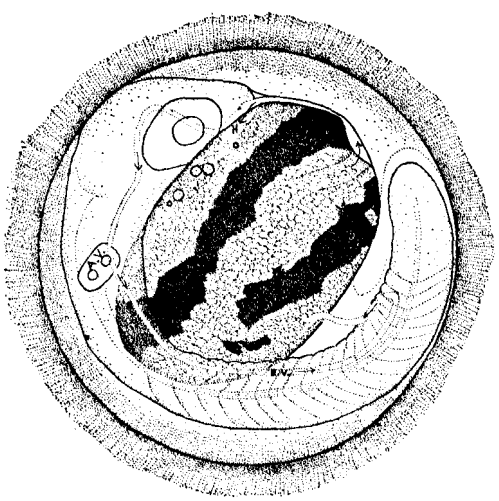

FIGURE 99.—*Hypleurochilus geminatus.* From egg with well-developed embryo; 2 days after fertilization. AV, auditory vesicle; H, heart; BV, blood vessels. Arrows indicate direction of flow of blood.

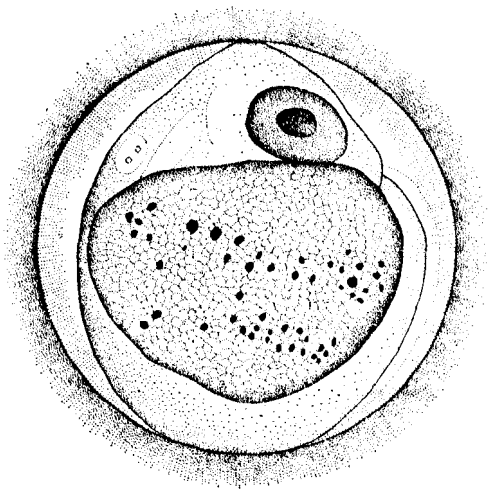

FIGURE 100.—*Hypleurochilus geminatus.* From egg with moderately large embryo, encircling the egg; 3 days after fertilization. Note pigment on the eye and compare pigment on the yolk with that shown in figures 98, 99, and 101.

About 72 hours (3 days) after fertilization, at a water temperature of 26° to 28° C., the embryo slightly more than encircles the egg, although its entire outline generally cannot be seen. The eyes now are completely pigmented with black and overcast with green, particularly above the pupil. Circulation is brisk. The violet colors have entirely disappeared from the yolk, but a few yellow spheres still persist in some specimens. The two dark bars on the yolk usually are broken up into dark spots at this stage. Considerable variation in this respect, however, was noticed. The yolk has been reduced greatly and now occupies only about half the space within the egg case (fig. 100).

Development progresses rather slowly in the advanced embryonic stages. About 96 hours (4 days) after fertilization, at a water temperature of 26° to 28° C., the embryo has curved somewhat further round the periphery of the egg than in the last-

described stage (72 hours), and shows greater activity. The tail appears to be quite free and the eyes, which are very prominent, frequently are "rolled" within their sockets. Circulation is very brisk, corpuscles now being plainly evident in the blood. The aorta can be seen to turn on itself in the tail of the embryo in those specimens that happen to be in such a position that a lateral view is obtainable. Several blood vessels are now visible in the yolk. Some golden color markings without definite outlines have appeared on the head of the embryo in some of the eggs and mixed with the golden color are two dark chromatophores. The yolk which has become greatly reduced and somewhat half-moon shaped usually is marked with several large irregularly shaped dark spots or blotches. Much variation in the size, shape, and number of these spots exists among specimens. One specimen, for example, had a single large elongate black blotch, whereas others had many smaller spots. A few specimens were seen in which a few yellow spheres remained in the yolk. The egg remains round, as seen from above in its attached position, and according to measurements made of four eggs no measurable change in the diameter has occurred (fig. 101).

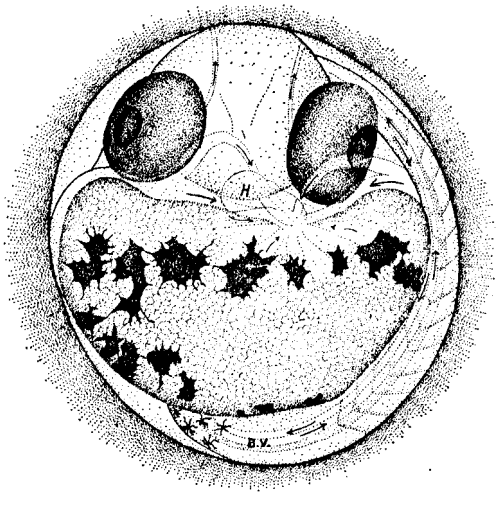

FIGURE 101.—*Hypleurochilus geminatus*. From egg with large embryo: 4 days after fertilization. H, heart; BV, blood vessels. Arrows indicate direction of flow of blood.

Hatching begins during the sixth or seventh day after fertilization when a temperature of about 26° to 28° C. prevails, and it may extend over a period of at least 24 hours. That is, among a batch of eggs all fertilized at the same time, some of the eggs may hatch fully a day earlier than others. An incubation period of 6 to 8 days at the comparatively high temperature which pervailed during the present study is regarded as a very long one for such a small egg. Many other marine fish eggs of similar size which have been studied hatched in 2 to 3 days.

Just before hatching, the eggs become somewhat distorted, that is, the portion of the egg case at the head of the embryo protrudes, causing the egg to become elongate and to have a somewhat uneven outline. The egg and embryo are more opaque than previously and the structures are even more difficult to see. On the head of the embryo is a network of yellow and black markings, and at midbody length are dark, more or less branched, cross lines. The embryo is capable of much movement and appears to struggle, probably in an effort to break the egg case.

Newly hatched fish.—The newly hatched fish is close to 2.4 mm long. It emerges with an extremely small yolksac. Although the fish is very stocky anteriorly its tail is long and rather slender; preanal length is contained 2.45, and postanal length 1.7 times in total length without the caudal fin membrane. The head is blunt, the mouth large and slightly inferior, and the pectoral finfold is prominent. The eye is relatively large, much longer than the snout, and nearly half the length of the head. About 26 myomeres are present. The body is quite transparent and the outline of the brain, the heart, and the circulation can be seen rather plainly.

The head and trunk are largely overcast with a yellowish tinge; two irregular dark spots (or simply a blotch in some specimens) are present below the auditory vesicle; a large dark area is present on the upper part of the abdominal mass; and

generally several dark chromatophores occupy the ventral edge of the abdomen, besides a few to several dots which are variously distributed. Dark bars, appearing as spots in a lateral view, are present on the ventral edge of several of the caudal myomeres in some specimens, and on most of them in others. The large eyes are black with a greenish sheen over the pupil. The newly hatched fish swims or floats on its back and is very active (fig. 102).

The fish hatched in the laboratory lived only about 2 days. No change worthy of note, except that the color on the abdomen became more diffuse, took place in the meantime.

Newly hatched larvae of this species are a little smaller (length 2.4 mm) than those of *Hypsoblennius hentz* (length 2.7 mm). The larvae of the latter species are also rather more stocky anteriorly. Furthermore, the black marks on the abdomen appear as separate branching chromatophores and are quite generally distributed, whereas in *H. geminatus* the black is concentrated mostly on the side near the upper margin of the

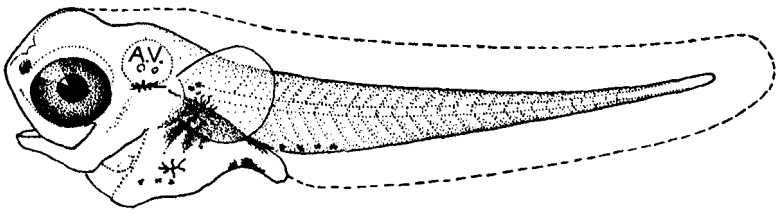

FIGURE 102.—*Hypleurochilus geminatus.* From a newly hatched fish 2.4 mm long when alive. AV, auditory vesicle.

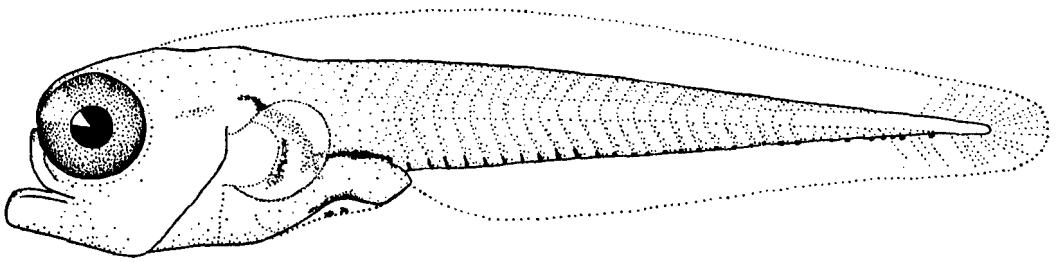

FIGURE 103.—*Hypleurochilus geminatus.* From a preserved specimen 1.6 mm long. This larva is smaller than the newly hatched live fish (Fig. 102) quite certainly because of shrinkage in preservative.

abdominal mass into almost solid black with only a few scattered chromatophores elsewhere. In *H. hentz* most of the inner surface of the pectoral fin membrane is dotted with black branching chromatophores, whereas in *H. geminatus* only a few black dots at most are present at the base of this fin.

Specimens 1.5 mm long.—The head and trunk in preserved specimens of this size are short and rather robust, while the tail is long, rather slender and compressed, the head and trunk being contained about 2.4 to 2.9 times in the total length without the caudal finfold. The snout is very short and round, scarcely extending beyond anterior margin of eye. The mouth is small, oblique, and terminal, with the tip of the lower jaw slightly below the level of the middle of the eye when the mouth is closed. The vertical finfold is continuous and without rays. The pectoral fins appear as mere tufts of membrane, scarcely longer than the pupil and the ventral fins are not evident. An oblique dark bar extends from the axile of the pectoral to the ventral outline just above the vent; the ventral surface of the chest and abdomen generally is marked with a few to several dark points; and a distinct dark bar crosses the forehead between the eyes. A rather close-set row of fine, vertically elongate, dark spots is present on the ventral outline of the tail, and the base of the rudimentary pectoral is mostly black (fig. 103).

Blennies of this size are difficult to identify. However, the specimens assigned to this species are a little less robust than those referred to *Hypsoblennius hentz*. Furthermore, those of the last-mentioned species have rather larger pectoral fin membranes with the basal two-thirds or three-fourths spotted with black, whereas specimens of *H. geminatus* have black only on the fleshy base of that fin.

It will be seen from the two foregoing descriptions that the live fish at hatching are longer than the larvae just described, although the latter are somewhat more advanced in development. The difference, no doubt, is the result of shrinkage during preservation in the last-mentioned group.

Specimens 2.0 to 3.0 mm long.—The body is rather strongly compressed throughout, the head being about half as broad as deep. The head and trunk are short in proportion to the tail, the distance from the tip of the snout to the vent being contained about 2.9 times in the total length without the caudal finfold. The snout, although rather blunt, especially in 2.0-mm fish, is more pointed than in *Hypsoblennius hentz* and about one-third (in 2.0-mm fish) to two-thirds (in 3.0-mm fish) the length of the eye. The mouth is terminal and strongly oblique, with the tip of the lower jaw a little above the level of the middle of the eye when the mouth is closed. The vertical finfold is continuous with indications of rays posteriorly in 3.0-mm fish, but not in smaller ones. The pectoral fins are short and broad and scarcely longer than the eye.

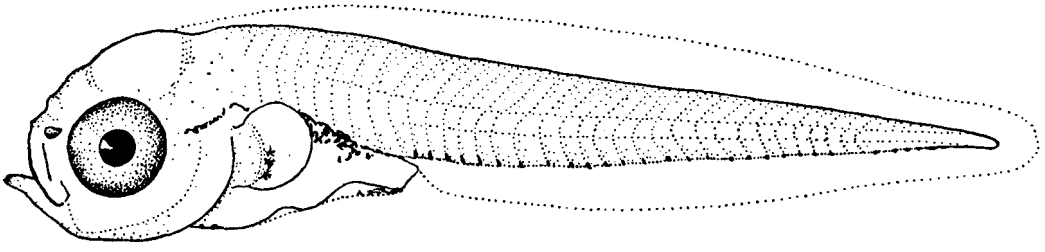

FIGURE 104.—*Hypleurochilus geminatus*. From a larva 2.1 mm long from the tow.

A broad black oblique band extends from the axile of the pectoral to ventral outline just above the protruding hindgut. The ventral outline of the chest and abdomen usually bear a few dark dots, the upper surface of the head and nape generally has one or more dark chromatophores, and usually a faint dark bar across the forehead between the eyes. A row of small, vertical, slightly elongate dark spots is situated on the ventral outline of the tail. Dark dots also are present on the base of the inner surface of the short pectorals (fig. 104).

This species is distinguished from *Hypsoblennius hentz* at this size chiefly by the longer and more pointed snout, less strongly elevated forehead, the more strongly oblique mouth, and the much shorter and broader pectorals which bear dark dots only at the base on the inner surface, whereas in *H. hentz* the dark specks extend to the tips of the fins. These differences are evident in specimens as small as 2.0 mm in length. Smaller larvae, as already stated, are difficult to identify.

Specimens 4.0 to 4.5 mm long.—The head and body are compressed, the caudal portion of the body being longer than the head and trunk, with the vent situated well in advance of midbody length. The head is deep and rather narrow, the interorbital space being only about half the width of eye. The snout is moderately pointed and about three-fourths as long as eye. The mouth is terminal, rather strongly oblique, the tip of the lower jaw being scarcely below the level of the middle of the eye. The eye is placed moderately high and is about equidistant from the dorsal and ventral

outlines of the head. Fin rays are only partly developed in the dorsal and anal fins, but much better in the caudal fin which has a round outline. Ventral fins are not evident and the pectoral fins are short and broad, and scarcely longer than the eye. Several more or less distinct dark dots are present on the ventral surface of the chest and abdomen, and on the head and nape; an obscure dark bar crosses the forehead between the eyes. An oblique black bar extends from the axile of the pectoral nearly to the vent; and the inner surface, only, of the base of the pectoral is black. A row of small black dots begins a short distance behind the vent and extends to the base of the caudal fin (fig. 105).

Specimens of this species at this size differ from those of the same size of *Hypsoblennius hentz* principally in the longer and more pointed snout, more strongly oblique, terminal mouth, in the much shorter pectoral fins, which are black at the base on the inner surface only, and in the somewhat more anterior position of the vent, the caudal portion of the body being longer than the head and trunk.

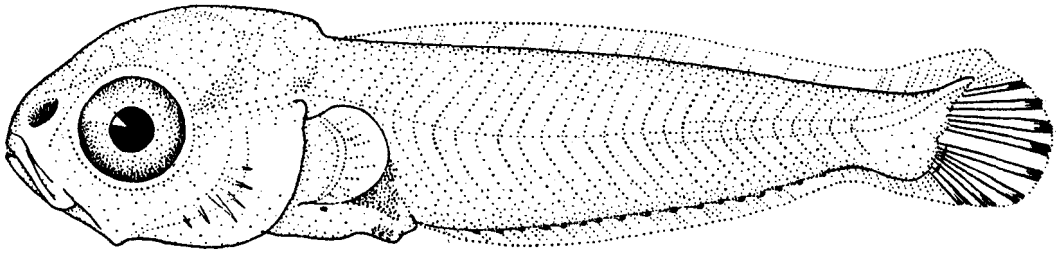

FIGURE 105.—*Hypleurochilus geminatus*. From a young fish 4.5 mm long.

Specimens 5.0 to 6.0 mm long.—The body is moderately deep and rather strongly compressed, having made no pronounced change in shape since a length of 4.0 mm was attained. The snout is slightly more rounded than in smaller specimens and usually only a little shorter than the eye. The interorbital is strongly convex and somewhat narrower than the eye. The mouth is terminal and the tip of the lower jaw is on or somewhat below the level of the center of the eye. The preopercle in some specimens shows indications of minute spines, but it appears to be smooth in others. Advancement in the development of rays in the dorsal and anal fins, since a length of 4.0 mm was attained, is not pronounced and a definite enumeration of the rays cannot be made. The caudal fin, however, has grown proportionately longer, is broadly rounded, and similar to the adult. Very minute ventrals are evident in only a few of the rather numerous specimens of this size examined. The pectorals have increased in proportionate length and frequently are about as long as the eye and snout. The black, confined to the inner base of the pectoral fin in smaller specimens, now extends somewhat on the lower rays of the fin, and the prominent oblique dark bar originating in the axile remains as described in smaller specimens. The ventral surface of the chest and abdomen usually bears several indefinite dark spots; the sides of the head generally have a few very small dark points; and the occipital surface of the head and nape has several more definite ones. A row of somewhat obliquely elongate dark spots begins a short distance behind the vent and extends to the base of the caudal fin, It is evident now that the spots are situated between the bases of the anal rays (fig. 106).

The principal characters distinguishing this species from *Hypsoblennius hentz* at this size do not differ greatly from the ones mentioned for specimens 4.0 to 4.5 mm in length. The snout in *H. geminatus* remains longer, although scarcely as pointed; the mouth is terminal and more strongly oblique; the pectoral fins, although they have

increased in proportionate length, remain shorter and the black on their bases is much less extensive. *H. hentz*, in the meantime, has developed a bony ridge over and in advance of the eye making the interorbital quite flat. This bony ridge is entirely missing in *H. geminatus* and the interorbital is strongly convex.

Specimens 8.0 to 10 mm long.—The body is moderately elongate and rather strongly compressed, the depth being contained about 5.3 to 5.7 times in the length without the caudal fin. The head is moderately deep; the snout tapers and is about three-fourths as long as the eye; and the forehead is not very steep, being rather evenly and fairly strongly convex. The mouth remains rather strongly oblique and terminal, as in smaller specimens. The tip of the lower jaw is slightly below the level of the middle of the eye, and the maxillary reaches only a little past the anterior margin of the orbit. The interobital remains strongly convex, with only slight indications of a bony ridge over and in advance of the eye. Very small preopercular spines are present, the longest scarcely exceeding the length of the pupil. The dorsal and anal fins are quite fully developed and a fairly accurate count of the rays can be made. The caudal fin has a straight to a round margin and is nearly as long as the head without the snout.

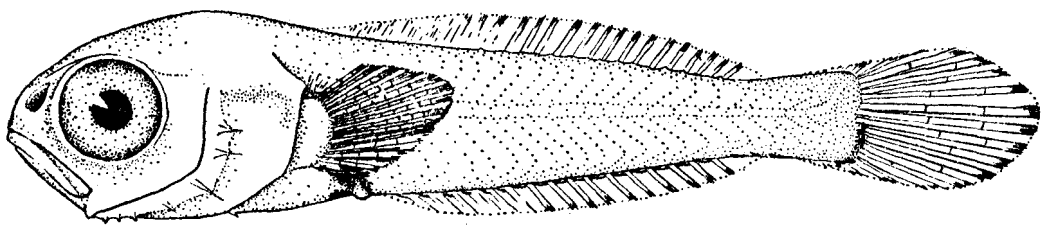

FIGURE 106.—*Hypleurochilus geminatus*. From a young fish 6 mm long.

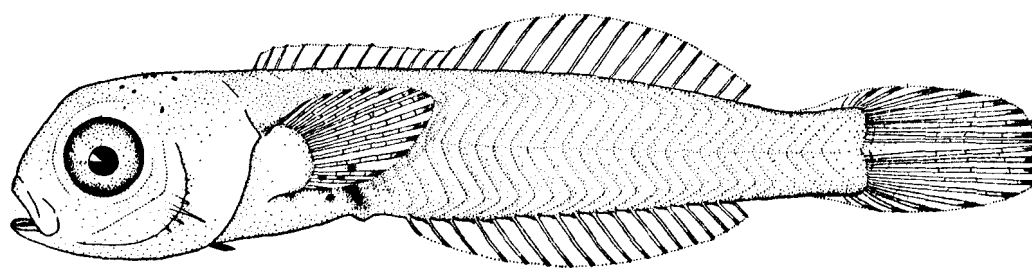

FIGURE 107. *Hypleurochilus geminatus*. From a young fish 8.5 mm long.

The ventral fins remain very small in specimens 8.0 mm long, but have increased considerably in length in fish 10 mm long, when they are about equal to the eye. The pectoral fins are broad at the base, the middle rays being somewhat produced and about as long as the head without the snout. The ventral surface of the chest and abdomen usually bears a few to several dark dots, sometimes a few dark markings also are present on the sides of the head, and the occipital portion of the head is marked either with small dark dots or with somewhat larger, less well-defined dark or brownish spots. The pectoral fin has a few to several dark dots at the base on its inner surface, and the oblique dark bar behind the pectoral, prominent in smaller specimens, has become quite indistinct in some specimens. Small elongate dark dots situated between the bases of the anal rays, described in smaller specimens, have become more elongate. Each one bends back abruptly and reaches the ray situated immediately behind it a short distance above the base of that ray (fig. 107).

The characters distinguishing the young of this species, when 5.0 to 6.0 mm long, from *Hypsoblennius hentz* of the same size, in general, also separate young 8 to

10 mm long. The difference in the depth of the body is somewhat more evident than in smaller fish, *H. hentz* being notably deeper and also somewhat stockier. The much longer preopercular spines, particularly those at the lower posterior angle in *H. hentz*, too, are useful in separating the species. Another helpful difference is found in the shape of the dark dots at the base of the anal, which have become elongate and form lines in *H. geminatus*, whereas they are round in *H. hentz*.

Specimens about 12 mm long.—The body has increased somewhat in robustness since a length of 10 mm was reached, but it remains much more slender than in specimens of *Hypsoblennius hentz*, of this size, the depth being contained in the length without the caudal fin 4.4 to 4.75 times. The forehead is strongly convex, but not vertical; the snout projects quite prominently, being fully three-fourths as long as the eye; and the mouth is terminal and only slightly oblique, with the tip of the lower jaw scarcely above the level of the lower margin of the eye. A low bony ridge, evident over the eye in somewhat smaller specimens, is scarcely visible now and the interorbital remains strongly convex. Minute preopercular spines remain present and do not seem to have either increased or decreased in proportionate length since the fish attained a size of 10 mm. A small fleshy tentacle, notably shorter than the pupil, is visible over the eye for the first time. The dorsal spines, as in the adult, are shorter than the soft rays of that fin; the caudal fin has a nearly straight margin; and the ventral fins have increased in proportionate length, being almost twice as long as the eye. Pigmentation remains virtually as in the smaller fish described in the preceding paragraph (fig. 108).

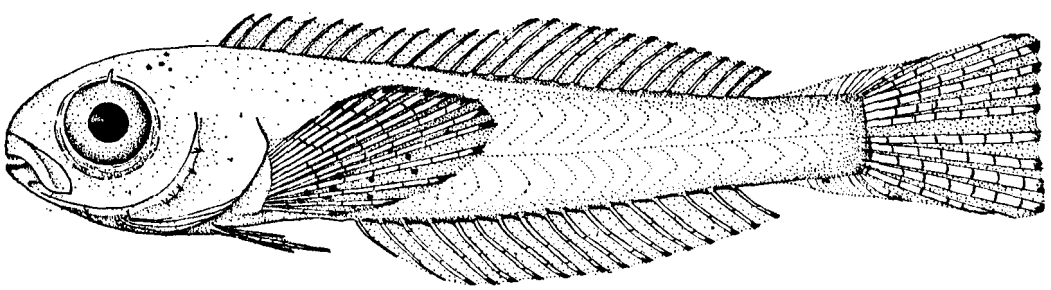

FIGURE 108.—*Hypleurochilus geminatus*. From a young fish 12 mm long.

Hypsoblennius hentz is distinguished from the present species at this size (as in smaller fish) by the vertical forehead, the slightly inferior horizontal mouth, the prominent bony ridge over and in advance of the eye, by the much larger preopercular spines, and by the greater amount of black color on the pectoral fins.

Specimens 15 to 16 mm long.—Specimens of this size are very similar in shape to the adult, and they have the appearance of being much older fish than 12- or even 14-mm specimens. The body has become deeper and more robust, the depth being contained in the length, without the caudal fin, 3.3 to 3.6 times. The snout projects rather prominently in advance of the forehead and it is nearly or quite equal to the length of the eye. The small mouth is now wholly below the level of the lower margin of the eye. It is almost horizontal, as in the adult. The lower jaw is slightly shorter than the upper one and the maxillary scarcely reaches beyond the anterior margin of the pupil. Preopercular spines, present in somewhat smaller specimens, are not evident. Three or four fleshy tentacles, placed close together and in a transverse row and rising from a common base, are present over each eye, the longest one being about as long as the pupil. Another fleshy tentacle is present behind the nostril. The fins are all shaped virtually as in the adult. The color cannot be fully described,

as only old alcoholic specimens (collected in 1912 and 1913) of this size are at hand. They are rather pale in color and have only a few dark points in advance of, as well as behind, the ventral and pectoral fins. Similar dots occur on the occipital portion of the head, and a row of elongate dark spots are present on the base of the anal fin (fig. 109).

Specimens 20 to 22 mm long.—A canine tooth on the posterior part of each jaw, constituting a generic character, has become evident at about this size. Pigmentation is general and complete, and similar to that of the adult. Recently preserved specimens (which do not differ greatly in color from live fish) are brownish. Some are plain dark brown and others, somewhat lighter in color, have indications of dark bars on the upper part of the sides. Indefinitely outlined dark spots are present along the middle of the sides and also on the base of the anal fin. The dorsal and anal fins are profusely dotted with brown, similar to the body, as seen under magnification. A dark spot is present on the membrane between the first two dorsal spines, the margin of the anal is pale, and the caudal fin has dark cross bars. The ventral and pectoral fins are finely dotted like the dorsal and anal, and the pectorals in addition bear larger dark spots.

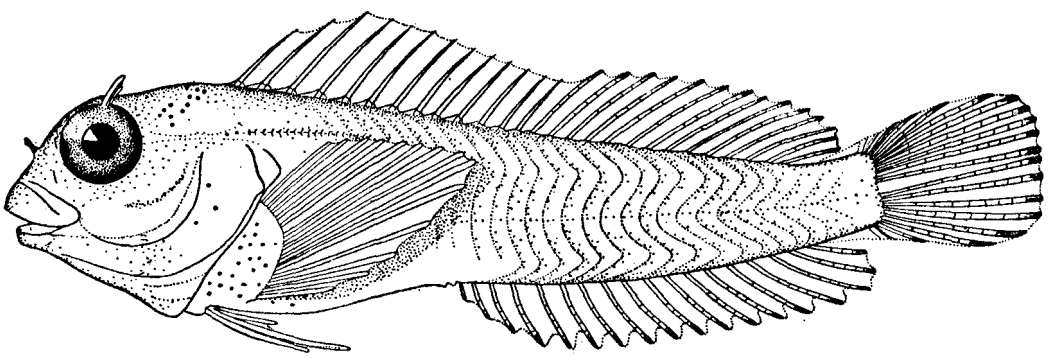

FIGURE 109.—*Hypleurochilus geminatus.* From a young fish 16 mm long.

Specimens 20 to 22 mm long virtually are "young adults" with posterior canines, and with the color almost identical with that of the adult. The size of the fish at which general pigmentation takes place, however, has not been determined, as only greatly bleached alcoholic specimens ranging from 14 to 18 mm in length are at hand. It can be stated at this time only that general pigmentation has not begun at a length of 14 mm, whereas it is complete at 20 mm.

DISTRIBUTION OF THE YOUNG

The fry were taken in towings in outside waters 76 times and in inside waters 12 times. No record of the numbers of towings taken was kept, but it is probable that nearly as many hauls were made in inside waters as in the outside ones. The collections show, therefore, that the young are more numerous off Beaufort Inlet than they are in Beaufort Harbor and adjacent sounds and estuaries.

The fry were taken in surface towings 65 times and in bottom hauls only 16 times. Although a considerably larger number of surface than bottom hauls was made, the discrepancy in the numbers of hauls certainly was not great enough to equalize the difference. Furthermore, in 1927 and 1928 the surface and bottom hauls were nearly equal in number and during those years the fry occurred in surface towings 51 times and in bottom drags 9 times. Since the bottom nets were not

closed while they were hauled in, it is possible that some of the fry caught may have been taken somewhere between the bottom and the surface. The larger fry (5.0 to 10 mm) were taken no more frequently in bottom drags than the smaller ones. Therefore, the evidence is that the larvae of this species, until a length of about 10 mm is reached, live in the open waters and are chiefly surface dwelling.

Fish of all sorts, after reaching a length of about 10 to 15 mm, are taken sparingly in 1-meter tow nets. Many species at this size may be taken in an otter trawl, having the cod end covered with bobbinet. That mode of collecting failed, however, for the present species, very probably because the fish no longer occurred in the open waters. The usual habitat of the adults, as stated elsewhere, is among marine growths attached to wharf and bridge piling, rocks, shells, etc., and specimens as small at 16 mm in length have been taken in such an environment. However, no special effort to collect small fish in the favorite haunts of the adults has been made. It seems probable that the young fish, after abandoning the open waters, take up their abode with the adults and that they will be found there when collections are made with suitable apparatus.

GROWTH

The data on the rate of growth are meager, owing to the scarcity in the collections of specimens ranging from about 10 to 15 mm in length. A change in habitat apparently takes place at about this time in the life of the fish, as already shown. The new habitat is not well known and requires further exploration. Examples around 8.0 mm long occurred in the tow as early as June 2 (1928), and are rather common thereafter throughout the summer. Also, several specimens about 10 mm long were caught in the tow during the summer, the first one of this size having been taken on July 3 (1928). However, a larger one (12 mm) was caught as early as June 28 (1927). These data indicate, therefore, that the larval stages are passed rather quickly and that a length of 8.0 to 10 or even 12 mm may be attained within 1 to 2 months after hatching.

Specimens 16 to 22 mm long were dredged on shelly bottom and caught on wharf piling in July and August. Such fish are "young adults" and may or may not belong to an older year class. They, at least, look much older and more mature than the single 14-mm specimen secured in the tow. The indications are, therefore, that no great increase in length takes place at the time (between about 14.0 and 16.0 mm) when the fish acquires nearly all the characters of the adult. It is during this time and probably somewhat earlier, as already pointed out, that the fish leaves the surface waters and begins to live with the adults among marine growths attached to rocks, shells, submerged timbers, wharf piling, and other objects.

CHASMODES BOSQUIANUS (LACÉPÈDE). BANDED BLENNY

This blenny is not very common at Beaufort, and the least numerous of the three local species. It is reported from New York to Florida, apparently being more numerous in Chesapeake Bay than elsewhere. It may be distinguished from the other blennies occurring locally by the more pointed snout, by the larger mouth (the maxillary reaching to or past posterior margin of the eye), the absence of canine teeth (present in *Hypleurochilus geminatus* only), by the rather longer dorsal and anal fins (the dorsal formula being XII, 18, and that of the anal II, 17 or 18), and the fewer rays in the pectoral fin (12, rarely only 11).

Insufficient specimens are at hand to determine the relative sizes attained by the sexes. No males or females exceeding a length of 70 mm were seen at Beaufort.

The secondary sex characters do not differ noticeably from those of the other local species. Each anal spine bears a fleshy expansion at the tip in adult males, and a membranous expansion is present immediately in advance of the anal fin. Also the female has a more or less distinct anal papilla (fig. 110).

This blenny apparently inhabits shelly bottom only at Beaufort, though in Chesapeake Bay it was taken on clay, mud, and sand (Hildebrand and Schroeder, 1928, p. 333). A few specimens were taken at Beaufort in nets hauled over shelly grounds. A somewhat larger number of fish, however, was taken by hand in oyster, clam, and scallop shells. The shells were occupied not only during the spawning season, but at other times also and by both sexes.

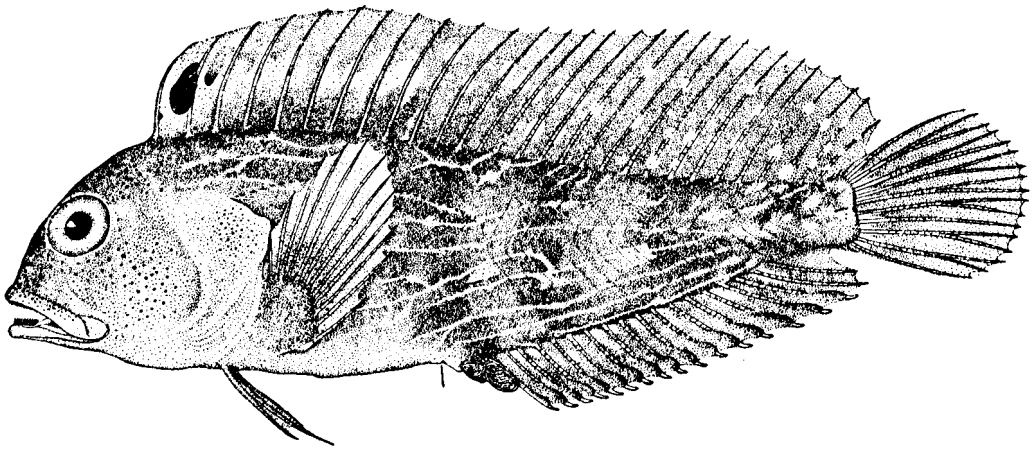

FIGURE 110.—*Chasmodes bosquianus*. From adult male.

The banded blenny is hardy. It lives well in confinement, and during cool weather at least it can live out of water a long time. For example, on the afternoon of November 24, 1927, an individual occupying a scallop shell containing some sand and mud was picked up by hand. It was placed in a dry container with the shell and left over night. The next morning the fish was still in a lively condition. Upon being placed in an aquarium it at first deserted the shell, but soon afterwards reoccupied it. It lived in the aquarium for several weeks, and allowed itself to be lifted from the water with the shell numerous times. Some of the nests found were so near the usual low-tide line that they must become exposed when rather exceptionally low tides occur. At such times if the male fish guarding the nest does not desert it, he may have to live for a while either without water, or at most only from water brought by the wash of waves. Observations indicate, however, that if the nest is deserted the eggs most probably will be destroyed soon by enemies, as explained subsequently.

This little fish is game and when handled fights vigorously. It will grasp the skin and flesh of the hand and hold on bulldog fashion. However, its jaws and teeth are too weak to inflict a wound.

The illustrations of the development of the egg and of the newly hatched fish, presented herewith, are all based on live specimens. The young were not taken in collections made in nature, and those hatched in the laboratory died within a day or so after hatching. Consequently, no material for the study of their development is available.

SPAWNING

This blenny, like the others reported upon in this paper, evidently does not spawn all of its eggs at one time, as ova of several different sizes are present in the ovary during the spawning period. The length of the spawning season has not been determined fully. The young have not been taken, and insufficient adults have been collected to make a full determination from the study of the gonads. However, a nest was found as early as May 15 (1920), and as late as August 14 (1930). Other nests were taken in June and July. Hildebrand and Schroeder (1928) report a nest taken May 22 (1922), at Cherrystone Island, Va. From these data it may be concluded that the spawning season extends at least from May to August.

The nesting habits of this blenny, so far as known, are identical with those of *Hypsoblennius hentz*. The eggs have been found only in oyster shells, although clam and scallop shells probably also are used. A full nest covers the entire inside of both valves of an oyster shell. The eggs are firmly attached in a single layer, though not always in definite rows, and are well separated by the adhesive disk which has a greater diameter than the egg itself. For study, the eggs with the disk may be removed from the shell with a sharp instrument, but the disk could not be separated from the egg.

In this species, as noted for *Hypsoblennius hentz* and *Hypleurochilus geminatus*, the eggs in a nest are not all in the same stage of development, a range from an early cleavage stage to an advanced embryonic stage having been observed. The remarks made under the discussion of *Hypsoblennius hentz* (p. 578) as to whether all the eggs in one nest are the product of one female apply equally as well to *Chasmodes bosquianus*.

Presumably the nests are always guarded by the male, as already indicated. The care of the male is evidently necessary to prevent the destruction of the eggs by enemies and to keep them clean and healthy. The eggs in a deserted nest in nature were destroyed quickly by the small flat mud crab, *Eurypanopeus depressus* (Smith), that also attacked the eggs of *Hypsoblennius hentz* (p. 579). Those in two other deserted nests, placed in tanks with running water, all died in an advanced embryonic stage, having become infested with hydroids and a copepod, *Tisbe furcata* (Baird).[11] A small percentage of several dozen eggs removed from a nest when in rather early developmental stages and placed in glass bowls, in which the water was changed twice daily, hatched successfully.

Spawning in this species, as in *Hypsoblennius hentz*, apparently takes place early in the morning, as only those nests taken before 10 o'clock contained eggs in the early cleavage stages.

DESCRIPTIONS OF THE EGGS AND THE NEWLY HATCHED YOUNG

Description of the egg.—The eggs of *Chasmodes bosquianus* are slightly flattened next to the adhesive disk or "foot" which attaches them to the inside of oyster shells and possibly to other bivalve mollusks also, as already explained. The eggs of the present species are larger than those of the other blennies discussed in the preceding pages. The greater axis has a length of 0.93 to 1.1 mm in 27 eggs measured and an average length of 1.04 mm. The lesser axis which cannot be measured accurately, because the grayish opaque adhesive disk obscures the outline of the egg, has a length of about 0.8 to 0.9 mm. The slightly flattened contour of the egg at the place of attachment is not shown in the drawings portraying lateral views, as the degree of depression could not be determined definitely.

[11] The writers are indebted to Dr. C. B. Wilson, State Teachers College, Westfield, Mass., for this identification.

The eggs as seen on an oyster shell with the unaided eye are very pale yellow. Under magnification just a tinge of yellow is evident. Numerous yellowish oil globules, mostly in that half of the yolk nearest the adhesive disc, are present. The eggs have a dense opaque central body, as in the other blennies studied. No bluish or reddish spots are present in the yolk and therein the eggs of this species differ conspicuously from those of the other local forms.

The eggs of this species apparently are even more opaque than those of the other blennies studied. The yolk is quite granular, becoming more so as development progresses. The egg membrane is cellular in appearance. When the microscope is refocused the lines have the appearance of deep ravines with elevations between them. This sculpture of the egg membrane is not shown in the accompanying illustrations. The adhesive disk described above, is shown in only one drawing (fig. 118), although of course it is always present.

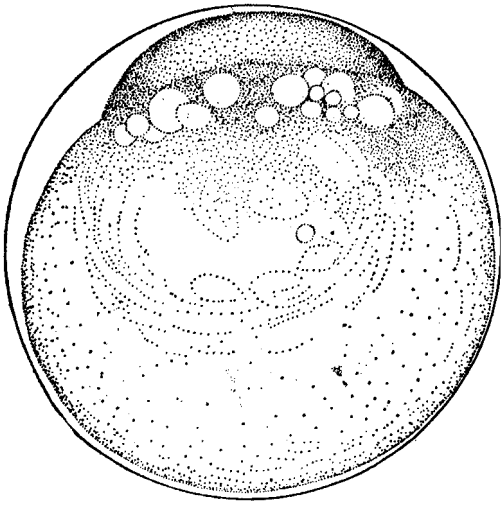

FIGURE 111.—*Chasmodes bosquianus*. From egg with blastodisc; shortly before the first cleavage; probably about an hour after fertilization. (Drawn by Nell Henry.)

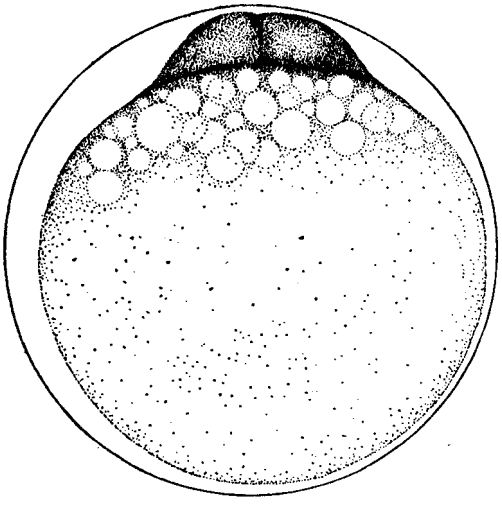

FIGURE 112.—*Chasmodes bosquianus*. From egg in 2-cell stage; about 2 hours after fertilization. (Drawn by Nell Henry.)

Segmentation and the development of the embryo.—The following account is based entirely upon eggs collected in nature. The exact time of spawning and fertilization is not known. Therefore, the time intervening between fertilization and the beginning of cleavage cannot be stated definitely. In a nest taken at 9:30 o'clock in the morning eggs were present in which the first cleavage took place about an hour after collection. It seems probable that these eggs were laid early on the morning the nest was brought to the laboratory, as already explained (p. 605). In *Hypleurochilus geminatus* about 2 hours intervened between fertilization and cleavage at a temperature of 26° to 28° C. It probably may be assumed that in Chasmodes about an equal length of time elapses between fertilization and segmentation, at nearly identical temperatures.

The blastodisc in all the eggs examined lay next to the adhesive foot by which it was largely obscured when viewed in the normal position. However, when the egg was turned so that the adhesive surface of the disk was at right angles to the side upon which it rested, a fair lateral view of the blastodisc and segmentation was obtainable. Accordingly, the illustrations showing different stages of cleavage are all lateral views. In general, only that part of the disc extending beyond the yolk is shown, as the opaqueness of the egg obscured the rest.

The blastodisc is large and projects prominently beyond the yolk. The pervitelline space is wide at the positive pole of the egg and very narrow or wanting at the negative pole (fig. 111). The first blastomeres are large and about equal in size, as usual in teleosts (fig. 112). The second cleavage plane is approximately at right angles to the first, and it followed the first, at a water temperature of about 26° C., in about 20 minutes (fig. 113). The third and fourth cleavages followed equally as rapidly.

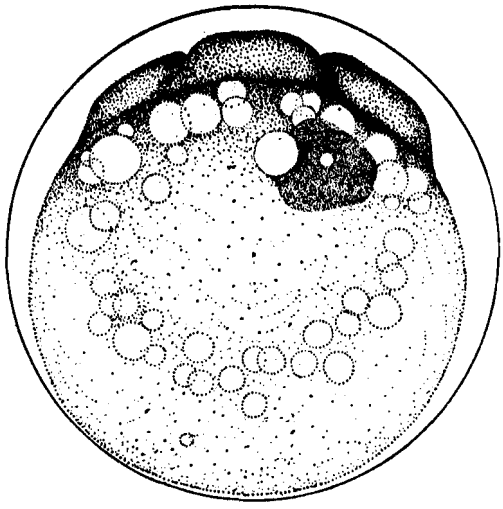

FIGURE 113.—*Chasmodes bosquianus*. From egg in 4-cell stage; about 2½ hours after fertilization. Owing to opaqueness of egg all the cells could not be seen from one viewpoint. (Drawn by Nell Henry.)

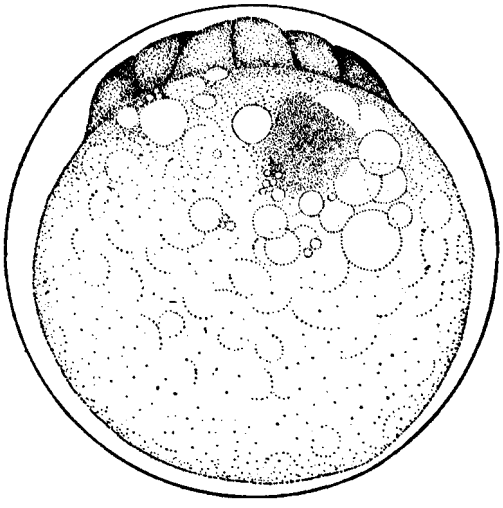

FIGURE 114.—*Chasmodes bosquianus*. From egg in 16-cell stage; about 3 hours after fertilization. (Drawn by Nell Henry.)

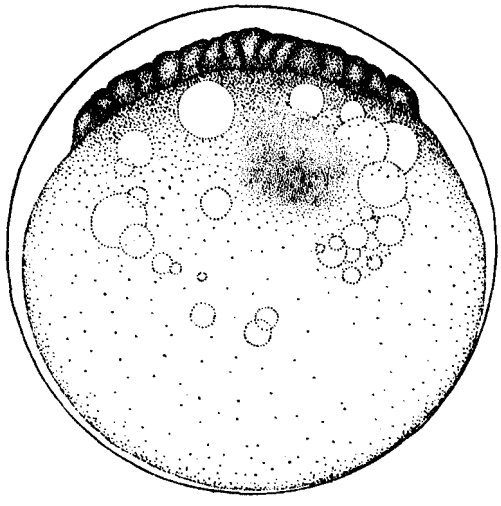

FIGURE 115.—*Chasmodes bosquianus*. From egg probably in the 64-cell stage; about 3½ hours after fertilization. Owing to opaqueness of the egg the cells could not be counted accurately. (Drawn by Nell Henry.)

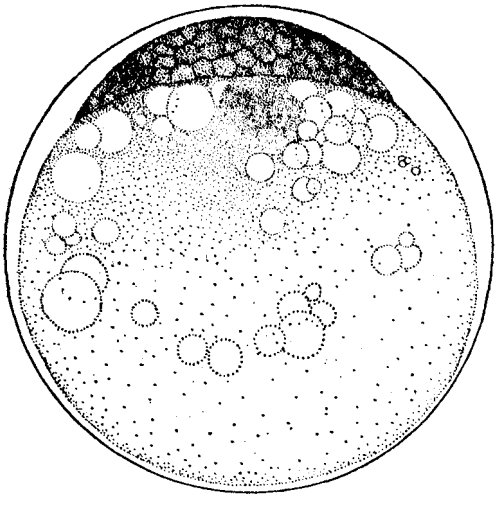

FIGURE 116.—*Chasmodes bosquianus*. From egg in rather advanced cleavage stage; about 6 or 7 hours after fertilization. Owing to opaqueness of the egg only that part of the blastoderm projecting above the yolk is visible from one view point. (Drawn by Nell Henry.)

When the eight-cell stage is reached, all the cells are no longer visible in a lateral view, and they cannot be seen in a surface view, as already explained. Therefore, further divisions cannot be clearly observed. The blastomeres are large and prominent until about the 16-cell stage is reached (fig. 114). Thereafter they get smaller and flatter rather rapidly (fig. 115).

The eggs in which cleavage started at about 10:30 in the morning reached a fairly advanced cleavage stage by the evening of the same day (fig. 116). The temperature of the water had remained near 26° C. throughout the period. No pronounced changes had taken place in the egg in the meantime, except that the yolk apparently had become more granular and rather more opaque.

Twenty-four hours after cleavage started a very early embryonic stage was reached, that is, the embryo was just becoming differentiated, though it was not yet possible to distinguish between the head and tail. The temperature of the water had dropped to 24.5° C. Little obvious headway was made during the next 12 hours. However, a fairly well-formed embryo, with the eyes partly developed, was present, at about 48 hours after fertilization. The temperature of the water had advanced to 26° C. The embryos evidently were not all in the same position in relation to the adhesive foot. In some eggs the embryo lay underneath the yolk, next to the foot, with only the head and tail visible if viewed from the side opposite the foot. Other embryos lay mostly above the yolk and therefore were entirely visible in eggs seen from the same angle. Positions intermediate of these also were observed. A few grayish blotches, variable in size, were noticed on the yolk for the first time (fig. 117).

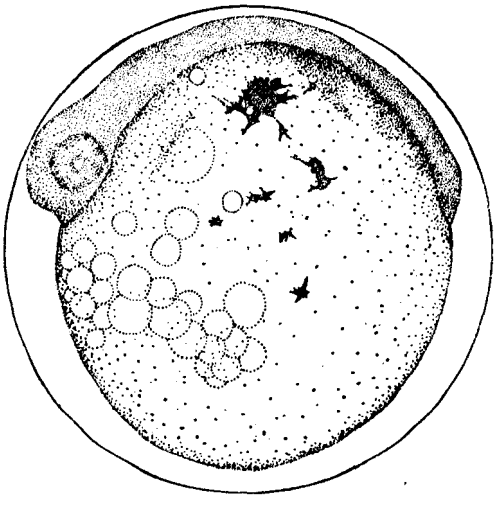

FIGURE 117.—*Chasmodes bosquianus*. From egg with moderately well-differentiated embryo; 2 days after fertilization. (Drawn by Nell Henry.)

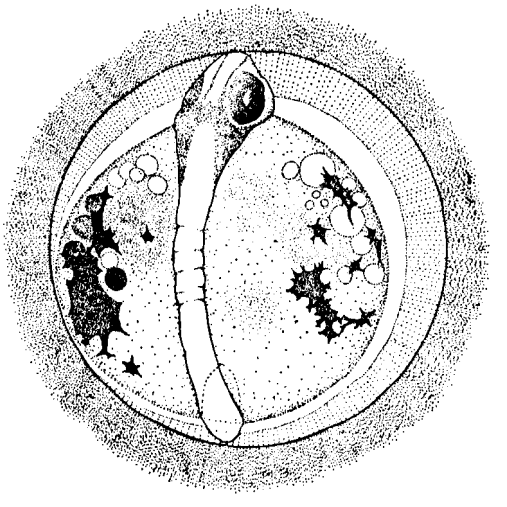

FIGURE 118.—*Chasmodes bosquianus*. From egg with well-formed embryo; 2½ days after fertilization. Tail of embryo curved under the opaque yolk. (Drawn by Nell Henry.)

About 60 hours (2½ days) after fertilization, the temperature of the water remaining near 26° C., the embryo was well formed, with a large head and partly pigmented eyes. It curved about two-thirds the distance around the egg. Indications of somites were present at midbody length and the heart beat slowly and rather feebly (about 90 beats per minute). Circulation was evident only near the heart, no definite blood vessels apparently having been formed. Black blotches, with irregular outlines, variable in size and shape in any one egg and variable in number in different eggs were present on the surface of the yolk (fig. 118).

On the fourth day of incubation, with the temperature of the water remaining quite constant at 26° C., the body segments had become plainly marked in the anterior caudal region, although the embryo had gained little in length. The eyes had many black pigment dots, most numerous along the upper margin; the yolk appeared very granular and had been cut into deeply by the embryo, and the dark spots on its surface

in general had become smaller and more numerous. The heart was beating rapidly, sending the blood to the body through a large vessel situated near the ventral outline. This artery left the embryo somewhat more than an eye's diameter from the tip of the tail where it entered the yolk and divided into several branches. These branches all coursed over the yolk and in a general way ran toward the snout of the embryo, underneath which the heart is situated. There they united just before pouring their contents into the heart (fig. 119).

On the fifth day of incubation, with the temperature of the water still remaining near 26° C., the embryo had encircled the egg. The tail reached opposite the head. It was free and moved frequently. The eyes were very prominent, being fully pigmented, and visible without magnification. The yolk was reduced to about two-thirds its original size and more or less crescent-shaped, having been cut into very deeply in the head region of the embryo. Oil globules of various sizes remained distributed throughout the yolk. The central opaque body, previously described, and still visible a day or so earlier, had disappeared. Dark markings on the yolk had become more

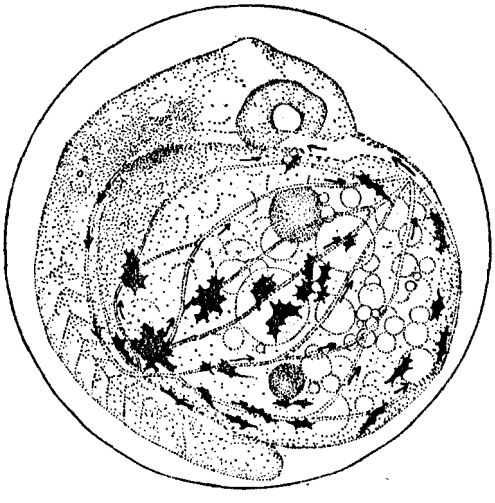

FIGURE 119.—*Chasmodes bosquianus*. From egg with developing embryo; 4 days after fertilization. Arrows indicate the direction of the flow of blood in the larger vessels. (Drawn by Nell Henry.)

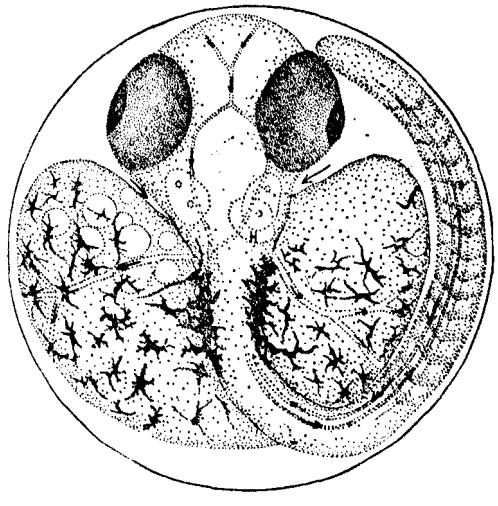

FIGURE 120.—*Chasmodes bosquianus*. From egg with advanced embryo; 5 days after fertilization. H, heart. Arrows indicate direction of flow of blood in the larger vessels. (Drawn by Nell Henry.)

numerous and in general smaller. They now consisted mostly of lines branching more or less from a central point, and many of them were shaped somewhat like crow's feet. A concentration of dark markings was taking place in the trunk region of the embryo. Circulation was brisk, and the blood returned within the embryo, the caudal vein being quite fully developed. Corpuscles were distinct, and the heart and large vessels near it had a pinkish tinge (fig. 120).

Development progressed slowly after about the fifth day of incubation. By the seventh day, with a drop in temperature to 24.5° C. between the sixth and seventh day, the tail of the embryo reached a little past the head. The embryo was capable of considerable movement, carrying the yolk with it as it turned in the egg case. The yolk had been cut into more deeply and was definitely crescent-shaped. The black markings on the yolk, described in the foregoing paragraph, although variable in number in different eggs, had become less numerous, and a further concentration of black had taken place in the trunk region of the embryo. Also an irregular black blotch was present at each auditory vesicle. Almost innumerable blood vessels were

visible in the vicinity of the head of the embryo and all poured their contents into the heart, which had the appearance of a pit (fig. 121).

No important changes in the embryo itself appeared after about the seventh day of incubation. The temperature remained near 24.5° C. from the fifth to the ninth day when it advanced to 26° C. On about the ninth day it was evident that the black color concentrated in the abdominal region of the embryo, first noticed on the fifth day, was on the embryo, whereas it at first appeared to be on the yolk. On some eggs a few "crow's feet" remained on the yolk, whereas in others they had all disappeared. A dark blotch was present between the anterior part of the eyes, and in some specimens short, branching, cross lines were evident on the ventral margin of some of the caudal myomeres. Also distinct black spots were present on the pectoral fin membranes which could be seen clearly through the egg case. The eggs in two unguarded nests (the writer was not successful in inducing a male of this species, to stay with his nest in the aquarium) all died between the fifth and ninth days of incubation, having become infested with hydroids and protozoa. Eggs removed from the nests while in early cleavage stages and placed in glass bowls, in which the water was changed twice daily, also nearly all became infested and only four hatched. The rest of this account is based on the few remaining eggs and the four larvae that emerged successfully.

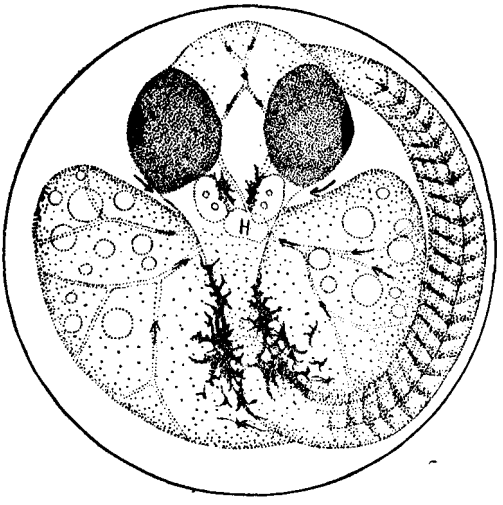

FIGURE 121.—*Chasmodes bosquianus*. From egg with large embryo; about 7 days after fertilization. H, heart. Arrows indicate direction of flow of blood in the larger vessels. (Drawn by Nell Henry.)

On the tenth day of the incubation period the temperature of the water advanced to 27° C. The embryos were very active. The dark color markings on the embryo, already evident on the ninth day or earlier, had become more distinct. The number of blood vessels had increased and the blood, when viewed under moderately low magnification, was seen pouring over the head and eyes in minute vessels as if in a sheet. Heart action was extremely rapid, the beats following each other in such close succession that they could not be enumerated accurately. The heart had a distinct reddish tinge, the red probably being in the blood.

Only four eggs survived, as previously stated, and these all hatched on the eleventh day of incubation. The temperature dropped from 27° to 25° C. between the tenth and the eleventh day. The incubation period of this blenny, therefore, is around 11 days when the temperature of the water in which the eggs are incubated ranges between 24.5° and 27° C., with a mean temperature around 26° C.

No attempt was made to keep the larvae alive. After measurements and a sketch had been made and a description prepared they were preserved.

Newly hatched fish.—The newly hatched fish range in length from 3.56 to 3.78 mm. The yolk is small at hatching. The head and trunk are short and robust, and the tail is long and slender. The vent is situated far in advance of midbody length; distance from snout to vent being 1.25 to 1.3 mm, from vent to tip of tail without finfold 2.1 to 2.3 mm. The snout is short and blunt, its length being less than half the diameter of the eye. The eye is large, its diameter (0.36 mm) being a little greater than the depth of the body just behind the vent (0.32 mm). The mouth is placed rather low,

anteriorly scarcely above the lower margin of the eye. The gape reaches to or a little behind the vertical from the anterior margin of eye. The vertical finfold is rather broad; originating above the auditory vesicle, it is continuous and extends to the vent. Large pectoral fin membranes, somewhat longer than the diameter of the eye, are also present. The body is fairly transparent. As a consequence, the outline of the brain and the circulation of the blood can be seen rather clearly. The aorta and the caudal vein remain rather close together, as in the embryo, both being located ventrally in the long tail. About 8 or 9 partly indefinitely outlined myomeres may be counted in advance of the vent and from 28 to 30 behind it. The vertebra count in two adults examined was 9+24 and 10+23. These counts seem to indicate that the total number of myomeres in the newly hatched fish is greater than the number of vertebrae in the adult. Since the demarcations between the myomeres both anteriorly and posteriorly are indistinct, it is barely possible that the count is excessive.

Nearly all the color markings on the newly hatched fish already were evident on the embryo several days before hatching. The black on the snout is in elongate "twin" blotches, situated over the anterior part of and somewhat in advance of the eye. The abdomen is largely black along its upper margin, the black reaching from the upper edge of the base of the pectoral to the vent. A few small black chromatophores remain on the ventral surface of the abdomen (yolksac). The tail has short branching cross lines on the ventral edge, which sometimes are wanting anteriorly and also posteriorly. The basal three-fourths of the inner surface of the pectoral has black chromatophores, the lowermost spot being very large, while those more distant from the base of the fin are smaller (fig. 122).

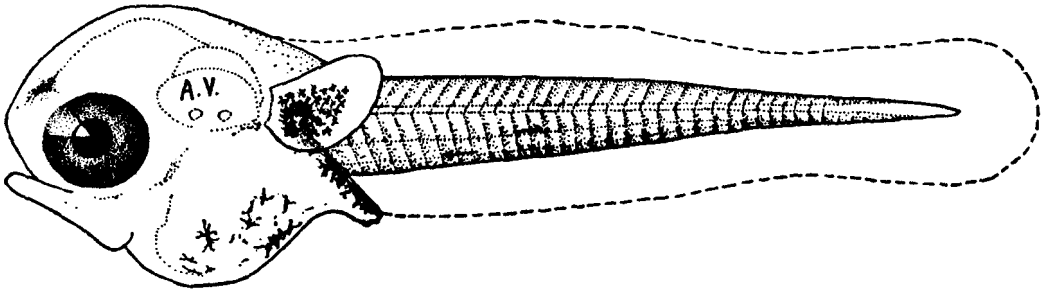

FIGURE 122.—*Chasmodes bosquianus*. From a newly hatched fish, 3.6 mm long. AV, auditory vesicle. Arrows indicate position and direction of the flow of blood in the aorta and caudal vein. (Drawn by Nell Henry.)

Chasmodes bosquianus is about 3.6 mm long at hatching, whereas *Hypsoblennius hentz* is about 2.7 mm long, and *Hypleurochilus geminatus* is only about 2.4 mm. Chasmodes apparently has a larger number of myomeres behind the vent, having about 28 to 30, whereas the other species have only about 23 or 24 at hatching. No black color markings were noticed under the auditory vesicle in Chasmodes, whereas more or less black is present in the other species. Chasmodes and Hypsoblennius agree in having most of the inner surface of the pectoral fin membrane dotted with black chromatophores, whereas Hypleurochilus at most has only a few black dots on the base of that fin. On the other hand, Chasmodes and Hypleurochilus agree in having a concentration of black points, forming almost solid black, along the upper margin of the abdomen, extending from above the base of the pectoral to the vent, while Hypsoblennius more usually has scattered branching chromatophores quite generally distributed over the abdomen. Considerable variation in the distribution of the black markings on the abdomen, however, has been noticed in all three species.

THE HAKES OF THE GENUS UROPHYCIS

The development and other life history data of four species of Urophycis, namely *chuss*, *regius*, *floridanus*, and *earlli*,[12] are discussed in the following pages.

Some of the hakes are rather widely distributed. *U. chuss* has been recorded from the Gulf of St. Lawrence southward to Cape Henry, Va. The known range is now extended southward to the coast of North Carolina, on the basis of some small specimens at hand, taken by the *Albatross* at sea off Kitty Hawk. *U. regius* is known to range from Nova Scotia southward to South Carolina; *U. floridanus* from Beaufort, N. C., to Pensacola, Fla., and *U. earlli* from Beaufort, N. C., to Charleston, S. C.

U. floridanus was first recorded from Beaufort by Hildebrand (1916, p. 306). Since that time, the young of this species, have been found to be common locally in shallow water during the winter and early spring, but the species apparently is absent there during the summer. *U. regius* is more common, the young being numerous during their first winter, but adults were rather rarely taken. It seems possible that these hakes, after spending the first several months in shallow water, live chiefly in deep water offshore where very little collecting has been done. The habitat of both the young and adults is discussed under the heading, "The distribution of the young."

According to our field records only four specimens of *U. earlli* were taken during the senior author's connection with the biological station at Beaufort from 1914 to 1917 and 1925 to 1931, notwithstanding that Smith (1907, p. 384) stated, "This hake * * * is not uncommon in the Beaufort and Cape Lookout regions. * * * On the adjacent shores the fish is common enough to have received a local name, 'Dickie,' although it has no economic value as yet." In view of the later, much more intensive collecting, one wonders if there was not confusion with one of the other more common species.

The southern species of hake do not grow large. *U. regius* is reported to attain a maximum length of 16 inches. The largest individual seen at Beaufort was 13½ inches long. The largest specimen of *floridanus* taken was only 8¼ inches long, and the largest one of *earlli* 15½ inches, though one 18 inches long has been recorded. *U. chuss* is reported to reach a length of about 30 inches, or even 42 inches, if *tenuis* is not distinguishable from that species, as suggested by Vladykov and McKenzie (1935, p. 71).

The hakes as yet are of no commercial value in North Carolina. Small catches are made in Chesapeake Bay and off Cape Henry, Va. The catch for Virginia (not separated by species) for 1934 is given as 21,000 pounds in the statistical report of the Bureau of Fisheries. Northward the hakes increase in importance, the catch for New Jersey for 1934 being 22,171 pounds, and for New York 139,954 pounds. Large catches are made in Massachusetts and Maine, and smaller ones in the other New England States, the total catch for those states for 1934 being 15,319,692 pounds. The meat of the hakes is soft, but it is of good flavor, and generally sells readily.

Adult hakes of the genus Urophycis, as here understood, are recognized by the elongate somewhat compressed body; subconical head; rather large, nearly horizontal mouth, with the maxillary generally reaching to or beyond the posterior margin of the eye; with unequal teeth on the jaws and vomer, none on the palatines; a small barbel

[12] Jordan, Evermann, and Clark (1930, pp. 212–213) place *earlli* in the older genus Phycis, leaving the other three species herein discussed in Urophycis. This classification does not seem justifiable, as *earlli* is closely related to *floridanus*, differing only in the smaller scales, rather longer dorsal and anal fins, and in color. In turn, *floridanus* differs in the same characters and in about the same degree from *regius*, the type of Urophycis. In addition, *floridanus* has a longer chin barbel, wherein it agrees with *earlli*. Certainly *earlli* is more closely related to *regius* than to *chuss* with its low broad head, large eyes, and produced dorsal ray. Evidently a further study of the group is necessary to determine the status of Urophycis. Perhaps all the species herein discussed should be assigned to the genus Phycis.

at the chin; and two dorsal fins, composed of soft rays only, the first one short, the second one long, and similar to the anal.

The ventral fins are described in current works as consisting of three slender rays, closely joined, and appearing as a bifid filament. In the young three separate rays are plainly evident, and sometimes a fourth one may be discernible. Upon removing the skin, it was found that two articulated rays are enclosed in each filament of the adult and a short "remanent" of a fifth ray (unarticulated) is present at the inner side of the base of the fin. These hakes, therefore, actually have four-rayed, or five-rayed ventral fins if the unarticulated remanent is counted.

The distinguishing characters of the adults of the species herein discussed are most readily shown in a key.

KEY TO THE SPECIES

a. Chin barbel very short, not exceeding the pupil of the eye in length.

b. Head depressed, notably broader than deep; eye large, equal to or wider than interorbital; scales small, 104 to 112 or more oblique series above the lateral line; first dorsal with a long filamentous ray; dorsal rays 9 to 11—56 to 61; anal rays 52 to 56; lateral line not in a black streak and without white spots; no white on first dorsal ..... *chuss*.

bb. Head scarcely depressed, deeper, its depth about equal to its width; eye smaller, not as wide as interorbital; scales larger, 89 to 97 oblique series above lateral line; first dorsal without a produced ray; dorsal rays 8 or 9—46 to 51; anal rays 43 to 49; lateral line in a black streak, interrupted by pale spots; first dorsal largely black, margined with white ..... *regius*.

aa. Chin barbel notably longer, always longer than the pupil, frequently nearly or fully as long as eye.

c. Scales moderately small, 110 to 130 oblique series above lateral line; dorsal rays 12 or 13—54 to 59; anal rays 40 to 49; color bluish or brownish above, silvery below; lateral line in a black streak, interrupted by pale spots; vertical fins mostly pale brownish, often with dusky margins, the first dorsal largely black, not margined with white ..... *floridanus*.

cc. Scales very small, 153 to 175 oblique series above lateral line; dorsal rays 8 or 9—54 to 63; anal rays 50 to 56; color dark brown to nearly black, sometimes with pale blotches; lateral line not in a black streak and without pale spots; the vertical fins frequently nearly black, no white on first dorsal ..... *earlli*.

SPAWNING

The eggs of Urophycis, as already stated, were not secured at Beaufort. Neither were ripe adult fish seen by us. However, the capture of spawning fish by the *Albatross* on the coast of the Carolinas in December, 1919 is reported in the field notes by the late W. W. Welsh. Small larvae, that is, young under 5.0 mm in length, were taken only a few times, as follows: One, 3.0 mm long, November 12, 1927, 13 miles west southwest of Cape Lookout; 13, ranging in length from 2.75 to 4.5 mm, December 6, 1927, at the same station; and 1, 3.0 mm long, December 6, 1927, 6 miles west southwest of Cape Lookout. These larvae, as stated elsewhere, apparently represent about equally *regius* and *floridanus*. Larger young were taken frequently and sometimes in abundance, during December and the following several months, as shown by tables 1 and 3.

The very small larvae taken are very probably only several days old, which seems to show that both *regius* and *floridanus* spawn in the general latitude of Beaufort at least during November and December. The small size of some of the young, though beyond the larval stage, taken during the several succeeding months suggests, however, that the spawning season extends over a longer period of time. A few specimens of *floridanus* and several of *regius*, 30 to 40 mm long, were collected as late as March, and a few of *regius* 38 and 39 mm long as late as April 15 (1931). Judging from the

growth data contained in tables 1–4, it apparently may be assumed that these species in the general latitude of Beaufort spawn from about November to February.

U. earlli is so scarce at Beaufort that very little material was obtainable. In fact only three young, 37, 75, and 103 mm long, were secured. Therefore, virtually nothing was learned concerning its life history. However, the two larger young were taken March 24 (1931), and the smallest one April 15 (1931), when *regius* of about the same size also were taken. It is possible, therefore, that *earlli*, like the other local species of hake spawns during the winter on the coast of North Carolina.

It may be stated with some assurance that the hakes do not spawn in the bays and estuaries at Beaufort, as the eggs and larvae were not taken in these waters during several years of intensive collecting. All the larvae of *regius* and *floridanus* at hand were taken at sea from 6 to 13 miles offshore, beyond which no collecting was done. It apparently may be assumed, therefore, that these hakes spawn only at sea in the vicinity of Beaufort. The abundance of young *floridanus*, and especially of *regius*, during the winter and early spring indicates rather extensive spawning in the Beaufort region.

We have included in the present discussion *U. chuss* for reasons already stated, though this species is not recorded from Beaufort. In regard to the spawning Bigelow and Welsh (1925, p. 452) stated that the height of the spawning season of this species falls in early summer in the Massachusetts Bay region and at least as early as June south of Cape Cod. Also, that the extreme limits of the spawning season were not known, but that the evidence collected indicated that it spawns in the Gulf of Maine from late spring until early autumn. We have at hand specimens 2.75 to 15 mm in length collected by the *Albatross* off Cape Henry, Va., October 30, 1919, and off Kitty Hawk, N. C., October 31, 1919. We, also, have specimens of similar size collected on the coast of New Jersey by the *Grampus*, July 19, 1912. It seems, therefore, that the spawning season of this species is a very long one.

DESCRIPTIONS OF THE EGGS AND YOUNG

The eggs of Urophycis were not recognized in collections made at Beaufort, and the larvae were not taken often. Those collected apparently are separable into two species, namely, *regius* and *floridanus*, as shown subsequently. The smallest specimen of *earlli* taken, the only other species of Urophycis known from Beaufort, is 38 mm long.

Various additional collections of young hakes from both north and south of Beaufort, made principally by the *Albatross*, the *Grampus* and the *Fish Hawk*, are at hand for study. These include almost a complete series of the northern hake, *U. chuss*, which is not known from Beaufort, though specimens taken off Kitty Hawk, N. C., are at hand.

We also have the notes and some rough camera lucida drawing of the development of the eggs, and newly hatched young of *chuss*, made by the late W. W. Welsh. Some of this information, together with two of the drawings, already has been published by Bigelow and Welsh (1925, p. 454). It seems desirable to bring to light more of the information gathered long ago (1916) by Mr. Welsh, and to include as full an account of the development of this species as the data and specimens at hand permit. This seems especially desirable because of the close similarity of the young to the species occurring at Beaufort.

The development of the shape of the body is most peculiar, as may be seen from the descriptions and illustrations of the stages of development. The early larvae are slender; next, at a length of 4.0 mm or so, they become considerably deeper and more

compressed. Then, at a length of about 10 mm, they have become slender again, and they remain so until they are fairly large fish, ranging upward of 100 mm in length, when, at least *regius* and *floridanus* again become deeper, and especially more robust, that is, less strongly compressed. It is interesting also that contrary to most of the other species discussed in this paper, the hakes, at no time have spines on the preopercular margin.

The eggs of U. chuss and their development.—The eggs were obtained by Mr. Welsh at Gloucester, Mass., evidently directly from ripe fish. It may be assumed that the eggs of all the species of Urophycis are similar. Therefore, the descriptions and drawings of those of *chuss*, offered herewith, may be useful in identifying those of the other species when they are taken.

The eggs are small and vary little in size. The diameter of 10 eggs ranged from 0.72 to 0.76 mm, the average being 0.74 mm. They are clear and buoyant, and contain many (54 counted in one egg) oil globules when first spawned. During incubation the oil globules decreased rapidly in number, until most eggs retained a single large one, much larger than any originally present, 6 hours after fertilization. Occasionally, however, a few minute scattered ones, in addition to the large one, were retained 26 hours after feritlization.

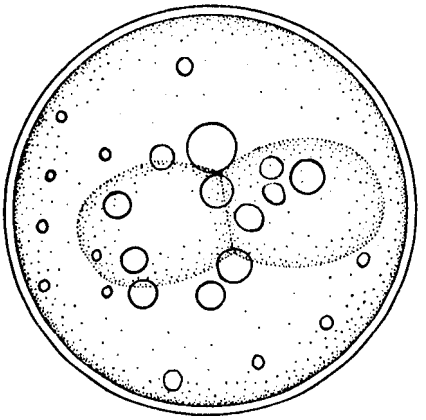

FIGURE 123.—*Urophycis chuss*. From egg in 2-cell stage; 1½ hours after fertilization. (From a camera lucida drawing by W. W. Welsh.)

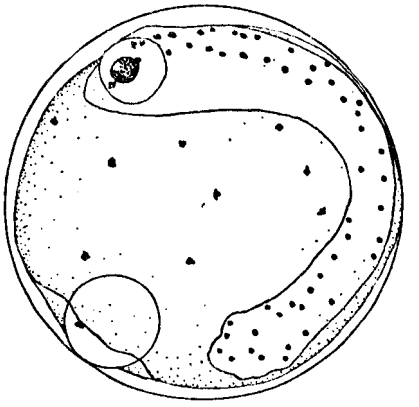

FIGURE 124.—*Urophycis chuss*. From egg with early embryo; 50 hours after fertilization. (From a camera lucida drawing by W. W. Welsh.)

The first cleavage took place 1½ hours after fertilization at a temperature of about 60° F. The number of oil globules already had decreased (fig. 123). Segmentation progressed rather rapidly, as the morula stage was attained about 26 hours after fertilization.

The embryo was well formed 50 hours after fertilization. It extended fully half the distance around the periphery of the egg, and the eyes were evident. Black chromatophores dotted the embryo (fig. 124). During the next 24 hours, that is, 74 hours after fertilization, no important changes took place, except that the embryo grew larger, and the amount of yolk was reduced. Pigmentation of the embryo remained unchanged. Some convulsive movements now were noticed (fig. 125).

At 90 hours of incubation, with a more or less constant temperature of 60° F., the eggs were ready to hatch. The pigment spots on the embryo had become notably

larger and had branched. The eyes, too, were now slightly pigmented. The single remaining oil globule lay under the abdomen (fig. 126).

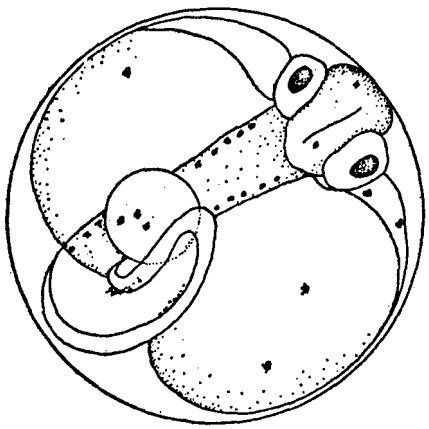

FIGURE 125.—*Urophycis chuss.* From egg with well-formed embryo; 74 hours after fertilization. (From a camera lucida drawing by W. W. Welsh.)

FIGURE 126.—*Urophycis chuss.* From egg with large embryo; 90 hours after fertilization. (From a camera lucida drawing by W. W. Welsh.)

Newly hatched U. chuss.—The newly hatched larvae ranged from 1.83 to 1.98 mm in length. The oil globule lay in the posterior part of the yolksac, or at midlength of the larva. Large pigment spots were present, principally along the dorsal and ventral outline, and also on top of the head. A few small dots were present on the eye, a few larger ones on the yolksac, and about three large branched ones on the oil globule (fig. 127).

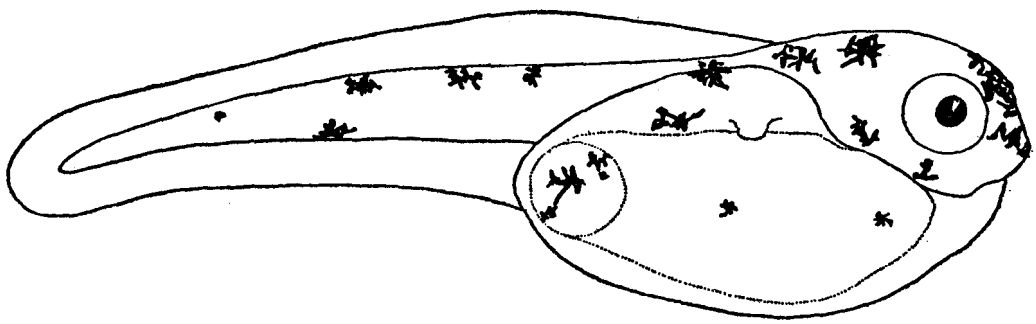

FIGURE 127.—*Urophycis chuss.* From newly hatched larva. (From a camera lucida drawing by W. W. Welsh.)

Specimens of U. floridanus (?) *2.75 to 3.0 mm long.*—The body is rather deep, robust, the greatest depth being contained 3.0 to 3.3 times in the length to the end of the notochord. The caudal portion of the body is relatively short and deep, notably shorter (without caudal fin membrane) than head and trunk, its depth just posterior to vent being contained about 2.2 times in its length. Myomeres are indistinct posteriorly. Upward of 40 may be counted. (Number of vertebrae in *regius*, 14+31; in *floridanus*, 16+34; one specimen of each species examined.) The head is large, compressed, and is contained about 3.0 times in the length to the end of the notochord. The mouth is almost vertical, the tip of the lower jaw being about at a level with the upper margin of the eye. The eye is large, fully twice as long as the snout, being contained about 2.0 times in the head. The vertical fin membranes remain continuous around the tail where there are rather distinct indications of the formation of rays. The pectorals are represented by broad short membranes, and

the ventrals appear as three hairlike rays, which do not nearly reach the vent, and which at this stage are inserted laterally below the base of the pectorals.

The color markings consist of some dark chromatophores on the head, some more on the back at the base of the dorsal finfold, one to several on the ventral edge of the body above base of the anal, and generally a few to several on the middle of the side, sometimes forming a more or less continuous black line. A few dark dots frequently are present around the mouth, and on the side along the upper margin of the abdomen. The distal part of the ventrals already are slightly dusky (fig. 128).

The specimens described in the foregoing paragraphs are from Beaufort, N. C., and may be *U. floridanus*. In the same lot are specimens that apparently differ only in the absence of dusky color on the ventral fins and generally in having no color markings above the base of the anal. As larger easily recognizable specimens of *U. regius* have no black on the ventral fins, it seems probable that small specimens destitute of this color also are *U. regius*.

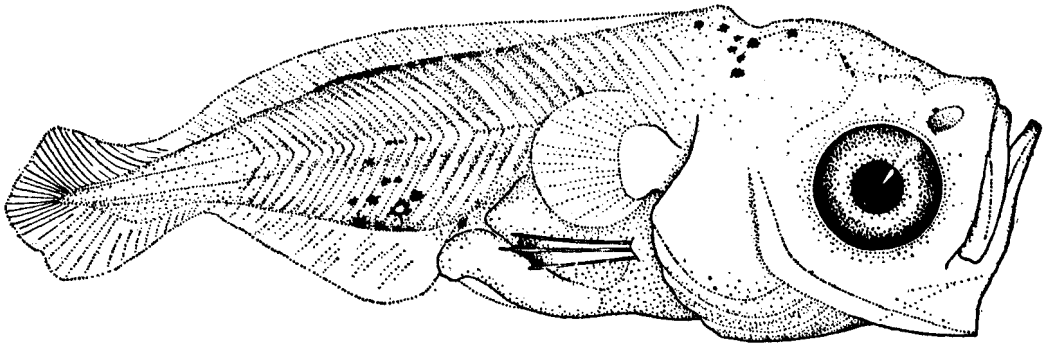

FIGURE 128.—*Urophycis floridanus* (?). From a specimen 3 mm long.

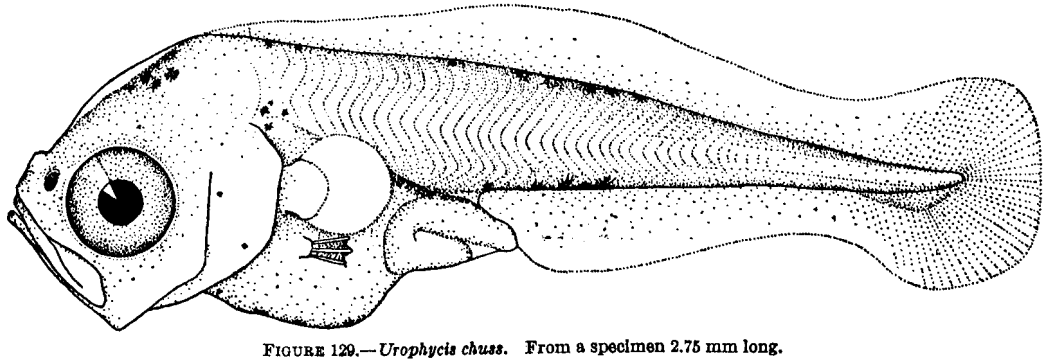

FIGURE 129.—*Urophycis chuss*. From a specimen 2.75 mm long.

In addition to the specimens already described, there are at hand specimens of the same size, taken off Cape Henry, Va., which apparently are representatives of a third species. The larvae differ rather markedly in having a proportionately much longer and more slender tail, the caudal portion of the body (without the finfold) being about equal in length to the head and trunk, and its depth just posterior to the vent is contained about 4.0 times in its length. The development of the ventral fins is somewhat more retarded in these specimens, no rays being present. However, in slightly larger ones in the same lot they are developed, and are distinctly black distally. Other color markings agree with the specimens already described. Larger and easily recognizable specimens of *U. chuss* have the distal parts of the ventrals black. As *U. floridanus*, which also has black ventrals, is not known to occur as far north as Cape Henry, it seems probable that the last described larvae are *U. chuss* (fig. 129).

Specimens about 4.0 mm long.—The advancement in development is not great. In specimens probably of *U. floridanus* the body has become rather more robust, the depth being contained in the length to the end of the notochord about 3.0 times. The caudal portion of the body has become proportionately rather longer, yet it remains decidedly shorter than the rest of the body. The mouth is less strongly vertical, the tip of the lower jaw now being slightly below the level of the middle of the eye. The ventral fins have increased in length and reach to or a little beyond the vent.

No change in color apparently has taken place. Most larvae have more dark dots above the base of the anal than the specimen drawn (fig. 130).

The difference between *U. floridanus* and *U. regius* remains one of color only, as in the smaller specimens, if both species actually are represented among the young at hand. The distal part of the membranes of the ventrals being black in *floridanus*, and pale in *regius*. Furthermore, in *regius* of this size, there generally are no black chromatophores above the base of the anal, though a few exceptions have been noticed.

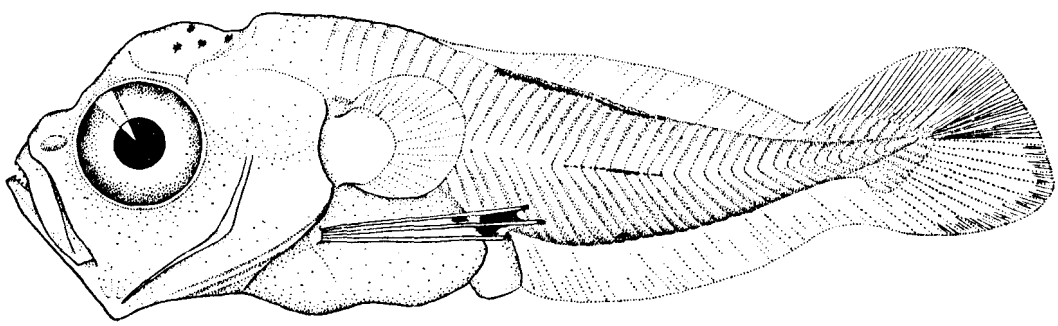

FIGURE 130.—*Urophycis floridanus* (?). From a specimen 4 mm long.

U. chuss continues to differ from both *regius* and *floridanus* in having a longer and more slender tail, though it has become proportionately shorter. Yet it is fully equal (without the caudal finfold) in length to the rest of the body, and its depth just posterior to the vent is contained 3.2 times in its length. The mouth is less nearly vertical than in the other species, and the dorsal profile is rounder. In color this species differs very little from *floridanus*, the black markings being similarly placed, though rather more numerous.

Specimens about 5.0 mm long.—*U. floridanus* apparently is missing among the specimens of this size. In fact, no specimens between a length of about 4.0 and 21 mm appear to be at hand.

In *U. regius* the body has continued to increase in robustness, the depth now being contained in the length to the end of the notochord about 2.8 times. The caudal portion of the body has increased further in proportionate length, and is contained about 1.6 times in the length to the end of the notochord.

It is deep and compressed, its depth just posterior to the vent being contained about 2.0 times in its length. The head is rather deep, compressed, and is contained 2.75 times in the length to the end of the notochord. The eye is nearly twice as long as the snout and is contained 2.75 in the head. The mouth is strongly oblique (not vertical), the tip of the lower jaw being slightly below the middle of the eye, and the maxillary reaches about under the middle of the eye. The notochord is bent upward very slightly distally. The vertical fin membranes remain continuous. The rounded caudal contains fairly well developed rays, but the dorsal and anal are more retarded

in development. The pectoral fin membranes remain short and broad, and without definite rays. The ventral hairlike rays (apparently three in number) have increased in length and reach well beyond the vent, the fins remaining inserted laterally below the base of the pectorals.

Black chromatophores remain present on the upper surface of the head, on the back below the anterior half to two-thirds of the dorsal, and occasionally one or more black dots are present at the base of anal. A dark lateral stripe, variable in length, is generally situated above the anterior half of the anal. A dusky area extends upward and forward from the vent, and often a dusky area is present at the upper angle of the gill opening, sometimes extending downward just posterior to the opercle. The fins remain without color, the ventrals being pale throughout.

U. chuss seems to differ from *U. regius* principally in the rather more slender body and in having a proportionately longer and more slender tail, the depth of the body being contained 3.5 times in the length to the end of the notochord; and the tail, from the vent to the tip of the notochord, is contained 2.2 times in the length. The depth just posterior to the vent is contained 2.3 times in the length of the caudal portion of the body to the tip of the notochord. In color *U. chuss* differs principally in that the interradial membranes of the ventrals are black distally (fig. 131).

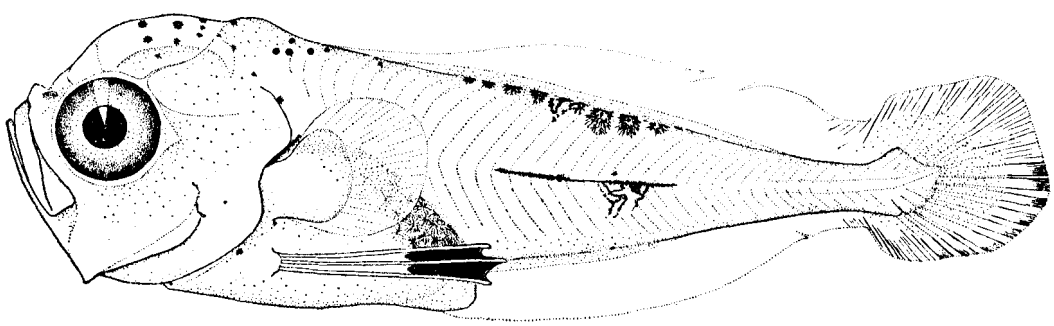

FIGURE 131.—*Urophycis chuss*. From a specimen 5 mm long.

Specimens about 7.0 mm long.—The most important advancement is the development of rays, or at least the fulcra, of most of the dorsal, and to a somewhat lesser extent of the anal rays. The number of rays in the second dorsal, as pointed out elsewhere, is diagnostic, as thereby *regius* (with 46 to 51 rays) is distinguished from the other local species, which have a greater number of rays. It is possible now, with transmitted light and fairly high magnification, to count about 43 fulcra in the second dorsal and about 45 in the anal in specimens with deep short tails, which have no black on the ventral fins. The specimens with short deep tails and without black on the ventrals among the younger stages, as indicated, were suspected of being *regius*. At a length of about 7.0 mm they may be so designated quite definitely, as shown subsequently.

The specimens with the rather longer and more slender tails, and with the ventrals distally black have about 50 to 52 fulcra developed in the second dorsal. The anal is somewhat more retarded in development than the dorsal and the rays and fulcra are not nearly all developed. Although the dorsal fulcra evidently, too, are not quite all developed, it is evident that the number that will be developed is greater than in adult *regius*. The specimens with the higher number of fulcra, developed at a length of about 7.0 mm, are from the vicinity of Cape Henry, Va., farther north than *floridanus* is known to occur. The only species recorded from the coast of Virginia are

regius and *chuss*. The specimens with the larger number of rays or fulcra in the dorsal certainly are not *regius*, and therefore apparently must be *chuss*.

It has been pointed out that in smaller specimens the caudal portion of the body was proportionately longer and more slender in *chuss* than in *regius*. This difference persists, but it is no longer pronounced. The distance from the vent to the tip of the notochord, in specimens about 7.0 mm long, is contained in the length of the fish, without the caudal fin, about 2.25 times in *regius*, and 2.1 times in *chuss*, and the depth just posterior to the vent is contained in the length of the tail 2.1 times in *regius*, and 2.5 times in *chuss*.

The body in both species has become more elongate, the depth in *regius* being contained 3.4 times in the length without the caudal fin, and 3.6 times in *chuss*.

The color is variable among specimens of both species, though not essentially different from smaller ones already described (figs. 132 and 133).

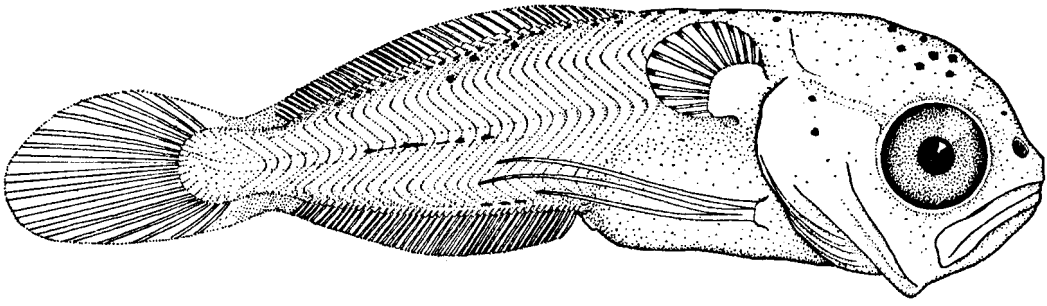

FIGURE 132.—*Urophycis regius*. From a specimen 7 mm long.

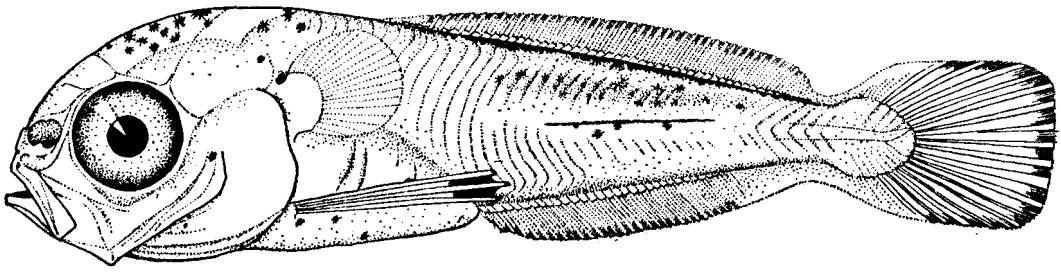

FIGURE 133.—*Urophycis chuss*. From a specimen 7.25 mm long.

Specimens 9.0 to 11 mm long.—The body in *regius*, as well as in *chuss*, has continued to grow proportionately more elongate, though it remains decidedly compressed. The depth in *regius* is contained 3.8 to 3.9 times in the standard length, and in *chuss* 4.0 to 4.3 times. The caudal portion of the body (without the caudal fin) is almost exactly equal in length to the head and trunk in *regius*, whereas in *chuss* it is noticeably longer. It is also deeper in *regius*, the depth just behind the vent being contained 2.9 times in the distance from the vent to the base of the caudal, whereas it is contained 3.1 to 3.3 times in that distance in *chuss*.

The mouth has become much less strongly oblique. However, it remains a little more strongly oblique in *regius* (wherein the tip of the lower jaw is about at the level of the lower margin of the eye) than in *chuss*, in which it is well below the eye.

The first dorsal is partly formed in both species under discussion, and is situated over the base of the pectoral. The second dorsal is well enough developed to permit a fairly accurate count of the rays, and especially of the fulcra. In *regius* 47 and 50 fulcra were counted, and in *chuss* 55 and 56, in two specimens of each species examined.

The anal rays are more retarded in development, and a full count is not yet obtainable. The pectoral fins remain short and rounded in both species. The ventral fins, though still lateral, are lower on the side and rather farther forward than in smaller fish, being inserted somewhat in advance of the base of pectorals, and the rays, of which three distinct ones of about equal length are present, reach well beyond the origin of the anal.

In color the two species do not seem to differ, except for the black on the ventrals in *chuss*, which is missing in *regius*. The number of dark dots have increased somewhat, though there is much variation among specimens. All specimens at hand of both species have black chromatophores on the head and back. Some specimens have black dots on the cheeks and opercles, some have a dark lateral stripe variable in length, and in others these markings are missing, apparently without regard to species. In the larger specimens of this group, dusky specks have begun to appear on the first dorsal (fig. 134).

Specimens about 15 mm long.—No pronounced changes in development have taken place since a length of 9.0 to 11 mm was attained in either species. However, the first dorsal is considerably higher and better developed, and the pectoral fins have become much longer, as shown in the accompanying illustrations. The caudal fin is quite variable in shape, for it may be rounded, straight, or slightly concave. The chin barbel first becomes evident in specimens of about this size.

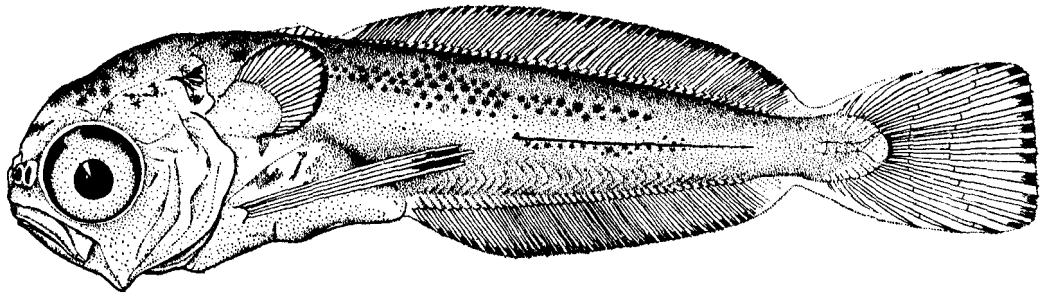

FIGURE 134.—*Urophycis chuss*. From a specimen 9.5 mm long.

The color is variable among specimens, some being more profusely spotted than others. In general, dark pigment has increased in both species. However, the only distinguishing feature in color noticed is the black on the distal part of the ventral in *chuss*, which is missing in *regius*, just as in much smaller specimens (figs. 135 and 136).

The proportionate length and depth of the caudal portion of the body, which aided in separating smaller specimens of *regius* and *chuss*, are now so nearly the same that the distinction has vanished.

The rays in the dorsal and anal, at least in some specimens, are not quite all formed. The development in 15-mm specimens, as in smaller ones, is rather more retarded in *chuss* than in *regius*. Some of the rays and fulcra remain difficult to see. However, with the use of comparatively high magnification and transmitted light, 9–54 rays were counted in the dorsal and 54 or 55 in the anal in three specimens of *chuss*. In two specimens of *regius* 7–46 and 7–47 rays were counted in the dorsal, and 44 and 47 in the anal. The counts, as shown in the key to the species, for adult *chuss* are—dorsal 9 to 11–56 to 61, anal 52 to 56; and for adult *regius*, dorsal 8 or 9–46 to 51, anal 39 to 49. Therefore, the difference in the counts between the two species in 15-mm specimens is quite evident.

The anal ray counts definitely separate *chuss* from *floridanus*, as the adults of the latter have only 40 to 49 anal rays. The specimens herein described as *chuss* were taken off Kitty Hawk, N. C., and northward, where *floridanus* is not known to occur. The smaller specimens were so identified largely by "locality", as in the absence of specimens of *floridanus* of similar size it was not possible to know how the two species differed. The anal fin ray counts in 15-mm fish, however, aid in establishing the identification on a morphological basis.

Specimens about 25 mm long.—At this length three species; namely, *regius*, *floridanus*, and *chuss*, are recognizable among the specimens studied, principally by the number of rays in the dorsal and anal fins, and by the length of the chin barbel, as shown subsequently.

The species are not distinguishable by the shape of the body, the shape and length of the head, the eye, the snout, nor the mouth. The body has become quite slender, and remains compressed, the depth in any one of the three species named being contained about 4.0 to 4.6 times in the standard length, and the head 3.3 to

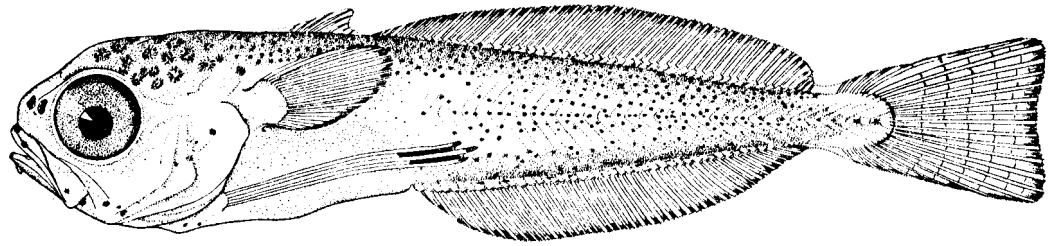

FIGURE 135.—*Urophycis chuss*. From a specimen 15 mm long.

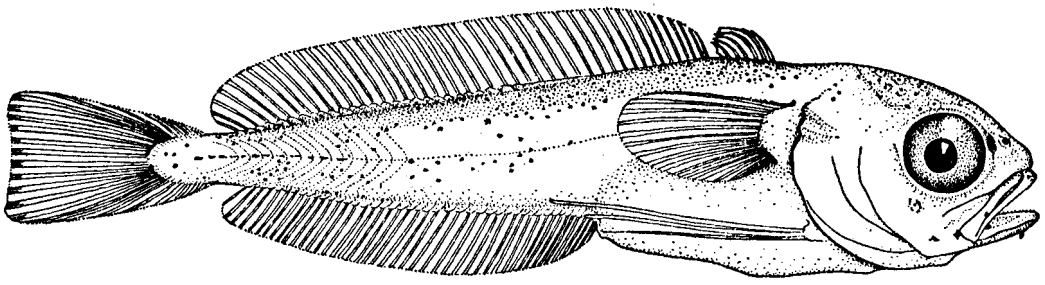

FIGURE 136.—*Urophycis regius*. From a specimen 15 mm long.

4.0 times. The snout is gradually increasing in length, being contained in the head about 4.0 to 4.4 times, and the eye 3.3 to 3.6 times. The mouth remains only slightly oblique, and it has become somewhat inferior, with the upper jaw a little in advance of the lower one, and the snout projecting slightly beyond the upper jaw. The maxillary reaches to or a little beyond the posterior margin of the pupil.

The barbel at the symphysis of the lower jaw, which first made its appearance in *regius* and *chuss* when about 15 mm long, remains minute, being scarcely a fourth the length of the pupil in those species. No specimens of *floridanus* around 15 mm in length are at hand. In specimens of this species, about 25 mm long, it is much longer than in the other species, being fully equal to the length of the pupil. The greater length of the chin barbel is a readily available morphological character at this size, as well as among larger fish, for separating *floridanus* from both *regius* and *chuss*.

Scales are present at a length of 25 mm in all three species, though not shown in the accompanying illustration. The series cannot be definitely enumerated, but it is evident already that the scales are larger in *regius* than in the other species.

The difference in the number of dorsal rays between *regius* and *chuss* is pointed out in a preceding section, as well as in the key to the species. However, *chuss* and *floridanus* have so nearly the same number of rays in the dorsal that they cannot be separated readily, if at all, by that character. Nevertheless, the last-mentioned species differ in the number of anal rays, *chuss* having 52 to 56, whereas *floridanus* has only 40 to 49 (the same number as in *regius*), as shown in the key to the species. The anal rays are well enough developed when the fish reach a length of about 25 mm to permit the use of this distinguishing character.

Much variation in color exists among specimens, some individuals being much more profusely spotted than others. The two specimens of *chuss* of this size at hand are much more profusely dotted than any others. However, insufficient specimens are available to determine whether it is of specific significance. The ventral fins of *floridanus* are black distally. However, no black is evident on these fins in the old preserved specimens of *chuss*, though of course the smaller ones have it. The first dorsal is partly dusky, there being as yet no distinction among the species in this respect (fig. 137).

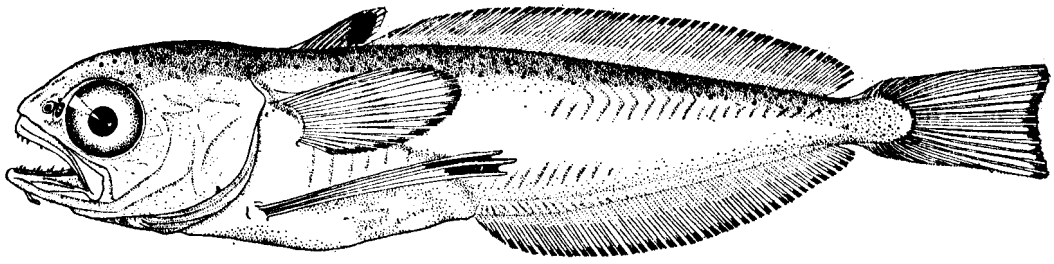

FIGURE 137.—*Urophycis floridanus*. From a specimen 26 mm long.

Specimens 35 to 50 mm long.—The three species; namely, *regius*, *floridanus*, and *chuss*, discussed in the preceding section, are readily recognizable among specimens 40 to 55 mm in length. They are distinguishable by the characters pointed out in the preceding section and some additional ones, as shown subsequently. A fourth species, namely, *earlli*, also is present. This species is discussed separately.

The body has continued to grow more slender and less strongly compressed, especially anteriorly, in *regius*, *floridanus*, and *chuss*. No measurable difference in the range in depth seems to exist among these species. In nine specimens, including three of each species, the range of the depth in the standard length is 5.0 to 5.75. In the same specimens, the head is contained 3.7 to 4.1 times in the standard length. The snout now is equal to, or only slightly shorter than the eye, being contained 3.75 to 4.5 in the head. The mouth is slightly oblique, and is definitely inferior, being situated essentially as in adults. The maxillary is broad posteriorly, and reaches nearly or quite opposite the posterior margin of the eye, being contained 1.8 to 2.2 times in the head.

The maxillary barbel remains minute in *regius* and *chuss*, wherein it is scarcely half as long as the pupil. In *floridanus* it is much longer, being equal to fully half the diameter of the eye.

The scales are quite fully developed and the series can be counted fairly accurately. (The number present in the different species is shown in the key to the species.) It is plainly evident, under magnification, without counting, that *regius* has notably larger scales than the other species.

The fins are all developed essentially as in adults. The pectoral fins are longer in *regius*, wherein they reach beyond the origin of the anal, than in the other species

in which they generally fail to reach opposite the origin of the anal. The ventrals are scarcely lateral; they are inserted well in advance of the pectorals, or nearly under the margin of the preopercle. The rays now generally appear as two in number, though a third short one sometimes remains evident. The two long rays (filaments) are free from each other distally, and they are rather variable in length, within any one species, the upper or outer one, which is the longer, generally reaches to or beyond the origin of the anal. The caudal fin varies in shape in all species, as its margin may be round, straight, or concave. The differences in the counts of the rays in the dorsal and anal fins are shown in the key to the species.

Pigmentation has become quite general, though variable among specimens of any one species. The color of preserved specimens is pale to rather dark brown above, and generally silvery below. In life *regius* and *floridanus* (no fresh specimens of *chuss* seen by us) may be bright green to bluish above, and the sides and lower parts bright silvery. The extent to which the body is covered with brownish dots varies even among specimens of the same species caught in one haul. The black on the distal part of the ventrals, present in smaller specimens of *floridanus* and *chuss*, rarely remains visible in specimens 40 mm long, and was not seen in any fish 50 mm and upward in length. The black on the first dorsal is now quite definitely surrounded by white, at least distally, in *regius* and distinguishes that species from *floridanus* and *chuss* in which the black extends nearly or quite to the margin of the fin and is not surrounded by white (fig. 138).

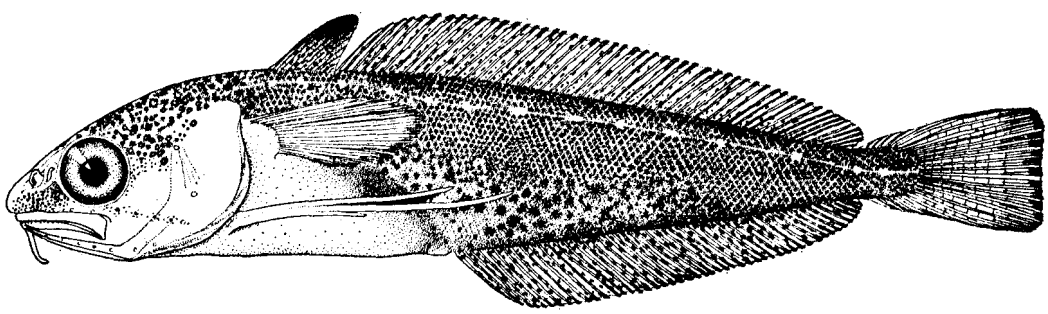

FIGURE 138.—*Urophycis floridanus*. From a specimen 40 mm long.

The fourth species, namely, *earlli*, is represented by a single specimen 37 mm long. This fish does not differ from the other species in the proportions usually calculated. However, it has much smaller scales, and the dorsal and anal rays are more numerous. (The counts are given in the key to the species.) The mouth is nearly horizontal and inferior, as in the other species, and the maxillary reaches almost below the posterior margin of the eye. The chin barbel is long and slender, even longer than in *floridanus*, as it exceeds half the length of eye.

The general color is dark brown, much darker than the darkest specimens of the other species, and this color extends on the dorsal and anal fins, only the margins posteriorly being pale. In fact, these fins are darker than the body. Only the chest and abdomen are silvery. The first dorsal is no darker than most of the second one. The caudal fin is dark brown at the base, and the rest of the fin is plain translucent. The pectorals and ventrals are brown at the base and colorless elsewhere (fig. 139).

Specimens 60 to 75 mm long.—The four species discussed in this work; namely, *chuss*, *regius*, *floridans*, and *earlli*, are all represented among the specimens of this size. In general, the characters of the adults, pointed out in the key to the species, can be used in separating the species. Therefore, only changes in development are pointed out in the following paragraphs.

The body has become slightly more elongate, and the head proportionately lower and broader. The interorbital now is equal to or wider than the eye in all four species. The snout has increased in proportionate length, and is definitely longer than the eye. If specimens of equal length are compared it is evident that *regius*, and especially *chuss*, have somewhat larger eyes than the other species. The longer pectoral of *regius* is quite distinctive at this size, falling short of the length of the head by only half the snout, whereas in the other species this fin does not exceed the length of the head without the snout.

The color continues to vary markedly among the specimens of any one species. However, *earlli* is notably darker, and has almost black fins. The dark stripe, broken by roundish pale spots at intervals, rather shorter than the diameter of the eye, in which the lateral line lies in adults of *regius* and *floridanus*, only, sometimes is present when the fish have reached a length of 60 mm, but often not until much later. Sometimes the pale spots appear in advance of the black stripe. In *regius* and *floridanus* four black dots in a vertical row sometimes are present behind the eye in specimens 60 mm long, but often not until much later, the upper one of which is in line with another spot over the eye and a third one over the posterior nostril. In addition about three dark dots are situated on the opercle. A pore is present in the center of each black spot. The pores, apparently are present in *chuss* and *earlli*, too, but in those species they are not surrounded with black.

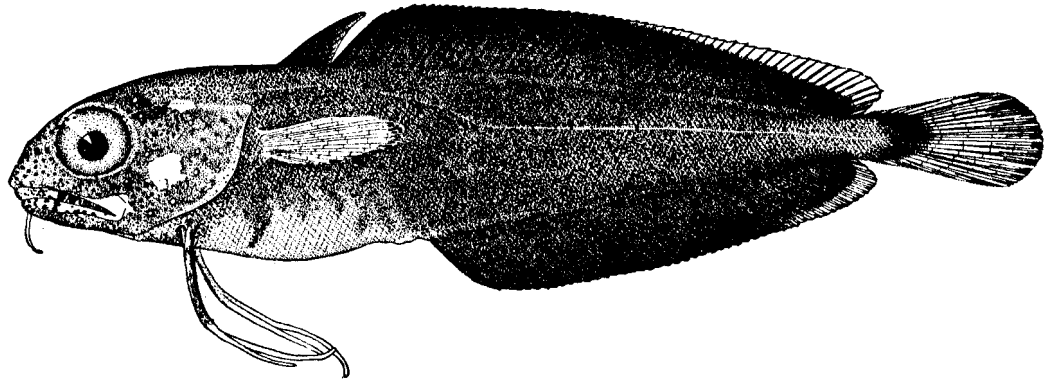

FIGURE 139.—*Urophycis earlli*. From a specimen 37 mm long.

Specimens 100 mm and upward in length.—The body in *regius*, *floridanus*, and *earlli* becomes more robust with age, and also rather deeper, the proportionate depth being about equal in all these species and contained 3.9 to 5.0 times in the standard length. Adults of *chuss* are notably more elongate, especially large fish, than those of the other species, the depth being contained 5.1 to 5.5 times in the length.

The head becomes broader and more depressed with age. This change is especially pronounced in *chuss*, for in large specimens of this species it is notably wider than deep, at the middle of the eyes, whereas in the other species the width of the head at the same point is about equal to its depth.

The larger eye in *chuss* becomes more noticeable with age. It is quite as wide as the interorbital in fish about 200 mm long, and is contained 4.1 to 4.6 times in the head. In specimens of about the same size of *regius*, which have a rather larger eye than those of *floridanus* and *earlli*, it is much narrower than the interorbital, and is contained 5.1 to 6.5 times in the head. The snout increases in proportionate length as the eye decreases, and in all species in specimens 100 mm and upward in length the snout is noticeably longer than the eye. It is a little broader in *chuss* than in

the other species, and, perhaps because of the larger eye, the maxillary reaches only to the posterior margin of the eye, whereas it reaches well beyond this point in large specimens of the other species. The snout projects more prominently beyond the mouth with age in all the species, and it becomes quite conical, though a little depressed in *chuss*.

The chin barbel remains short throughout life in *regius* and *chuss*, in which it never exceeds the pupil of the eye in length. In large specimens of *floridanus* and *earlli* it is nearly or quite equal to the diameter of the eye.

The third ray of the first dorsal is greatly produced in adults of *chuss*, reaching about to the end of the first third of the second dorsal. It is not evident at what size the ray becomes produced from the specimens at hand, as fish ranging from 70 to 185 mm in length are missing. In the smaller fish it is not produced, but in the larger ones it is long. In all the other species the first dorsal becomes rather pointed, but none of the rays are especially produced. The differences in the length and shape of the other fins remain about the same as in smaller specimens already discussed.

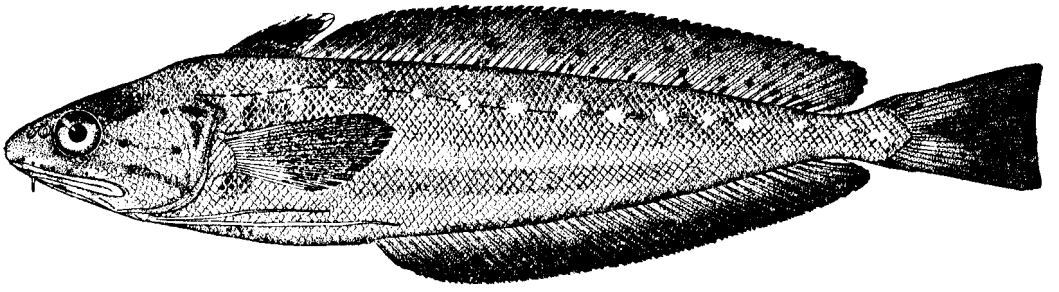

FIGURE 140.—*Urophycis regius*. From a specimen 124 mm long.

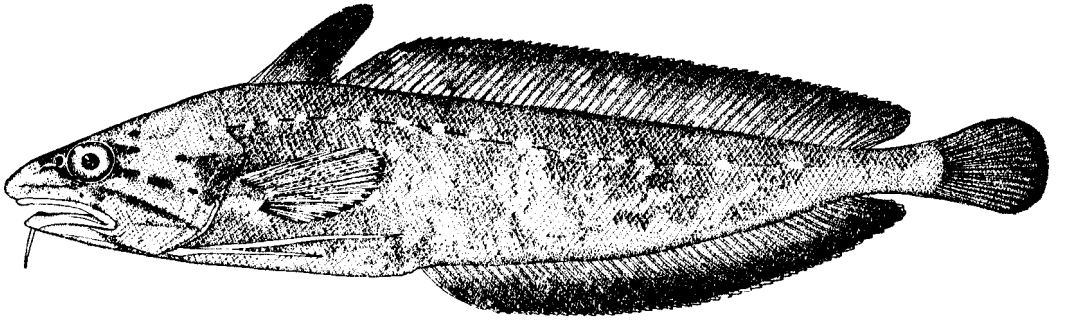

FIGURE 141.—*Urophycis floridanus*. From a specimen 126 mm long.

The differences in color remain virtually the same as in the smaller specimens described in the immediately preceding section. The general color of *earlli* remains much darker than in any of the other species. A specimen about 100 mm long is uniform dark brown, with the vertical fins almost black. Larger fish sometimes are more or less blotched with pale color. No deep black is evident on the first dorsal, as in the other species herein considered. Of these, *regius* differs strikingly in having the deep black color of this fin margined with snow white (figs. 140 and 141).

DISTRIBUTION OF THE YOUNG

It is shown under the heading, "Spawning," that the early larvae, under 5.0 mm in length, apparently consisting of both *regius* and *floridanus*, the only common species of Urophycis at Beaufort, were taken only at stations 6 to 13 miles offshore,

beyond which no collecting was done. Larger young, too, were taken offshore as well as near the shore. However, no young measuring less than 40 mm long were found in the bays and estuaries, and not many until a length of 50 to 60 mm had been attained. Thereafter, for a period of about 3 months, February, March, and April, they were common to numerous on muddy bottom in the estuary of Newport River, but no more so than on the very muddy bottom in the vicinity of the "sea buoy" at the entrance of Beaufort Inlet. However, those taken in Newport River averaged larger in size. *U. regius* nearly always was greatly in the majority, though in its habitat it did not seem to differ from *floridanus*.

The young, up to 40 mm in length, sometimes were taken at the surface, though more frequently at the bottom. All the larvae, except one specimen measuring under 10 mm in length were taken in surface nets. Presuming that the eggs of *regius* and *floridanus* are pelagic, like those of *chuss*, the young would be expected to remain at the surface, where they are hatched, at least until the yolksac, with its oil globule, is absorbed. That they not only stay there until the yolk is absorbed but for some time afterward, is indicated by the catches made. However, the hakes, with inferior mouths and ventral fins developed as feelers (presumably for prowling around on the bottom), are typical bottom-dwelling fishes. According to our data that is the common, if not the exclusive, habitat after a length of 40 mm or so is attained. Futhermore, they seem to prefer muddy bottom, as already stated.

Although young *regius* and *floridanus* are common to numerous, in the areas named, during winter and early spring, they disappear almost entirely from shallow water by June 1, and the adults either are scarce or missing at all times. Definite information as to where the young go was not obtained. It seems probable, however, that they merely withdraw to deeper water. It at least seems rather certain that the adults are common in the offshore waters in the vicinity of Beaufort during the reproductive season as considerable spawning must take place locally, for the young at times were taken in great abundance, outnumbering all other species. In the absence of information to the contrary, it may perhaps be assumed that the deeper offshore water is the regular habitat of the local species of hakes. The abundance of the young in the shallow water during their first winter suggests an abundant population. It might even be possible to develop a hake fishery if their habitat could be located, which apparently should be sought in rather deep water with muddy bottom.

GROWTH

The measurements of fish tabulated in the accompanying tables are based wholly on young fish believed to be 6 or 7 months and less of age. Certainly there is no break in the growth curve. Very few larger fish were taken. Assuming that the fish for which measurements are given are all under 6 or 7 months old a rapid rate of growth is indicated, for a few individuals of both *regius* and *floridanus* apparently reached a length slightly upward of 8 inches at an age of about 6 months. If *regius* attains a length of only about 16 inches and *floridanus* is even smaller, as shown by the data available, early maturity surely would result if such a rapid rate of growth were maintained.

TABLE 1.—*Length frequencies of 2,054 hakes (Urophycis regius), all less than a year old*

[Measurements to nearest mm; in 5-mm groups]

Millimeters	November	December	January	February	March	April	May	June
0–4	1	6						
5–9		2						
10–14		1						
15–19		4						
20–24		5		1				
25–29								
30–34					1		1	
35–39			1	13		2		
40–44			4	71	4	4		
45–49			22	89	10	2		
50–54			25	53	20	12	2	
55–59			10	47	29	24	2	
60–64			4	57	31	10		
65–69			1	46	33	8		
70–74			3	56	32	7		
75–79			1	35	41	1	1	
80–84				24	62	1	1	
85–89			1	28	52	4		
90–94				23	75	7	1	
95–99				20	59	9		
100–104			2	18	66	11		
105–109				9	63	17		
110–114				12	46	31	1	
115–119				3	50	26	1	
120–124				7	46	18	2	
125–129				7	33	18	2	
130–134				5	37	24		
135–139				4	22	16		
140–144				2	28	19	2	
145–149				3	23	20	1	
150–154					11	17		1
155–159					13	16		
160–164					8	12	1	
165–169					3	15		
170–174						14		
175–179					1	7		
180–184					1	7	2	
185–189				1	2	10		
190–194					1	3		
195–199						4		
200–204						3		
205–209						2		
210–214								
215–219						1	1	

TABLE 2.—*Monthly summaries of length measurements of 2,054 hakes (Urophycis regius) during the first several months of life*

[Measurements based on the same fish as in table 1]

Month	Fish measured	Smallest	Largest	Average	Month	Fish measured	Smallest	Largest	Average
		Mm	*Mm*	*Mm*			*Mm*	*Mm*	*Mm*
November	1	3.0			March	902	30.00	192	102.3
December	18	2.75	23	18.8	April	402	38.00	215	123.9
January	74	38.00	101	53.9	May	21	33.00	219	115.3
February	634	24.00	147	67.0	June	1	152.00		

TABLE 3.—*Length frequencies of 218 hakes (Urophycis floridanus), all less than a year old*

[Measurements to nearest mm; in 5-mm groups]

Millimeters	December	January	February	March	April	May
0–4	6					
5–9						
10–14						
15–19						
20–24	1		1			
25–29	3	1				
30–34		1				
35–39			4	1		
40–44	1		13	1		
45–49		2	4			
50–54			8	1		
55–59			7	2		
60–64		1	2	6		
65–69			2	3		
70–74			3	5		
75–79			1	8		
80–84			1	5	1	
85–89				3	1	2
90–94			1	7	1	1
95–99				4	1	1
100–104				2	3	
105–109					1	1
110–114				1		3
115–119				1	3	1
120–124					1	4
125–129					2	2
130–134					4	3
135–139				1	5	3
140–144					3	2
145–149					5	3
150–154					2	1
155–159					1	2
160–164					3	2
165–169					3	
170–174					5	1
175–179					5	1
180–184					5	1
185–189					4	
190–194					2	2
195–199						1
200–204					3	1
205–209						
210–214					1	

TABLE 4.—*Monthly summaries of length measurements of 218 hakes (Urophycis floridanus), during the first several months of life*

[Measurements based on the same fish as in table 3]

Month	Fish measured	Smallest	Largest	Average	Month	Fish measured	Smallest	Largest	Average
		Mm	*Mm*	*Mm*			*Mm*	*Mm*	*Mm*
December	11	3	40	14.8	March	51	37	135	79.6
January	5	25	62	45.0	April	66	83	212	152.8
February	47	24	91	51.7	May	38	86	202	139.5

ACHIRUS FASCIATUS LACÉPÈDE. AMERICAN SOLE

The American sole, *Achirus fasciatus*,[13] as understood here, ranges from Massachusetts to Texas, and is also recorded from the Atlantic coast of Panama. This species is very common on the coast of North Carolina, where it is often found in abundance in estuaries, and the mouths of fresh-water streams, on muddy bottom. It generally may be secured in numbers in the estuary of the Newport River at Beaufort, and the young especially range in abundance up the river into fresh water.

Small examples of this sole sometimes are taken in fresh water far from the sea. For example, it is a more or less permanent resident, at least during the summer, of the Potomac River as far up as Washington. The senior author also has seen a small specimen taken in the Savannah River at Augusta, Ga., slightly more than 200 miles from the sea, following the course of the river. He also has a specimen from the Pascagoula River, taken at Merrill, Miss., probably fully 75 miles by the course of the river from the Gulf, where we were informed by a local game warden the fish, though considered a curiosity, is taken from time to time. It may be said, therefore, that this sole ranges from salt, through brackish water, and sometimes far into fresh water. However, in the vicinity of Beaufort, N. C., at least, it is most numerous in water that is more or less brackish. It is, of course, a bottom-dwelling fish, like other flatfishes.

The usual book name of this species is American sole. In the field the names, sole, flounder, and hogchoker, are heard. In North Carolina hogchoker is almost universally used. In bygone times, and to a limited extent to the present day, hogs have fed on waste fish, cast on the shore by fishermen. Among them, of course, was the sole, for it has no commercial value. It is related that occasionally this sole actually became a hogchoker. In case the hog masticated poorly and tried to swallow the fish tail foremost, the fish sometimes lodged in the hog's throat, because of its extremely rough (ctenoid) scales. The hog, apparently being unable either to swallow or regurgitate the fish, eventually was choked to death.

CHARACTERS OF THE ADULT

The hogchoker is characterized chiefly by the short deep body, the depth generally being contained in the length to the base of the caudal fin considerably less than two (1.6 to 1.81) times. The eyes, which are very small, and the color, are on the right side of the body. The color is variable; generally it is brownish with darker blotches, and with about seven or eight dark cross lines. The mouth is very small, terminal, and the jaws are twisted; the maxillary reaches under the lower eye. The dorsal and anal fins are long, the former having 50 to 56 rays and the latter 36 to 42. The caudal fin is round, and the pectoral fins are missing.

METHODS OF COLLECTING

Adult fish, as well as young ones ranging upward of 18 mm in length, were collected mostly with otter trawls, though larger ones frequently were taken with seines also.

[13] Considerable discussion relative to the correct scientific name of the American sole has taken place during the past several years The reader interested is referred to Chabanaud (1928 and 1935), Myers (1929), and Hubbs (1932.) If the set-up of genera proposed by Chabanand, who recognizes more genera than most authors, is accepted the name, *Achirus*, is not available for the American sole, and is replaced by *Trinectes*. According to Hubbs and Chabanaud, *fasciatus* should be replaced by *maculatus*. Notwithstanding that this name was assigned to a fish of the Indian fauna by the original describers, it is now claimed that the designation of that locality was an error. Therefore, the last mentioned authors arrive at the conclusion that the correct name of the American sole is *Trinectes maculatus* (Bloch and Schneider). The present writers, nevertheless, prefer to retain the long familiar name *Achirus fasciatus*, for the reason that the extensive splitting of genera does not seem to us to be advantageous, and because there seems to be insufficient evidence that *fasciatus* actually is a synonym of *maculatus*.

The eggs were often secured in abundance with meter tow nets made of number 20 bolting silk. They were also obtained several times from the overflow of tanks supplied with running water in which gravid fish were confined. Unfortunately the eggs secured from fish in captivity never appeared to be fertilized, presumably because no ripe males were present. However, these eggs served a very useful purpose, as they aided us in positively identifying hogchoker eggs taken in the tow.

Hogchoker eggs, indeed, had been taken in the tow by us over a period of several summers before their identity became definitely known on June 8, 1929, from a comparison with eggs secured from fish held in confinement.[14]

The more advanced stages of the larvae shown in the accompanying illustrations were drawn from fish reared in the laboratory by the junior author. In the rearing experiments comparatively large numbers of young were placed in glass evaporating dishes having a depth of about 3 inches and a diameter of 8 to 10 inches. Only about an inch of water was used in each dish, thus exposing a large surface, in comparison with the small amount of water, to the air for absorption of oxygen. No artificial aeration was used. To keep the water at a fairly uniform temperature the dishes were partly submerged in the large laboratory tanks supplied with running sea water fed from a 12,000 gallon tank by gravity.

While the larvae were very small they were fed daily with towings strained through number 20 bolting silk. After the fish had gained some growth, towings were introduced without straining. Ample time for feeding, that is, an hour or so, was given after introducing the towings, and then the fish were removed with a pipette to clean dishes supplied with water brought to the laboratory in a clean container directly from the laboratory pier.

SPAWNING

The spawning season of the hogchoker seems to be a long one, the eggs having been obtained from spawning fish held in tanks, as early as May 18 (1931), and as late as August 14 (1930). In the tow the eggs were noticed as early as May 20 (1931), and as late as August 5 (1928). It is evident, then, that at Beaufort the spawning season extends, at least from midspring to midsummer.

Ripe or nearly ripe fish were taken only in the estuary of Newport River, where the eggs also were secured. However, eggs also were taken in several other localities within the harbor, as well as at sea as far out as 6 miles off Bogue Banks. Hogchoker eggs often were collected in abundance, being among the most numerous fish eggs in season.

Spawning evidently takes place only in the evening, principally from about 6 to 8 o'clock. It was during that time when the eggs were spawned in the laboratory tanks, and it was only in the *early* evening, as shown by many towings, that eggs in early cleavage stages were secured. In addition to the very recently spawned eggs, older ones with rather well-developed embryos, extending about two-thirds the distance around the periphery of the eggs, were present in the early evening towings. The older eggs evidently had been spawned the previous evening, and were about 24 hours old.

According to other studies made at Beaufort, partly published by the writers (1930) and partly still unpublished, it would seem that early evening spawning is quite usual among marine fishes.

[14] Dr. Albert Kuntz, working for the Bureau of Fisheries at Beaufort, N. C., temporarily, secured the eggs, drew up descriptions and had sketches of the development of the eggs and early young prepared (unpublished) as early as 1913. However, the eggs were not identified. In 1916 Dr. Lewis Radcliffe secured the eggs in Chesapeake Bay, drew up descriptions and some sketches (also unpublished), which he labeled "hogchoker." How he arrived at the tentative conclusion is not evident from his notes.

Although the eggs were very numerous in the tow at times during the spawning season, the larvae were not found, notwithstanding that an extensive search was made for them. The smallest young taken in nature was 18 mm long. Therefore, nothing can be reported at this time on the habitat and distribution of the larvae.

DESCRIPTIONS OF THE EGGS AND YOUNG

The eggs are spherical, richly supplied with oil globules, and float at the surface. According to 200 unfertilized eggs, spawned in a tank on two different dates (the product of two or more fish), the diameter varies from 0.66 to 0.84 mm, the average being 0.73 mm. Eggs especially selected for range in size from several hundred taken in the tow, and in an advanced cleavage stage when measured, ranged in diameter from 0.67 to 0.71 mm.

The oil globules are variable in number, as few as 15 and as many as 34 having been counted. They also are variable in distribution, sometimes lying close together, giving the egg a beaded appearance, and sometimes more or less uniformily distributed over the surface of the egg. They also vary in size from very minute dots to about 0.06 mm in diameter. The variation in position, number, and size is shown, at least in part, in the accompanying drawings. The large number of oil gloubles give the egg buoyancy. No perivitalline space is noticeable (fig. 142).

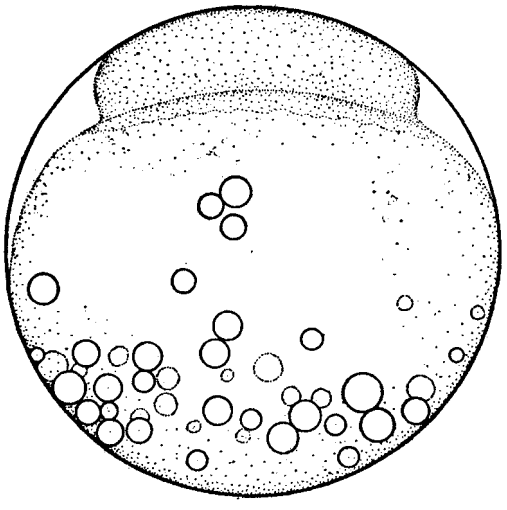

FIGURE 142.—*Achirus fasciatus*. From egg with fully formed blastodisc.

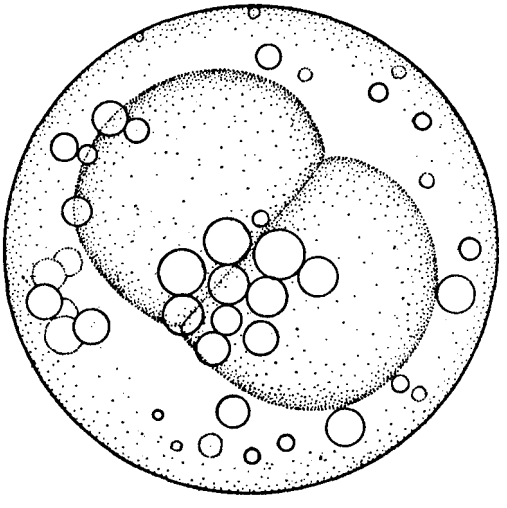

FIGURE 143.—*Achirus fasciatus*. From egg in 2-cell stage; about half hour after fertilization.

The eggs, though quite transparent, have a slight greenish tinge (described as yellowish by Albert Kuntz, MS.) This color seems to be contained in minute yolk granules, discernible under rather high magnification (fig. 143).

Cell division proceeds rapidly after fertilization. Eggs collected between 7:30 and 8 p. m. (May 20, 1931), quite surely spawned after 6 p. m. of the same day, ranged from four-cell to many-cell stages when examined in the laboratory at 8:30 p. m. on the same evening (figs. 144 to 147). An hour later, or from about 2 to 3 hours after fertilization, all had reached advanced cleavage stages (fig. 147).

On the morning of the following day, or about 13 to 14 hours after fertilization, the eggs contained well-outlined embryos, with eyes just becoming visible, the stage showing the embryonic streak having been passed in the meantime (figs. 148 and 149). About 20 hours after fertilization the embryo extended almost two-thirds the distance

around the periphery of the egg; and at 26 hours after fertilization it extended fully three-fourths the distance around the egg. Its tail was sharply recurved, its heart was beating slowly, and it was capable of considerable movement (fig. 150).

When next observed, about 36 hours after fertilization, the eggs had hatched; that is, hatching had taken place sometime between 26 and 36 hours after fertilization. The temperature of the water in the dishes in which the eggs were hatched had varied only from about 74° to 76° F.

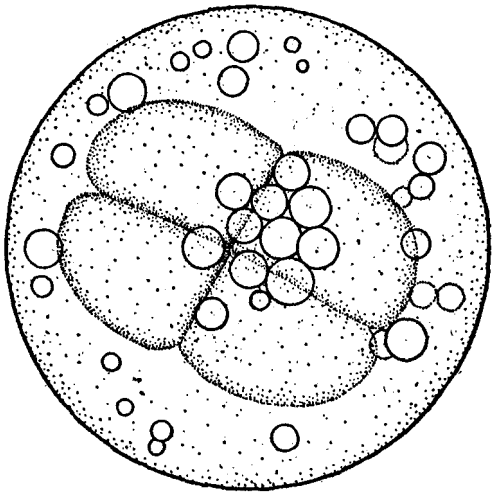

FIGURE 144.—*Achirus fasciatus*. From egg in 4-cell stage, following the 2-cell stage in about 15 minutes.

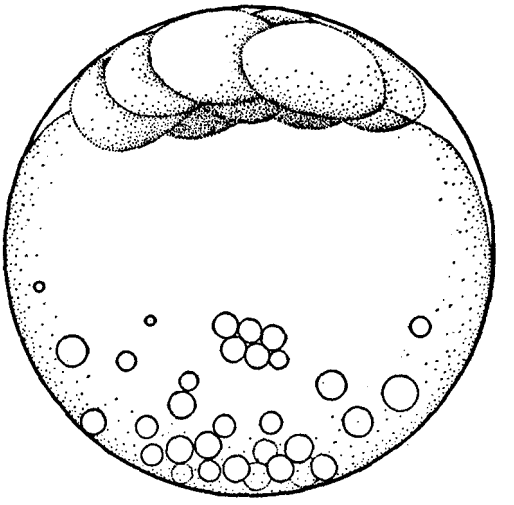

FIGURE 145.—*Achirus fasciatus*. From egg in 8-cell stage, following the 4-cell stage in about 15 minutes.

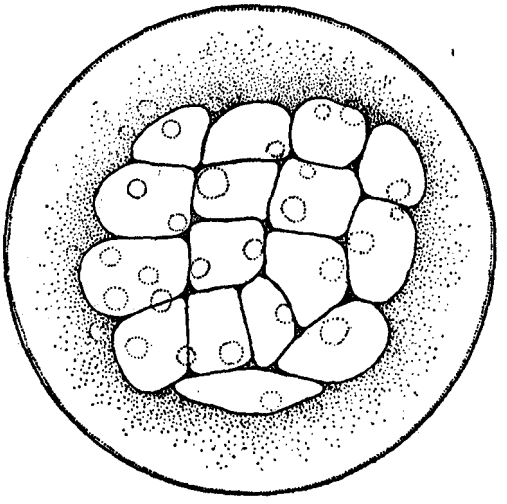

FIGURE 146.—*Achirus fasciatus*. From egg in 16-cell stage, showing irregularity of cells. (Drawn by Effie B. Decker.)

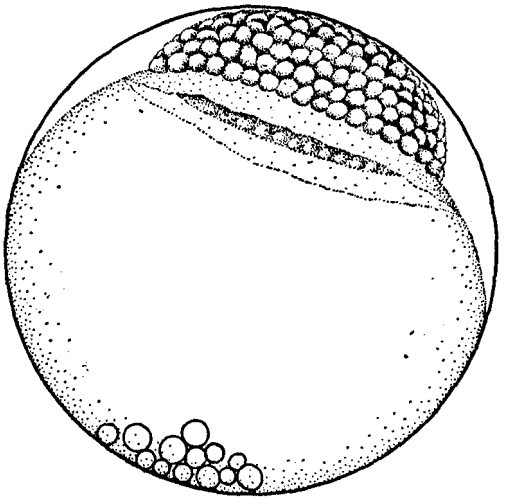

FIGURE 147.—*Achirus fasciatus*. From egg in advanced cleavage stage; about 3 to 4 hours after fertilization.

The older eggs taken at the same time as those for which the development is described in the foregoing paragraphs, which contained advanced embryos, hatched within 12 hours after collection. As these eggs quite certainly were spawned a day earlier than the others, the period of incubation also fell between 26 and 36 hours. It may be stated rather definitely, therefore, that the incubation period almost surely does not exceed 36 hours, at temperatures usually prevailing at Beaufort during the spawning period of the hogchoker.

The development of the egg of the hogchoker is quite usual for a teleost and is well shown by the drawings presented herewith. Therefore, extended descriptions of the different stages in the development are not necessary. In the series of illustrations prepared during our investigation the cells are all shown as of fairly uniform size and shape. Some eggs were observed, however, in which the cells were more or less unequal in size and somewhat different in shape. Figure 146, prepared by Mrs. Effie B. Decker under the supervision of Dr. Albert Kuntz, is introduced to show a rather extreme case of unsymmetrical cleavage. Too many eggs with more or less unequal cells were seen to permit us to consider variation an abnormality. It may be assumed, therefore, that the cells in the early cleavage stages are apt to vary somewhat.

During the early cleavage stages the blastoderm appears as a rather flat mass of cells. However, in the more advanced cleavage stages it is very distinctly dome-shaped, with a cavity beneath it, as shown in a side view, in figure 147. This stage apparently is reached within 2 or 3 hours after fertilization.

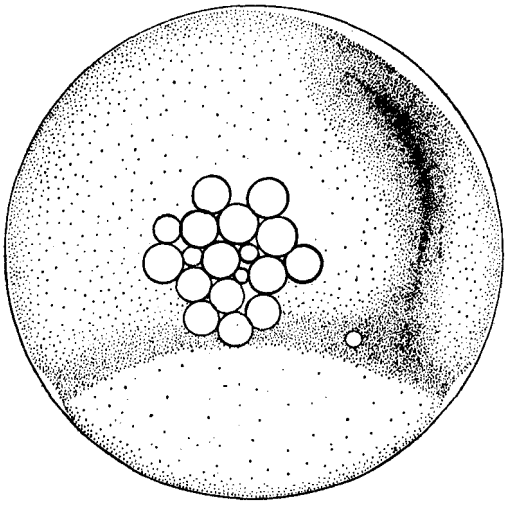

FIGURE 148.—*Achirus fasciatus*. From egg showing an early stage in the differentiation of the embryo (the shaded streak to the right).

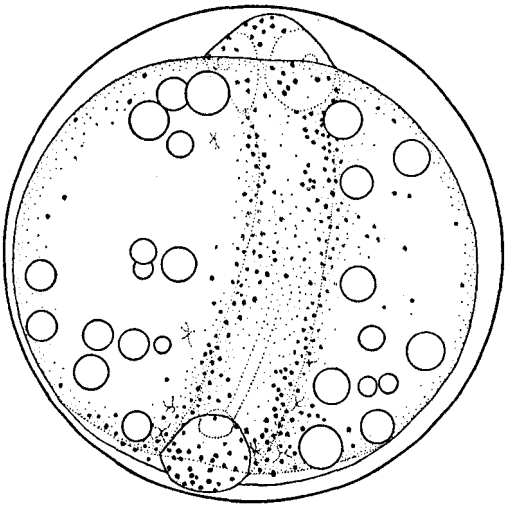

FIGURE 149.—*Achirus fasciatus*. Egg showing later stage in differentiation of embryo; about 12 hours after fertilization.

The development shown in figure 148, a rather early stage in the differentiation of the embryonic axis (the dark streak to the right), is attained about 6 to 8 hours after fertilization. Many greenish granules are present within the egg. Note the concentration of the oil globules in figure 148 in contrast with their scattered positions in figure 149, as well as in some of the other illustrations. This concentration is not characteristic of this nor any other particular stage of development, but varies in individual eggs.

The rather early embryonic stage shown in figure 149 was attained in about 13 to 14 hours. Note that the eyes with lenses are just becoming differentiated. No somites are visible, probably because the embryo is too opaque. Many greenish specks are present on the embryo and some scattered ones on the yolk. A few more or less definitely formed chromatophores, too, are becoming visible.

The moderately advanced embryonic stage shown in figure 150 was attained in about 26 hours. The embryo evidentally is too opaque to allow the somites to be seen. It is capable of considerable movement, and slow heart action may be seen. Green specks still are numerous, and comparatively many chromatophores are present,

both on the embryo and the yolk. Note that few oil globules, most of them being small, are present. This again is not characteristic of this stage, but only of the particular egg drawn.

Newly hatched larvae.—The newly hatched fish is only about 1.7 to 1.9 mm long. The dorsal and ventral finfolds are very wide, making the larva seem short and deep. The head is slightly deflected, and on its dorsal surface is a pronounced hump. The tail is straight and pointed.

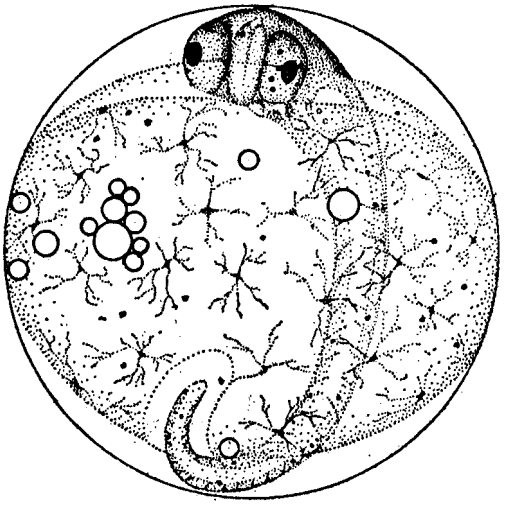

FIGURE 150.—*Achirus fasciatus.* From egg with rather advanced embryo.

The yolksac is comparatively large and some or all the oil globules present in the egg are retained. The number of globules in the yolksac is equally as variable as in the egg. The yolksac also retains the green specks and chromatophores described for the eggs in advanced embryonic stages.

Green specks also are present on the body of the larva, except on the distal part of the tail. On the vertical finfolds green specks are concentrated to form blotches, which are somewhat variable among individuals in size, intensity, and position. There is one on the dorsal finfold above the yolksac; another on the fold above the vent; generally a more or less definite corresponding one on the ventral finfold just behind the vent; and another pair on the fold at about midcaudal length. In some individuals the concentration of color is continued more or less on the body of the larvae, forming indications of cross bars, which become more distinct as the fish grow. In addition to the green specks more or less definite dark chromatophores are variously distributed over the body and finfolds.

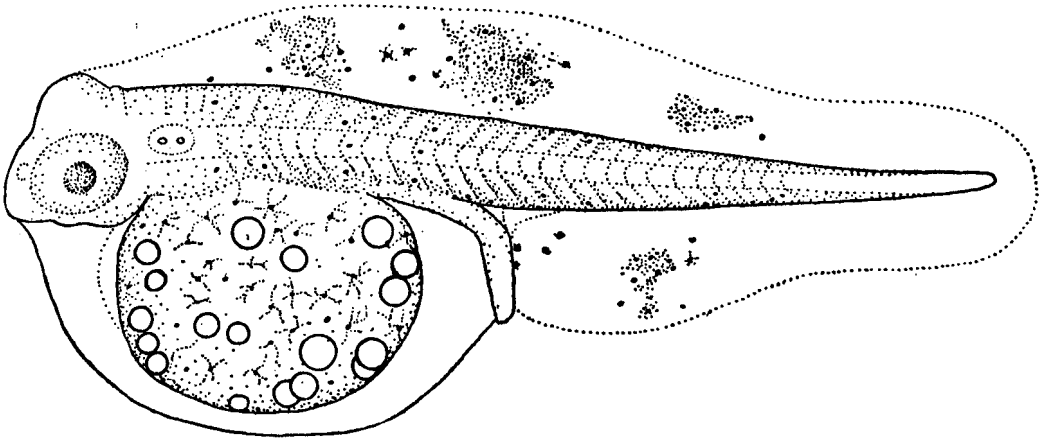

FIGURE 151.—*Achirus fasciatus.* From newly hatched young 1.8 mm long.

Heart action is visible, but due to the opaqueness of the fish the circulation cannot be seen. The vent is located at about midbody length. The newly hatched fish swims, or floats on its back, presumably being held in that position by the bouyancy of the many oil globules in the yolksac (fig. 151).

Larvae 16 hours old, 2.2 to 2.4 mm long.—In about 16 hours the yolksac is nearly all absorbed. The very small amount remaining is crowded with oil globules. The fish is now about 2.2 to 2.4 mm long. The head no longer is deflexed, but is rather elevated, with the hump even more prominent than in the newly hatched fish. The mouth is open, and the pectoral finfold on each side is plainly visible.

It is interesting that, although pectoral finfolds are present in the larvae, pectoral fins are not developed. At least, not a rudiment of a pectoral fin was found in 186 adults, collected at various places along the Atlantic and Gulf coasts of the United States, especially examined for this character (fig. 152).

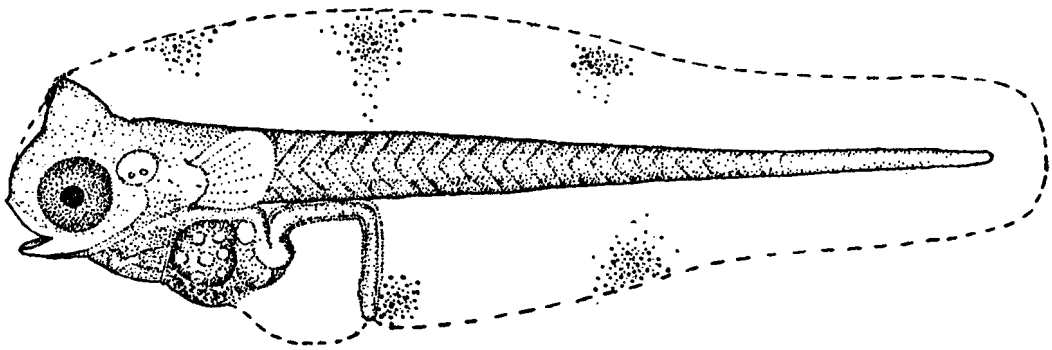

FIGURE 152.—*Achirus fasciatus*. From a young fish with yolk mostly absorbed, 2.4 mm long.

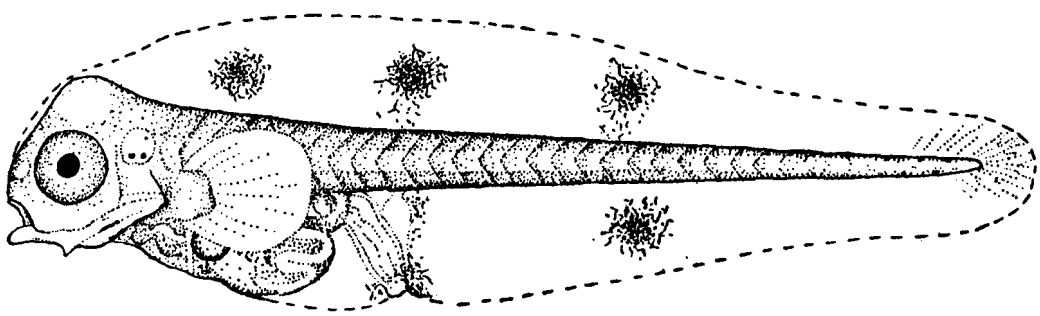

FIGURE 153.—*Achirus fasciatus*. From a young fish with yolk absorbed, 2.2 mm long.

Larvae 24 hours old.—In the aquarium the fish did not increase much, if any, in length for several days after the yolk was absorbed. The fish shown in figure 153 was only 2.18 mm long at 2 days of age, and therefore a little shorter than the younger fish shown in figure 152. Development, nevertheless, progressed somewhat. The yolksac with its oil globules had entirely disappeared. In its place there was a body wall through which the internal organs in part were visible. The hump on the head had become rather lower, and the mouth had moved forward somewhat with the lower jaw projecting slightly. The general color remained about the same as in the younger larvae. However, the pigment areas in the finfolds had become smaller and the pigment dots more concentrated (fig. 153).

Larvae 4 days old.—Four days after hatching the larvae still did not exceed a length of 2.5 mm. The head now had become more elongate, and the mouth more prominent with the lower jaw projecting rather strongly. The body had remained slender, as in the younger larvae.

The critical stage in the life of the larvae seems to be reached about the fourth day, and few survived until the fifth in the glass dishes in which they were kept in the laboratory. However, among those fed with towings, of which mention already has

been made, a few survived much longer and those specimens furnish the clue to the further development of the larvae.

Larvae 7 days old.—The fish shown in figure 154 is 7 days old and was 3.0 mm long. This fish differs little from the 4-day old one, already described. Very definite dark chromatophores are now present on the head and abdomen, and rather definite cross bars generally are present. Anteriorly the body has increased considerably in depth.

Larvae 14 days old.—Figure 155 is based on a preserved specimen 14 days old, measuring only 2.0 mm in length after preservation. It may be assumed that considerable shrinkage had taken place. The fish at this stage is deep and strongly compressed. The pigment spots on the dorsal finfold, tending to form bars on the body, are present

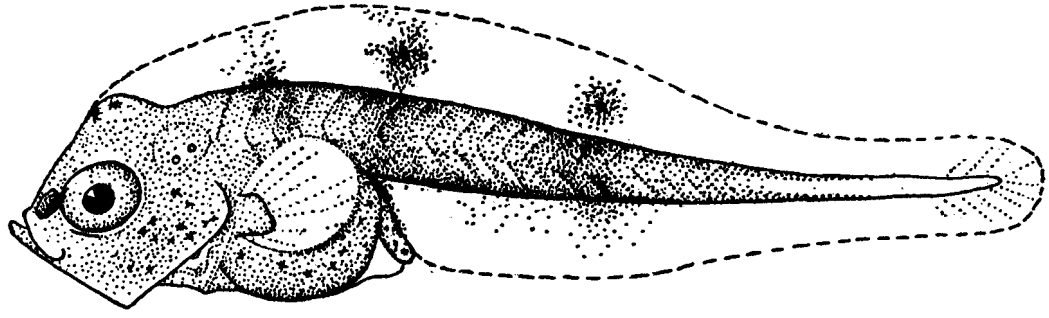

FIGURE 154.—*Achirus fasciatus.* From a young fish, 7 days old, 3 mm long.

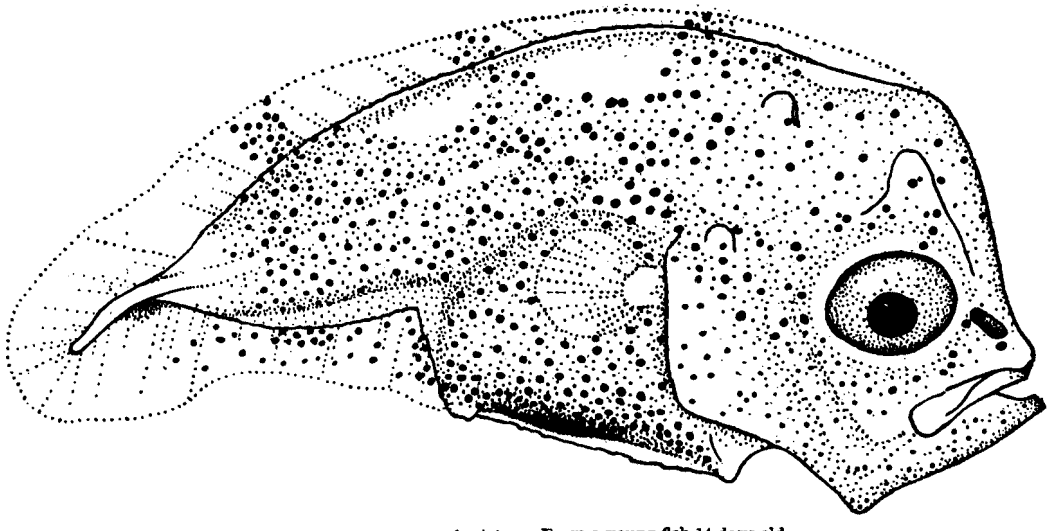

FIGURE 155.—*Achirus fasciatus.* From a young fish 14 days old.

about as in the early larvae. The pigment on the ventral finfold, however, is not concentrated in blotches in the single specimen studied. A great increase in dark dots on the body has taken place.

Young fish 17 days old.—It is evident from figure 156, based on a specimen 17 days old, 3.8 mm long after preservation, that development progressed rapidly. The fish has become much more shapely. The distal part of the tail, instead of being curved downward, is now bent upward, giving it the heterocercal appearance characteristic at this stage of development of telosts with homocercal tails. Indications of rays are present in the finfolds. Note that the pectoral finfold remains prominent. The eyes are quite symmetrically placed on the opposite sides of the head, and there is as

yet no indication that one of them (the left one) will "migrate." Pigmentation has increased greatly, and is equally developed on both sides.

Young fish 26 days old.—Growth among the five fish alive at the age of 26 days was quite unequal. In the larger ones, 3.8 mm long when alive, rays are quite fully

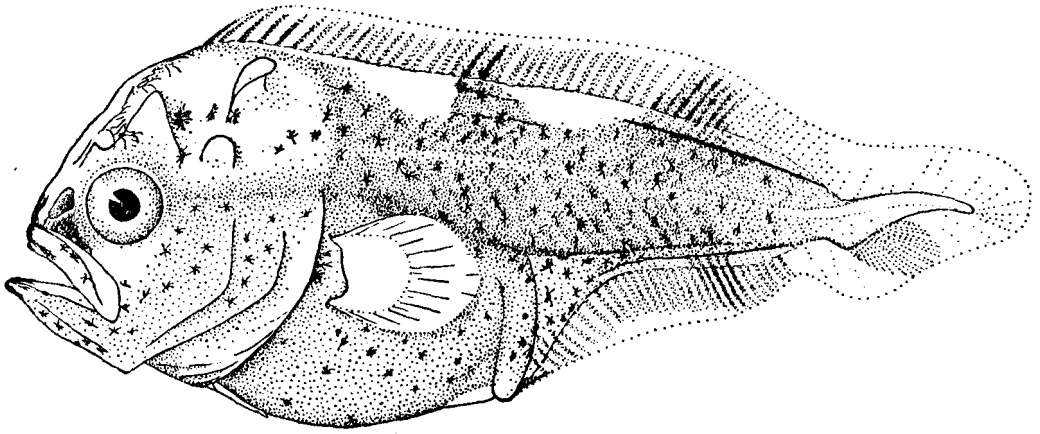

FIGURE 156.—*Achirus fasciatus*. From a young fish 17 days old.

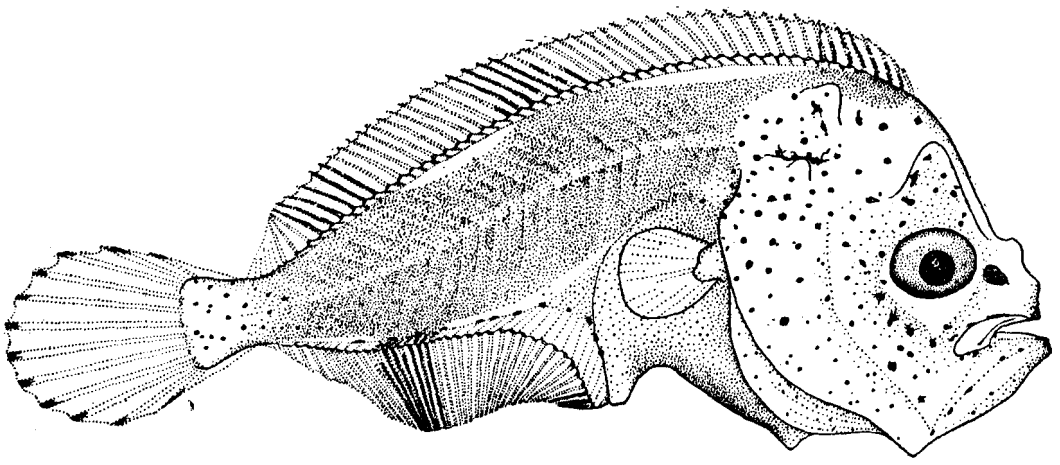

FIGURE 157.—*Achirus fasciatus*. From a young fish 32 days old.

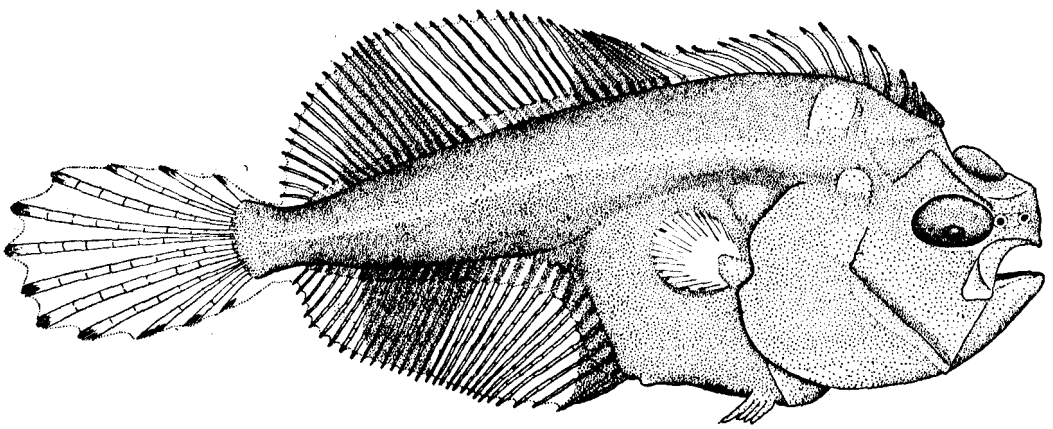

FIGURE 158.—*Achirus fasciatus*. From a young fish 34 days old. Though only a few days older than the one illustrated in fig. 157, development is much further advanced.

developed in the vertical fins. A slight depression is evident above the right eye through which the left eye is destined to migrate, as illustrated in the older fish shown in figure 158. However, at this stage the eyes remain symmetrically placed. The fish still swam upright in deep water, but on a hollowed microscope slide containing insufficient water to "float" them vertically, they invaribly swam or rested on the left side.

Young fish 32 days old.—The specimen illustrated in figure 157, which is 32 days old and 3.0 mm long, after preservation, has the depression over the right eye, described for the fish 26 days old, more pronounced. The second line shown in the drawing is the actual outline of the interorbital, for above it is only a transparent membrane. However, the eyes remain symmetrically placed on the opposite sides of the head. Note in the illustration that the pigment blotches on the dorsal and anal fins remain placed essentially as in the early larvae.

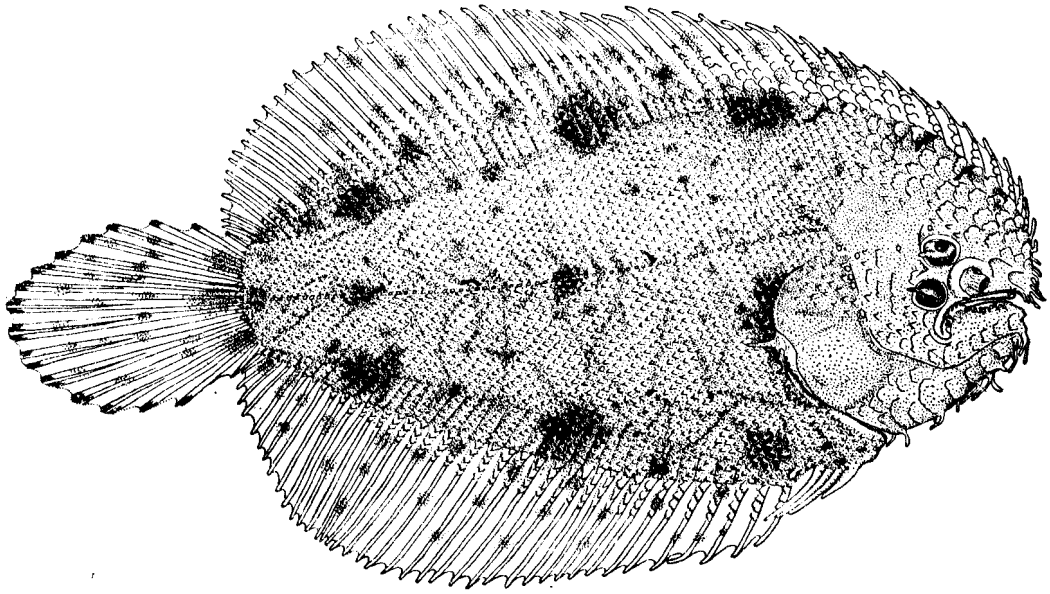

FIGURE 159.—*Achirus fasciatus*. From a young adult 18 mm long.

Young fish 34 days old.—The fish illustrated in figure 158 is 34 days old. Therefore, only 2 days older than the one shown in figure 157. However, this fish is larger, being 5.0 mm long after preservation, and it is much advanced in development. Note in the illustration that the left eye has just entered the depression in the forehead. At this size the mouth already is much twisted, essentially as in the adult. Ventral fins now are developed. Note also that the pectoral fin membranes persist. It seems significant, however, that in contrast with the other fins no definite rays have developed. It is, furthermore, noteworthy that the pigment spots on the dorsal and anal fins persist essentially as in the early larvae. No loss of pigmentation on the blind side has taken place.

Although one fish lived in the aquarium to reach the age of 41 days, development had not proceeded as far as in the specimen 34 days old, just described. As the smallest specimen taken in nature is 18 mm long, and essentially a young adult, an unfilled gap in the development remains between this specimen and the 5.0-mm one, described in the foregoing paragraph.

Young fish 18 mm long.—The 18-mm specimen illustrated in figure 159 already is fully scaled. Fleshy tentacles are developed on the head, though not in the profusion of fully grown fish. The left eye has completed the migration, both eyes appearing close together on the right side of the head, the upper one (originally the left one) being a little in advance of the lower one just as in the fully grown fish. The pectoral finfold remains in part, having the appearance of a fleshy tentacle as shown in the illustration. Most of the fish examined had lost this rudiment of a pectoral at a length of 25 to 30 mm. However, one specimen 43 mm long retained it. It would not be surprising, therefore, if occasionally it were retained longer, or even throughout life. The ventral and anal fins have approached each other as in the adult. In the process the vent and the anal fin have "migrated" forward. (See figures 158 and 159.)

The 18-mm specimen is fully pigmented on the right or eyed side. It is interesting that the dark blotches on the dorsal and ventral fin folds of the newly hatched larvae have been retained on the right side of this fish in essentially the same position. These juvenile spots are lost, however, when the fish reach a length of about 25 mm. As the fish grows, spots generally become much more numerous than in the 18-mm one illustrated. Frequently about seven or eight more or less definite blackish cross lines are also developed in adults. Much variation in color among individuals exists. The small specimen drawn is destitute of pigment on the blind side, which is quite usual among adults. Yet, many exceptions have been noticed. In fact, various degrees of pigmentation have been seen, ranging from a few obscure dusky spots or a dusky shade here and there to a general dusky to blackish coloration with definite blackish spots.

GROWTH

An insufficient number of hogchokers has been measured to determine the rate of growth with any degree of certainty. According to length measurements of 440 specimens, regarded as belonging to the 0-class, taken during April (1931), this class ranges in length from 18 to about 100 mm, the mode being at about 55 mm. A considerable range in size would be expected because of the very long spawning season, which extends at least from May to August. The specimens measured, therefore, may have varied in age from about 7 to nearly 12 months.

Subsequent growth remains almost entirely undertermined, though among a limited number of larger specimens, measured in April (1931), there is another slight mode around 140 mm, indicating that fish approaching an age of 2 years probably are fully grown.

The largest hogchocker taken at Beaufort was 184 mm (7½ inches) long. The largest one ever reported (Hildebrand & Schroeder, 1928, p. 176), so far as known to the writers, was 200 mm (8 inches) long. The average size of mature fish apparently is around 125 mm (5 inches). It is obvious, therefore, that the hogchocker is too small to be of commercial value. So far as the writers are aware it is never eaten.

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