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# Reproduction and Development of Whitings or Kingfishes Drums, Spot, Croaker, and Weakfishes or Sea Trouts Family Sciaenidae, of the Atlantic Coast of the United States

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# REPRODUCTION AND DEVELOPMENT OF WHITINGS OR KINGFISHES, DRUMS, SPOT, CROAKER, AND WEAKFISHES OR SEA TROUTS, FAMILY SCIAENIDAE, OF THE ATLANTIC COAST OF THE UNITED STATES[1]

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## INTRODUCTION

The account of the Sciaenidae that follows is based mostly on specimens collected on the coast of North Carolina. However, some specimens from the coast of New Jersey, from Chesapeake Bay, and from the coast of Texas have also been studied. In the preparation of the keys to the eggs and young, specimens were used as far as

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available, and the last six papers listed in the bibliography were drawn upon freely. The keys form a sort of summary of the present state of knowledge of the characters of the eggs and young of the Sciaenidae of the Atlantic coast of North America. It is hoped that they will prove useful in the further study of the eggs and the young of this family of large fishes, most of the members of which are of much economic importance.

It is evident from the present treatise that considerable gaps remain to be filled to make known fully the embryology and larval development of the Sciaenidae, though quite a number of stages in the development of several species, heretofore unknown, are described and figured. It has been particularly difficult to identify the eggs; and female fish, ripe enough for stripping, have been taken seldom. In a few instances the eggs were secured by confining nearly ripe females in tanks. However, this procedure was successful only if the females were ripe enough to spawn the first or second night after capture. If not, the fish retained the eggs. It was shown by Hildebrand and Cable (1930, p. 418) that spots (*Leiostomus xanthurus*), though containing advanced roe, retained it for several months after capture, that is, long after the spawning season had ended. The principal hope of securing the eggs for certain identification, therefore, lies in the capture of fully, or almost fully, ripe fish.

The illustrations accompanying this report, unless otherwise stated, were prepared by the junior author, who also made many of the preliminary identifications and assisted in various ways in the study of the specimens. The senior author is responsible for the final identifications and the composition of the report.

## ARTIFICIAL KEYS TO THE EGGS AND YOUNG SO FAR AS KNOWN

The following series of keys are entirely artificial, that is, they are designed to identify the fish rather than to show the natural relationship. The eggs of only three species of Sciaenidae from the Atlantic coast of the United States are known to date. A key by which the eggs of these three species may be identified is offered. The other keys are intended to identify the young of various sizes. The "Key to the newly hatched young" is based on live specimens hatched in the laboratory. It is limited, therefore, to the three species for which the eggs are known. All the other keys are based on preserved specimens. The length of the newly hatched young given in some instances exceeds that of the specimens treated in the next key, notwithstanding that the "smaller" specimens (1.7 to 1.8 millimeters long) were older fish, as shown by their development. The apparent decrease in length no doubt is caused by shrinkage in the preservatives. Some of the species included in the keys for the larger size groups are missing in those for the smaller fish, because the smaller stages are not yet known.

The size groups chosen for the keys are thought to be close enough together to make it possible to identify specimens of intermediate lengths. Specimens of lengths intermediate of those on which the keys are based should be identified by the key covering a range nearest their size. For example, specimens 11 millimeters long could be identified most readily by using the key for specimens 8 to 10 millimeters long, whereas specimens 14 millimeters long should be identified by using the key prepared for specimens 15 to 20 millimeters in length. Specimens exactly half way between two groups, in general, should be identifiable as readily by the key for the smaller specimens as by the one for the larger ones.

No key is offered for specimens more than 35 millimeters long because it is believed that such specimens have sufficient adult characters developed to be identified by keys prepared from adult fish, such as appear in various taxonomic treatises.

More complete descriptions of the eggs and young than are contained in the keys presented occur in the following works. For descriptions of the eggs and newly hatched young of *Menticirrhus saxatilis* see Welsh and Breder (1924). For accounts of the egg and larval development of *Bairdiella chrysura* consult Kuntz (1914) and Hildebrand and Cable (1930). For descriptions of young *Sciaenops ocellatus* and *Pogonias cromis* refer to Pearson (1929). For accounts of the development of the eggs and the young of *Cynoscion regalis* see Welsh and Breder (1923) and Pearson.[2] And for descriptions of young *Leiostomus xanthurus* and *Micropogon undulatus* refer to Hildebrand and Cable (1930). Accounts of the other species included in the keys are contained in the present paper.

## KEY TO THE EGGS[3]

[Sciaenid eggs so far as known are pelagic and spherical in form]

*a.* Eggs generally with only 1 oil globule, rarely with more than 2.

*b.* Range in diameter 0.66 to 0.77 millimeter, average 0.69; yolk with only a few pigment spots (dark green in color) in advanced state of development, none in younger stages; embryo and oil globule in advanced stages with somewhat scattered dark dots. *Bairdiella chrysura*

*bb.* Range in diameter probably about 0.8 to 0.92 millimeter, average 0.84; yolk profusely dotted (with dark green granules) in advanced state of development, some dots appearing during the cleavage stages; embryo and oil globule profusely spotted. *Cynoscion regalis*

*aa.* Eggs generally with more than 1 oil globule, often with 3 or 4, sometimes with as many as 13 to 18, reduced to 1 in advanced embryonic stages. Range in diameter 0.76 to 0.92 millimeter, average about 0.83. Yolk without pigment spots, the embryo with rather prominent scattered grayish dots. *Menticirrhus saxatilis*

## KEY TO NEWLY HATCHED YOUNG[4]

*a.* Length at hatching 1.5 to 1.8 millimeters, average about 1.6; vent nearer end of snout than tip of tail (notochord) by a distance equal to almost twice the diameter of eye. Caudal portion of body with a congregation of dark green chromatophores forming a suggestion of a cross bar at midcaudal length. *Bairdiella chrysura*

*aa.* Length at hatching 1.75 to 2.0 millimeters, average about 1.9; vent less than an eye's diameter nearer end of snout than tip of tail (notochord). Caudal portion of body with two cross bars composed of dark green chromatophores, one at about midcaudal length and the other one (less distinct) about midway between the vent and the first mentioned bar. *Cynoscion regalis*

*aaa.* Length at hatching 2.0 to 2.25 millimeters; vent about an eye's diameter nearer end of snout than tip of tail (notochord); caudal portion of body with 3 equally spaced black and golden bars, the first one being situated immediately behind the vent. *Menticirrhus saxatilis*

## KEY TO SPECIMENS 1.7 TO 1.8 MILLIMETERS LONG

*a.* Caudal portion of body long and slender, much longer than rest of body; distance from end of snout to vent about 2.75 times in length to tip of tail (without finfold); depth immediately behind vent notably less than diameter of eye.

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[1] Unpublished manuscript in the files of the Bureau of Fisheries entitled "Seasonal Distribution and Abundance of Pelagic Marine Fish Eggs and Young Fishes at the entrance to Chesapeake Bay, Va."

[3] The key is based on live eggs.

[4] The key is based on live larvae. Keys to all other young are founded on preserved specimens.

*b.* Head and body rather deep, greatest depth about 4.0 in length to tip of tail (notochord); mouth well developed, very strongly oblique, the gape anteriorly well above middle of eye. Color plain or with a row of minute dark chromatophores along ventral outline of the tail, none in advance of vent, sometimes with one dark chromatophore on middle of side above vent, occasionally a few on the head ..... *Leiostomus xanthurus*

*bb;* Head and body more slender, greatest depth about 4.5 in length to tip of tail (notochord); mouth less perfectly developed, the gape anteriorly at about middle of eye; the imperfectly developed maxillary apparently reaching only slightly past anterior margin of eye. Ventral outline of the trunk as well as the tail with distinct, well separated black chromatophores, also a few definite ones on the head, none on side of the trunk and tail. *Cynoscion regalis*

*aa.* Caudal portion of body proportionately shorter and deeper; distance from snout to vent about 2.2 to 2.5 times in length to tip of tail (without finfold); depth immediately behind vent equal to or greater than diameter of eye.

*c.* Head and trunk rather short and deep, the greatest depth about 3.1 times in length without caudal finfold; preanal distance 2.1 to 2.4 times, and postanal distance without finfold 1.75 to 1.9 times; depth immediately behind vent about equal to diameter of eye. Ventral outline of chest and abdomen with dark markings, with a large prominent spot just in advance of vent; anterior half to two-thirds of ventral outline of tail with a close-set series of dark dots; base of primitive pectoral pale ..... *Cynoscion nebulosus*

*cc.* Head and trunk very short and deep, the greatest depth about 2.6 times in length without caudal finfold; preanal distance 2.25 times; and postanal distance without finfold 1.88 times in length; depth immediately behind vent notably greater than diameter of eye. Caudal portion of body with an almost continuous dark longitudinal line along middle of side, and another one on the ventral outline; no prominent dark spot in advance of vent; base of primitive pectoral pale ..... *Menticirrhus americanus*

*ccc.* Head and trunk rather short and deep, the greatest depth about 3.1 times in length without caudal finfold; preanal distance 2.4 times and postanal distance without finfold 1.6 times; depth immediately behind vent about equal to diameter of eye. Median line of abdomen with a small black spot just before vent, generally with an elongated black spot on ventral outline at about midcaudal length, sometimes with several small dark spots; inner surface of base of primitive pectoral black ..... *Stellifer lanceolatus*

*cccc.* Head and trunk moderately long and deep, greatest depth 3.1 to 3.4 in length without caudal finfold; preanal distance 1.9 to 2.0 times and postanal distance 1.9 to 2.2 times; depth immediately behind vent somewhat greater than diameter of eye. Ventral outline of tail generally with a row of black spots; a black spot at angle of opercle; fresh specimens with a black vertical band at shoulder, which generally fades in preservative; inside of base of primitive pectoral pale ..... *Bairdiella chrysura*

## KEY TO SPECIMENS 2.5 TO 3.0 MILLIMETERS LONG

*a.* Caudal portion of body long, slender, generally longer (much longer in *Cynscion regalis* and *Leiostomus xanthurus*) than rest of body; distance from snout to vent about 2.0 to 2.5 times in total length (without caudal finfold).

*b.* An abrupt and pronounced break present in contour at vent; caudal portion of body very slender; depth immediately behind vent less than 1.5 times diameter of eye; distance from tip of snout to vent about 2.2 to 2.6 in total length without caudal finfold.

*c.* Caudal portion of body moderately slender, depth immediately behind vent about 1.1 times the diameter of eye; mouth almost vertical; the gape anteriorly near level of upper margin of eye; a few dark chromatophores on chest or abdomen; an elongate one posterior to hind-gut at its juncture with the tail; a series of widely spaced chromatophores along the ventral outline of the tail; no black lateral stripe or spots present ..... *Leiostomus xanthurus*

*cc.* Caudal portion of body very slender, depth immediately behind vent about equal to diameter of eye; mouth moderately oblique; the gape anteriorly at or below middle of eye; ventral outline of chest and abdomen generally with a few chromatophores, a prominent one just in advance of vent; ventral outline of tail with well separated dark chromatophores, one at about midcaudal length enlarged and usually with long radiating lines; no black lateral stripe or spots present ..... *Cynoscion regalis*

*bb.* The break in contour at vent less pronounced; caudal portion of body proportionately deeper; depth immediately behind vent about 1.7 to 1.85 times diameter of eye; distance from tip of snout to vent about 2.0 in total length without caudal finfold; mouth strongly oblique, the gape anteriorly generally above middle of eye; ventral outline of trunk and tail with very small dark chromatophores, none on side or back ... *Micropogon undulatus*

*aa.* Caudal portion of body shorter, about equal to or shorter (without finfold) than rest of body; distance from snout to vent about 1.75 to 1.9 in total length (without caudal finfold).

*d.* Caudal portion of body anteriorly with a black lateral stripe, continuous or composed of more or less separated elongated spots; ventral outline behind vent with close-set black chromatophores, often forming a nearly continuous line.

*e.* Body moderately deep, the greatest depth about 2.6 in total length without caudal finfold; vent situated almost exactly at midbody length; depth immediately behind vent about 1.25 times diameter of eye; mouth moderately oblique, the gape anteriorly being somewhat below middle of eye; black lateral stripe on anterior half to two-thirds of tail composed of somewhat disconnected dashes; no black on the dorsal outline. *Cynoscion nebulosus*

*ee.* Body very deep, the greatest depth about 2.4 times in total length without caudal finfold; vent situated well in advance of midbody length; depth immediately behind vent about 1.5 times diameter of eye; mouth strongly oblique, the gape anteriorly being about on a level with upper margin of eye; black lateral stripe on anterior half to two-thirds of tail continuous; dorsal outline of anterior part of tail with an almost continuous black line ..... *Menticirrhus americanus*

*dd.* Caudal portion of body without a black lateral stripe; ventral outline behind vent with a few to a series of several well-separated black chromatophores.

*f.* Inner surface of base of primitive pectoral black; no black cross bar at shoulder, nor a black spot at lower angle of opercle; an elongate black spot on ventral surface at about midcaudal length.

*g.* Body quite deep and robust, greatest depth 2.3 to 2.5 in total length without caudal finfold; mouth large, very broad, rather strongly oblique, the gape anteriorly being about on a level with the middle of the eye; maxillary reaching almost to middle of eye; preopercle with a few spines ..... *Stellifer lanceolatus*

*gg.* Body more slender, the greatest depth 2.8 to 3.2 in total length without caudal finfold; mouth somewhat smaller, narrower, rather less strongly oblique, the gape anteriorly being about on level with lower margin of pupil; maxillary reaching about to anterior margin of pupil; preopercle without evident spines. *Larimus fasciatus*

*ff.* Inner surface of base of pectoral not black; a broad black cross bar at shoulder (at least in fresh specimens), and a black spot at lower angle of opercle; ventral surface of tail with a series of dark dots, none of them especially enlarged; body quite slender, the greatest depth 2.8 to 3.0 in the total length without the caudal finfold. *Bairdiella chrysura*

## KEY TO SPECIMENS 3.5 TO 4.0 MILLIMETERS LONG

[Caudal fin generally more or less developed, and the notochord is bent upward posteriorly]

*a.* Body moderately slender, the greatest depth more than 3 (about 3.3 to 3.8) times in length to end of notochord.

*b.* Body without a black longitudinal stripe on side; mouth strongly oblique, the gape anteriorly above middle of eye; vent near midbody length, the distance from snout to vent being contained 2.0 to 2.1 times in length to end of notochord.

*c.* Body abruptly more slender posterior to vent; greatest depth of body 3.3 to 3.4, and the greatest depth behind vent 6.2 to 7.5 in length to end of notochord; eye large, equal to length of snout, its diameter 1.35 to 1.4 in greatest depth behind vent. *Leiostomus xanthurus*

*cc.* Body proportionately deeper behind vent; greatest depth of body 3.4 to 3.8, and the greatest depth behind vent 4.8 to 5.6 in length to end of notochord; eye smaller, shorter than snout, 1.9 to 2.2 in greatest depth behind vent ..... *Micropogon undulatus*

*bb.* Body with a black longitudinal stripe on side; ventral outline of tail with a rather close-set series of dark spots, none of the spots especially enlarged; mouth less strongly oblique, the gape anteriorly about on level with middle of eye; vent situated behind midbody length, the distance from snout to vent being contained 1.75 to 1.8 times in length to end of notochord; body moderately elongate, the greatest depth 3.4 to 3.6 in length to end of notochord ..... *Cynoscion nebulosus*

*aa.* Body deeper, the greatest depth generally less than 3 (about 2.2 to 3.0) times in the length to the end of the notochord.

*d.* Inside of base of primitive pectoral pale, never black; body moderately elongate; greatest depth generally more than 2.5 (about 2.6 to 3.0) times in length to end of notochord; vent at or near midbody length, the distance from snout to vent being contained about 1.75 to 2.0 times in the length to end of notochord.

*e.* Body without a dark longitudinal stripe on side; ventral outline without a continuous stripe, with or without a series of dark spots; vent almost at midbody length, the distance from snout to vent being contained about 1.9 to 2.0 times in the length to end of notochord.

*f.* No black cross bar at shoulder; ventral outline of tail with a series of well-separated black spots, one of the spots at about midcaudal length enlarged, generally with branching lines; chest and abdomen with a few large branching chromatophores; greatest depth 2.7 to 3.0 in length to end of notochord ..... *Cynoscion regalis*

*ff.* Shoulder region with a broad ill-defined black cross bar (at least in fresh specimens); ventral outline of tail with several indefinite dark spots, also two on the back, none with branching lines; greatest depth about 2.6 in length to end of notochord. *Bairdiella chrysura*

*ee.* Body with a dark longitudinal stripe on the side, one along the ventral outline of the tail and another one on the back; vent somewhat behind midbody length, the distance from snout to vent being contained about 1.75 times in the length to end of notochord; greatest depth about 2.7 in length to end of notochord ..... *Menticirrhus americanus*

*dd.* Inside of base of primitive pectoral black; body quite deep; greatest depth generally less than 2.5 (about 2.2 to 2.5) times in length to end of notochord; vent notably behind midbody length, the distance from the snout to vent being contained about 1.5 to 1.7 times in the length to the end of the notochord.

*g.* Body robust anteriorly; a large vacant space between brain and cranium; preopercle with spines; mouth moderately oblique, the gape anteriorly not much above lower margin of eye; maxillary reaching about to pupil ..... *Stellifer lanceolatus*

*gg.* Body more compressed anteriorly; no vacant space between brain and cranium; no preopercular spines; mouth strongly oblique, the gape anteriorly on level with middle of eye; maxillary reaching under middle of eye ..... *Larimus fasciatus*

## KEY TO SPECIMENS 5 TO 6 MILLIMETERS LONG

[The vertical fins, and sometimes the pectoral fins, are sufficiently developed to permit the enumeration of at least the soft rays]

*a.* Anal fin long, with II, 9 to 13 rays. (Spines not always developed.)

*b.* Body moderately deep, the greatest depth about 2.7 to 3.0 in length to base of caudal fin; mouth strongly oblique, the gape anteriorly only slightly below upper margin of eye; anal with 11 or 12 soft rays; body without dark stripes or bars; a prominent black chromatophore present below posterior half of base of anal ..... *Cynoscion regalis*

*bb.* Body rather deep, greatest depth about 3.1 in length to base of caudal fin; mouth rather strongly oblique, the gape anteriorly about on level with middle of eye; anal with 12 or 13 soft rays; body without dark stripes or bars; ventral outline behind vent with a series of small dark spots of about uniform size ..... *Leiostomus xanthurus*

*bbb.* Body quite deep, greatest depth 2.6 to 2.8 in length to base of caudal fin; mouth moderately oblique, the gape anteriorly usually on level with lower margin of pupil; anal with 9 or 10 soft rays; a broad black ill-defined bar across chest and extending to shoulder; ventral outline behind vent with a single prominent black chromatophore situated below last anal rays ..... *Bairdiella chrysura*

*aa.* Anal fin shorter, with I or II, 6 to 8 rays. (Spines not always developed.)

*c.* Body moderately slender, the greatest depth more than 2.2 times in the length to base of caudal; vent at or near midbody length, never more than an eye's diameter in advance of or behind the midpoint between tip of snout and base of caudal.

*d.* Anal fin with only 1 spine and 7, rarely 8, soft rays; body rather deep, compressed, depth about 2.75 in length to base of caudal; mouth moderately oblique, the gape wholly below level of lower margin of eye; caudal portions of body usually with a dark stripe along middle of side and another along ventral edge, these sometimes faint or broken up into spots ..... *Menticirrhus americanus*

*dd.* Anal fin with 2 spines; body without stripes, or at most with an indication of a stripe along middle of side of caudal portion, the color of the stripe when present being subsurface.

*e.* Eye small, shorter than snout, the diameter also less than depth of caudal peduncle.

*f.* Mouth strongly oblique, the gape anteriorly about on level with middle of eye; maxillary reaching to or slightly past anterior margin of eye; anal with 8 soft rays; color plain, consisting principally of dark chromatophores along ventral outline, none on head or side ..... *Micropogon undulatus*

*ff.* Mouth slightly oblique, the gape anteriorly about on level with lower margin of eye; maxillary reaching about under middle of eye; anal with 6 or 7 soft rays (sometimes insufficiently developed to be enumerated accurately); color consisting principally of dark chromatophores on head, along sides and along ventral outline behind vent ..... *Pogonias cromis*

*ee.* Eye larger, equal to or longer than snout, the diameter also equal to or greater than depth of caudal peduncle; anal fin with II, 8 rays.

*g.* Body moderately slender, depth 3.3 to 3.5 in length to base of caudal; vent somewhat nearer base of caudal than tip of snout; distance from snout to vent 1.6 to 1.85 in length to base of caudal; a broken dark band on middle of side under second dorsal sometimes present, the color being subsurface; a large black chromatophore with branching lines present below base of posterior anal rays and generally another one on upper part of side, somewhat in advance of origin of second dorsal ..... *Sciaenops ocellatus*

*gg.* Body rather deep, greatest depth 2.6 to 2.8 in length to base of caudal; vent generally nearer tip of snout than base of caudal; distance from snout to vent 2.0 to 2.3 in length to base of caudal; no dark lateral band; a few dark points on chest and abdomen; a slight dark spot at origin of anal generally present and another definite one at end of anal; a slight shoulder spot present ..... *Stellifer lanceolatus*

*cc.* Body very deep, depth about 2.15 times in length to base of caudal; vent notably more than an eye's diameter nearer base of caudal than tip of snout; distance from snout to vent 1.4 times in length to base of caudal; mouth strongly oblique; the gape anteriorly somewhat above middle of eye; anal with II, 6 to 8 rays; inside of base of pectorals black. *Larimus fasciatus*

## KEY TO SPECIMENS 8 TO 10 MILLIMETERS LONG

[All the fins are developed and an accurate enumeration of the rays is now possible]

*a.* Anal fin with a single weak spine and 7 or 8 soft rays; body wholly or largely covered with large black chromatophores; no dark band on snout in front of eye; base of pectoral fins not black.

*b.* Body moderately compressed and fairly deep, greatest depth 3.6 to 3.8 in length to base of caudal fin; pupil of eye almost perfectly round; caudal fin nearly symmetrical, long and pointed; anal fin usually with I, 7 (rarely 8) rays; spinous dorsal often partly black; ventrals colorless ..... *Menticirrhus americanus*

*bb.* Body strongly compressed and deep; depth 2.8 to 3.0 in length to base of caudal; pupil of eye elliptical, that is, vertically elongate; caudal fin asymmetrical, more or less rounded, never sharply pointed, the longest rays in lower half of fin; anal fin usually with I, 8 (rarely 9) rays; spinous dorsal and ventrals usually wholly black ..... *Menticirrhus saxatilis*

*bbb.* Body somewhat compressed, rather broad and low; depth 3.6 to 4.0 in length to base of caudal; pupil of eye elliptical, that is, vertically elongate; caudal fin asymmetrical, more or less rounded, never sharply pointed, the longest rays in lower half of fin; anal fin with I, 7 rays; fins all colorless ..... *Menticirrhus littoralis*

*aa.* Anal fin with 2 spines, usually rather strong, and 6 to 13 soft rays; body generally with few or no black chromatophores on sides and back, largely unspotted.

*c.* Dorsal fin with X to XII–I, 20 to 22 rays (the spines sometimes not all developed).

*d.* Body quite deep, depth 2.6 to 2.75 in length to base of caudal; an abrupt decrease in depth posterior to vent; vent more than an eye's diameter in advance of anal; mouth strongly oblique, the gape anteriorly only a little below middle of eye; anal fin with II, 8 rays; caudal fin long, pointed; an elongate black spot or line in advance of upper anterior angle of gill opening; no black chromatophores at origin of first dorsal. *Stellifer lanceolatus*

*dd.* Body moderately deep, depth about 2.5 in length to base of caudal; no abrupt decrease in depth posterior to vent; vent not more than an eye's diameter in advance of origin of anal; anal fin with II, 9 or 10 rays; caudal fin round; no black spot or line in advance of upper anterior angle of gill opening; some black chromatophores on upper part of side near origin of first dorsal ..... *Bairdiella chrysura*

*ddd.* Body somewhat more slender, depth about 3.0 in length to base of caudal; no abrupt decrease in depth posterior to vent; vent less than an eye's diameter in advance of origin of anal; mouth rather strongly oblique, the gape anteriorly about on level with lower margin of pupil; anal fin with II, 6 or 7 rays; no black spot or line in advance of upper anterior angle of gill opening; upper surface of head and sides variously dotted with black chromatophores ..... *Pogonias cromis*

*cc.* Dorsal fin with X or XI–I, 23 to 34 rays (the spines not always developed).

*e.* Dorsal and anal fins long, the former with 30 to 34, and the latter with 12 or 13 soft rays; mouth moderately oblique, the gape anteriorly slightly above level of lower margin of eye; maxillary reachings almost to middle of eye; caudal fin rather short, slightly rounded or straight; a few dark chromatophores present along ventral outline only ..... *Leiostomus xanthurus*

*ee.* Dorsal and anal fins shorter, the former with 23 to 29 rays, and the latter with 6 to 12 rays (rarely with 13 in *Cynoscion regalis*).

*f.* Body very deep, strongly compressed, depth about 1.9 in length to base of caudal; mouth rather strongly oblique, the gape anteriorly a little above lower margin of eye; anal fin short with II, 6 rays; caudal fin rather long pointed; sides with large branching chromatophores, variable in number among specimens, partly at least arranged in longitudinal series; lower half of pectorals and ventrals black. *Larimus fasciatus*

*ff.* Body more slender, the depth more than 2.5 times in length to base of caudal; anal fin longer, with more than 7 soft rays; basal half of pectorals and ventrals not black.

*g.* Anal generally with 8 or 9 soft rays (*Cynoscion nothus* rarely with 10 rays).

*h.* Second dorsal moderately short, with 23 to 25 soft rays; eye large, about as long as snout, its diameter nearly equal to least depth of caudal peduncle; a broken lateral stripe present posteriorly, the color subsurface; body variously marked above and below with black chromatophores; a large branching chromatophore at base of posterior anal rays, and usually another prominent one on upper part of side, somewhat in advance of second dorsal ..... *Sciaenops ocellatus*

*hh.* Second dorsal rather long, with 28 or 29 soft-rays; eye small, shorter than snout, its diameter shorter than least depth of caudal peduncle; ventral surface with small black chromatophores; sides and back plain without black markings ..... *Micropogon undulatus*

*hhh.* Second dorsal moderately long, generally with 25 to 27 rays (sometimes 24 to 28); eye rather small, somewhat shorter than snout, its diameter notably shorter than least depth of caudal peduncle; body moderately deep; depth 3.0 to 3.25 in length to base of caudal; vent far in advance of origin of anal, the distance notably longer than diameter of eye; black lateral band wanting; 2 elongate dusky spots at base of anal, [1] at anterior rays and another at the posterior ones ... *Cynoscion nothus*

*gg.* Anal generally with 10 to 12 soft rays (*Cynoscion regalis* sometimes with 13).

*i.* Body moderately deep; depth 2.95 to 3.0 in length to base of caudal; vent more than an eye's diameter in advance of origin of anal; snout

moderately blunt; lower jaw scarcely projecting; no black lateral stripe, sides generally with groups of black chromatophores; a large black branching chromatophore below base of last anal rays..*Cynoscion regalis*

*ii.* Body more elongate; depth 3.6 to 4.0 in length to base of caudal; vent less than an eye's diameter in advance of origin of anal; snout pointed; lower jaw projecting prominently; a black lateral stripe present on posterior part of body; a black band in front of eye, sometimes extending through eye to opercle; no prominent black chromatophores at base of anal.....*Cynoscion nebulosus*

## KEY TO SPECIMENS 15 TO 20 MILLIMETERS LONG

[Scales usually are developed at this range in size and sometimes the body is fully covered at a length of 20 millimeters]

*a.* Anal fin with a single weak spine and 7 to 9 soft rays; mouth more or less inferior, nearly horizontal; lower jaw with a rather prominent knob at tip (which develops into a short thick barbel as the fish grows).

*b.* Body moderately deep, greatest depth 3.6 to 3.8 in length to base of caudal; pupil almost perfectly round; caudal fin long and pointed, the longest rays being longer than head; anal with I, 7 (rarely 8) rays; spinous dorsal and ventrals with black chromatophores, not wholly black.....*Menticirrhus americanus*

*bb.* Body deeper, greatest depth 3.25 to 3.4 in length to base of caudal; pupil elliptical; caudal fin broadly pointed, the longest rays in lower half of fin, notably shorter than head; anal with I, 8 (rarely 9) rays; spinous dorsal and ventrals black. *Menticirrhus saxatilis*

*bbb.* Body quite elongate, greatest depth 3.75 to 4.2 in length to base of caudal; pupil elliptical; caudal fin asymmetrically rounded, the longest rays in lower half of fin, shorter than head; anal with I, 7 rays; spinous dorsal and ventrals not pigmented.
*Menticirrhus littoralis*

*aa.* Anal fin with 2 rather strong spines and 6 to 13 soft rays; lower jaw without a knob at tip.

*c.* Snout more or less pointed; lower jaw projecting prominently; anal with II, 9 to 13 rays (rarely II, 8 in *Cynoscion nothus*).

*d.* Anal usually with 9, occasionally with 8 or 10, soft rays; body rather deep, the greatest depth 3.2 to 3.6 in length to base of caudal; caudal fin evidently very long and pointed, the longest rays longer than head; chromatophores small, forming indefinite blotches, blotches on back and in lateral line if present separate, not forming cross bars.....*Cynoscion nothus*

*dd.* Anal usually with 11 or 12, occasionally with 13, soft rays; body rather deep as in *C. nothus*; caudal fin rather long and pointed, the longest rays about equal to length of head; chromatophores large, forming rather distinct blotches, those on back and in lateral line connected, forming more or less definite cross bars on anterior part of body.....*Cynoscion regalis*

*ddd.* Anal with 10 or 11 soft rays; body slender, the greatest depth 3.9 to 4.1 in length to base of caudal; caudal fin short, broadly pointed, the longest rays notably shorter than head; chromatophores very small, arranged so as to form an indefinite lateral band and another band along base of dorsal and generally extending forward on head; no blotches or cross bars present.....*Cynoscion nebulosus*

*cc.* Snout not pointed, usually short and blunt; lower jaw not projecting (except in *Larimus fasciatus*) equal to or more usually shorter than upper jaw; anal with II, 6 to 8 rays, exclusive of *Leiostomus xanthurus* which has II, 12 or 13.

*e.* Anal long, with 12 or 13 soft rays; second dorsal with 30 to 34 soft rays; body moderately deep, the greatest depth about 3.4 to 3.8 in length to base of caudal; margin of caudal fin distinctly concave.....*Leiostomus xanthurus*

*ee.* Anal shorter, with 6 to 10 soft rays; second dorsal shorter, with 19 to 29 soft rays; margin of caudal rounded or pointed.

*f.* Second dorsal with 19 to 22 soft rays; first dorsal with 10, 11, or 12 spines.

*g.* First dorsal with 11 or 12 spines; anal with 8 to 10 soft rays.

*h.* Head broad, spongy; eye small, shorter than the snout; interorbital notably broader than eye; anal with 8 soft rays; caudal fin long, pointed.....*Stellifer lanceolatus*

*hh.* Head narrow, compressed, not spongy; eye larger, fully as long as snout, about as wide as interorbital; anal with 9 or 10 soft rays; caudal fin rather short, the margin round ..... *Bairdella chrysura*

*gg.* First dorsal with 10 spines; anal with 6 or 7 soft rays; head deep, compressed; mouth inferior; a series of short barbels generally visible on lower jaw; dark cross bars present ..... *Pogonias cromis*

*ff.* Second dorsal with 23 to 29 soft rays; first dorsal with 10 spines only.

*i.* Body very deep, compressed, the depth 2.4 in length to base of caudal; mouth strongly oblique, the gape anteriorly above lower margin of eye; second dorsal with 24 to 27 soft rays; anal with 6 to 8 soft rays; caudal fin long, pointed; body with very large chromatophores, forming an indefinite band on anterior part of body; pectorals and ventrals largely black; spinous dorsal with big black spots ..... *Larimus fasciatus*

*ii.* Body more elongate, the depth being contained more than three times in length to base of caudal; mouth only slightly oblique, the gape wholly below the eye; caudal fin more or less rounded, not long and pointed.

*j.* Second dorsal with 28 or 29 soft rays; caudal fin long, pointed, as long as head; a row of short, slender barbels visible on chin in some specimens. *Micropogon undulatus*

*jj.* Second dorsal with 23 to 25 soft rays; caudal fin short, angulate, shorter than head; no barbels on chin ..... *Sciaenops ocellatus*

## KEY TO SPECIMENS 30 TO 35 MILLIMETERS LONG

[At this size the body generally is fully pigmented and frequently the color pattern of the adult is present]

*a.* Anal fin with a single weak spine and 7 to 9 soft rays; mouth notably inferior, nearly or quite horizontal, the conical snout usually projecting beyond it; lower jaw with a very short thick barbel at tip.

*b.* Ventral fins small, shorter than pectorals, not reaching beyond tips of pectorals; scales on chest not much smaller than on rest of body; sides with dark blotches or more usually with black bands.

*c.* Body slender, greatest depth 3.8 to 4 in length to base of caudal; pupil round; anal rays typically 7, rarely 8; caudal fin long and pointed, the longest rays fully as long as head; sides with dark blotches, usually forming indefinite cross bars, not forming a V on the side under spinous dorsal ..... *Menticirrhus americanus*

*cc.* Body deeper, greatest depth 3.5 to 3.65 in length to base of caudal; pupil eliptical; anal rays typically 8, sometimes 9; caudal fin not long and pointed, angulate, the longest rays shorter than the head; sides usually with black cross bars, the second and third nearly or quite meeting on middle of side, forming a V under spinous dorsal. *Menticirrhus saxatilis*

*bb.* Ventral fins large, longer than pectorals and reaching far beyond them; scales on chest notably reduced in size; body slender, greatest depth 4.05 to 4.3 in length to base of caudal; pupil eliptical; anal rays typically 7; caudal fin short, the lower lobe longest, notably shorter than head; sides with a few black dots, no large blotches or bars, color mostly silvery ..... *Menticirrhus littoralis*

*aa.* Anal fin with 2 rather strong spines; mouth superior, terminal, or only slightly inferior, the snout not projecting prominently; lower jaw with or without barbels, numerous if present.

*d.* Snout pointed; lower jaw projecting prominently; barbels wanting; upper jaw anteriorly with enlarged canines, curved backward; body elongate, greatest depth 3.2 to 4.2 in length to base of caudal; anal with 9 to 13 soft rays (rarely only 8 in *Cynoscion nothus*).

*e.* Body rather deep, greatest depth 3.2 to 3.6 in length to base of caudal; snout only moderately pointed; mouth oblique, the gape anteriorly somewhat above lower margin of eye; lower jaw projecting moderately; caudal fin long, pointed, the longest rays longer than head; sides usually with dark blotches or dark bars, no longitudinal black bands present.

*f.* Anal fin usually with 9, occasionally with 8 or 10 soft rays; sides generally with dark blotches in two series, one along the back and the other on the middle of the side ..... *Cynoscion nothus*

*ff.* Anal fin usually with 11 or 12, occasionally with 13, rays; sides with more or less definite dark cross bars ..... *Cynoscion regalis*

*ee.* Body more slender, greatest depth 3.95 to 4.2 in length to base of caudal; snout sharply pointed; mouth less oblique, the gape anteriorly below eye; lower jaw projecting strongly; caudal fin not very long nor sharply pointed, the longest rays shorter than head; anal fin with 10 or 11 rays; side and back each with a black longitudinal band, no blotches or cross bars present ..... *Cynoscion nebulosus*

*dd.* Snout not pointed; lower jaw equal to or shorter than the upper, projecting slightly in *Larimus fasciatus;* no enlarged canine teeth in upper jaw; body sometimes deep, sometimes elongate; anal with 6 to 8 soft rays, exclusive of *Leiostomus xanthurus* which has 12 or 13.

*g.* Anal long, with 12 or 13 soft rays; second dorsal with 30 to 34 soft rays; body moderately deep, greatest depth about 3.3 times in length to base of caudal; margin of caudal fin distinctly concave ..... *Leiostomus xanthurus*

*gg.* Anal shorter, with 6 to 10 soft rays; second dorsal shorter, with 19 to 29 soft rays; margin of caudal round or pointed, not concave.

*h.* Second dorsal with 19 to 22 soft rays; first dorsal with 10, 11, or 12 spines.

*i.* Body deep, compressed, depth 2.5 to 2.65 in length; head narrow, compressed; mouth horizontal, inferior; lower jaw distinctly shorter than the upper one, with numerous small barbels; anal with 6 or 7 soft rays; body with about 5 black cross bars ..... *Pogonias cromis*

*ii.* Body not quite as deep, depth about 2.9 to 3.1 in length to base of caudal; mouth somewhat oblique, terminal, the jaws of about equal length; no barbels on lower jaw; anal with 8 to 10 soft rays; no cross bars on body.

*j.* Head, narrow, compressed; interorbital not broader than large eye; skull hard, not spongy; anal with 9 or 10 soft rays; caudal fin round, not long; no dark blotches on back ..... *Bairdiella chrysura*

*jj.* Head broad, scarcely compressed; interorbital about two times as wide as the small eye; skull soft, spongy, cavernous; anal with 8 soft rays; caudal fin long and pointed; back with a series of black blotches. *Stellifer lanceolatus*

*hh.* Second dorsal with 23 to 29 soft rays; first dorsal with 10 spines only.

*k.* Body deep, compressed, greatest depth 2.6 to 2.8 in length to base of caudal; mouth strongly oblique, the lower jaw projecting somewhat; anal with 6 to 8 soft rays; caudal fin long and pointed; body with a broad cross bar under spinous dorsal and 4 or 5 narrower ones behind it ..... *Larimnus fasciatus*

*kk.* Body elongate, the depth about 3.3 to 3.6 in length to base of caudal; mouth horizontal, inferior, lower jaw included; anal with 8 soft rays; no cross bars on body.

*l.* Second dorsal with 28 to 29 soft rays; a row of short slender barbels usually visible on lower jaw; caudal fin long and pointed, the longest rays equal to length of head; body with small dark spots on sides and back. *Micropogon undulatus*

*ll.* Second dorsal with 23 to 25 soft rays; barbels wanting; caudal fin short, only slightly angulate, the longest rays notably shorter than head; body with dark spots placed as in *M. undulatus*, but larger and more distinct. *Sciaenops ocellatus*

## THE WHITINGS OR KINGFISHES (Menticirrhus americanus, M. saxatilis and M. littoralis)

Three species of whiting, namely, *Meticirrhus americanus, M. saxatilis*, and *M. littoralis*, occur on the coast of North Carolina. The species resemble each other so closely that the fishermen generally fail to distinguish them, and they are not separated in the market. The most widely used common names, in books at least, are whiting and king whiting. Other local names are kingfish, roundhead, sea mullet, and sea mink. The fish are known at Beaufort as "sea mullet", and much less commonly as "sea mink." Since the species are not separated in the market, the relative abundance of each cannot be ascertained from commercial records. It is

known from personal observation, however, that *americanus* is by far the most numerous and commercially the most important species in the vicinity of Beaufort. The other two are about equally common, but not abundant.

The whitings are choice food fishes and generally command a good price. One or more species is common enough to enter into the commercial catches along the coast all the way from Massachusetts to Texas. The States having the largest catches in 1929 are the following: [5] New Jersey, 52,408 pounds; Virginia, 54,650; North Carolina, 387,168; South Carolina, 100,754; Georgia 51,500; Florida, 664,943; and Louisiana, 41,829 pounds.

It is evident from the foregoing records that the whitings are important food fishes over a wide range of the eastern and southern shores of the United States. The writers are pleased, therefore, to offer some new information in regard to the life histories of these useful fishes.

No young under 9 or 10 millimeters in length have been recognized either as *saxatilis* or *littoralis*. Since the local species of the genus are readily distinguishable at the size mentioned, as pointed out in the descriptions of the young, it is improbable that the smaller specimens (unless it be the very smallest ones) consist of more than one species, and all seem referable to *americanus*.

The three local species apparently all spawn simultaneously at Beaufort, the reproductive period occurring in the spring and early summer. A rapid rate of growth is indicated during the first several months of life. The habitat of the smaller young, ranging from about 10 to 60 millimeters in length, appears to be identical in *saxatilis* and *littoralis*, as these fish were taken only in the surf along the outer shores of the "banks", while *americanus* occurs further off shore and also in the inside protected waters. The adults of *americanus* and *saxatilis* are found both in the inside and outside waters, while *littoralis* evidently is confined almost entirely to the outside open waters.

## CHARACTERS OF THE ADULTS

The body is long and rather low in the three species under consideration. The back is notably narrower than the abdomen, and much more strongly curved than the ventral outline. The head is low, and the conical snout projects well beyond the horizontal mouth. A short, thick barbel is present at the chin. The number of vertebrae is about the same in each species. In one specimen of each species counted, *americanus* and *littoralis* each had 10 body and 15 caudal vertebrae, and *saxatilis* had 10 body and 16 caudal vertebrae. The pupil of the eye is large and nearly or quite round in *americanus* at all ages, while it is smaller and vertically quite elongate in the young of about 6 inches and less in length of *saxatilis* and *littoralis*. In large preserved specimens of the last-mentioned species the pupil does not always appear elongate. Dorsal with 10 or 11 spines; anal with 1 weak spine. The chief diagnostic characters of the adults are included in the following key.

### KEY TO THE SPECIES

*a*. Scales on chest not especially smaller than on sides; pectoral fins long, reaching to or past tips of the ventrals.

*b*. Sides plain or with obscure bars, not forming a V; anal usually with 7 soft rays; none of the dorsal spines especially produced, and none reaching far, if at all, beyond origin of second dorsal; scales 86 to 90, counting vertical series above lateral line ..... *americanus*

[5] The statistics are taken from the "Fisheries Industries of the United States in 1930", by R. H. Fiedler. Appendix II, Report, U.S. Commissioner of Fisheries, 1931 (1932), pp. 109–552, 23 figs. Washington. The fish are listed under "king whiting" or "king-fish."

*bb.* Sides usually with black bars, the one on the nape and the one below the spinous dorsal meeting on the side forming a V; anal usually with 8 soft rays; the longest dorsal spine produced, reaching far past origin of second dorsal; scales 91 to 96, counting vertical series above lateral line ..... *saxatilis*

*aa.* Scales on chest much smaller than on sides; pectoral fins short, failing conspicuously to reach tips of ventrals; dorsal spines short, none of them produced; anal usually with 7 soft rays; scales 70 to 75, counting vertical series above lateral line; coloration normally plain silvery ..... *littoralis*

## MENTICIRRHUS AMERICANUS (Linnaeus)

*Menticirrhus americanus* ranges from New York to Texas and apparently is commercially the most important species of the genus from Chesapeake Bay southward. The maximum weight reported is 2½ pounds. However, the average weigh probably does not exceed a half pound per fish. This species is taken throughout the year in the vicinity of Beaufort. It becomes quite scarce, however, during the winter and especially during cold spells. It is most numerous in the spring when large catches are made with "sink nets",[6] operated chiefly from Beaufort Inlet to Cape Lookout. During comparatively recent years, since the otter trawl has come into use locally, it is taken in the deeper waters with that gear also. In the inside waters it is taken chiefly with drag nets or seines. It takes the hook now and then, but it scarcely holds a place at Beaufort as a sport or game fish.

### SPAWNING

Fish with well-developed roe have been seen at Beaufort from time to time from April to June. However, mature eggs of this species have not been secured. It is evident from the capture of two larvae 4.0 and 5.5 millimeters long in the tow on April 23 and 26 (1927) that spawning, some years at least, commences as early as April. The capture of young under 10 millimeters, and some under 5.0 millimeters in length during each succeeding month until about the middle of September shows almost certainly that the spawning season at Beaufort extends from April through August and possibly into the early part of September. (See table 1.) The principal spawning period, judging mainly from the abundance of the larvae in the tow, seems to extend from the latter part of June through July and August. Fish with large roe were seen most commonly during May and June.

Spawning in the vicinity of Beaufort probably occurs chiefly along the outside shores of the "banks", although it seems probable that some spawning may take place also within the inside waters. While the eggs if taken (in the tow) were not recognized, it is known that adult fish are common along the outer shores of the banks during the spawning season, where they no doubt congregate to carry out reproductive activities. Furthermore, 15 of the 18 young, 5.0 millimeters and under in length in the collection were caught along the outside shores. The larger young, up to 20 millimeters in length, of which many were taken, too, were much more numerous there than in the inside waters. It seems highly probable, therefore, that spawning in the vicinity of Beaufort takes place chiefly in the ocean along the shores of the "banks."

Welsh and Breder (1923, p. 187) suggest that this species may have two spawning seasons. No evidence of more than one spawning period was secured at Beaufort. (See table 1.) However, the spawning season, as pointed out in a preceding para-

[6] Sink nets are gill nets, weighted and sunk to the bottom (hence sink nets) in several fathoms of water.

graph, evidently is a long one. Therefore, the range in the size of the young of any one season is very great. The range in length in September, for example, according to examples measured extends from 2.75 to 156 millimeters. (See table 2.) Specimens of early and late spawnings, without intermediate ones, might readily lead to the conclusion that they represented the product of two distinct spawning periods. It is possible that the authors mentioned might have been misled because of insufficient material, that is, by the absence of specimens in their collections from the entire spawning period.

Spawning evidently takes place about simultaneously in Chesapeake Bay and Beaufort, as Hildebrand and Schroeder (1928, p. 293) report the observation of ripe fish from Cape Charles, Va., in May and other ripe ones in the Norfolk (Va.) market in June. These writers, also, report the capture in Chesapeake Bay of "young, three fourths inch or more in length, early in the summer." Welsh and Breder (1923, p. 186), working at Atlantic City, N.J., on the other hand, had found no ripe fish and no spent ones there as late as August (1920), although many females with well-developed but hard, row were seen. Nor do these investigators report the capture of young in that locality. Therefore, it would seem that the fish spawn much later in New Jersey than in North Carolina.

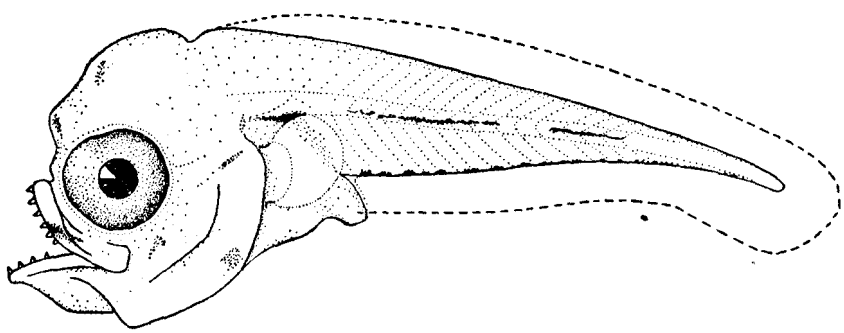

FIGURE 1.—*Menticirrhus americanus*. From a specimen 1.7 millimeters long.

## DESCRIPTIONS OF THE YOUNG

*Specimen 1.7 millimeters long.*—The head and body are rather robust, somewhat compressed, greatest depth only a little less than length of body to vent. The tail is moderately slender, it tapers gradually and ends in a sharp point as usual in recently hatched teleosts. Myomeres are too indistinct to be definitely enumerated, about 16 evident. The mouth is very strongly oblique and moderately large, and prominent teeth are present on the jaws. The eye is prominent, being fully half as long as the head, and it has a round pupil. The vent is situated somewhat in advance of midbody length. The vertical finfold, in the only specimen of this size at hand, is largely torn away, being present, however, around the tip of the tail. The distal portion of the notochord is straight and in line with the axis of the body. The color is mostly pale, with dark markings (specks) around the mouth, along most of the ventral outline and along the middle of the tail. These markings are close enough together to form a longitudinal dark line along the ventral outline of the tail and another one along the middle line of the anterior portion of the tail. These dark lines are quite characteristic and are an aid in identifying the very small larvae with larger ones in which the dark lines are more strongly emphasized (fig. 1).

The specimen described, which was taken in the tow, has been compared with preserved specimens of newly hatched larvae of *saxatilis*. The latter were hatched by the late William W. Welsh from eggs stripped from fish taken at Atlantic City, N.J., on July 27, 1920. The larvae (preserved in formalin) although quite as long as the specimen described, evidently are much younger, as shown by the state of development. The resemblance is not striking, as the specimen of *americanus* is much deeper anteriorly, and the mouth, jaws, and teeth are much further advanced in development. The specimens of *saxatilis* retain no color markings. It is evident, however, from the description and illustrations by Welsh and Breder (1923, pp. 190–193) that rather definite markings were present when the larvae were alive. A slight resemblance is evident in the markings of the most advanced stage figured by Welsh and Breder of *saxatilis* and the 1.7 millimeter specimen of *americanus* already described. This resemblance consists chiefly in a series of dark dots along the ventral outline of the tail. The pupil of the eye is round in the specimens at hand of both species, although in larger examples (10.0 millimeters and upward in length) of *saxatilis* the pupil is vertically elongate, whereas it is always nearly or quite round in *americanus*.

The comparison of the small fry at hand of *americanus* and *saxatilis*, because of the comparatively great difference in age, even though they are of about equal length, does not aid greatly in determining the likenesses and differences that exist between the early larval stages of the two species. Since no newly hatched larvae of *americanus* have been secured, no young of *saxatilis* under 10.0 millimeters (exclusive of the newly hatched fry), and none of *littoralis* less than 9.0 millimeters in length, the study of the relationship of the smaller fry of the local species of the genus must await the collection of specimens of the proper sizes and ages.

*Specimens 2.9 millimeters long.*—The body is very deep, somewhat compressed, with an abruptly more slender and rapidly tapering tail which ends in a sharp point. A very sharp break in the ventral outline occurs at the vent, where the depth diminishes abruptly. The greatest depth of the body is only slightly less than the length of the body to the vent. Myomeres are mostly indistinct, about 23 evident. The mouth is somewhat less oblique than in the smaller specimen described in the foregoing paragraph, the margin of the upper jaw being about on the same level as the upper margin of the eye, and the gape reaches nearly to the pupil. The teeth in the jaws apparently are much smaller than in the smaller specimen described in the preceding section. The vent is situated notably nearer the tip of the tail (notochord) than the tip of the snout. The vertical finfold remains continuous, with slight indications of rays at the distal part of the tail. Pectoral finfolds are rather prominent, but the ventrals are not evident. The general color is pale, with faint ill-defined dark spots about the mouth and along the ventral outline of the abdomen. Two prominent longitudinal black stripes are situated on the anterior two thirds of the tail, one follows the middle line and the other the ventral outline. Several minute dark dots forming an indefinite line are present also on the dorsal outline of the anterior part of the tail (fig. 2).

The very deep body, with the abruptly more slender tail and the two evident black stripes on the caudal portion of the body are the chief recognition marks at this size. These characters also identify smaller specimens, as shown in the description of a 1.7 millimeter fish, but they are much more prominent and pronounced in somewhat larger specimens.

*Specimens 3.8 millimeters long.*—The body is deep and compressed, and the tail has become proportionately much deeper and less sharply tapering since a length of about 2.9 millimeters was attained. The break in the ventral contour described in smaller fish remains, but is less pronounced. The greatest depth is now equal to only about two-thirds the length of the body to the vent. The mouth, although still strongly oblique, has become somewhat lower, the gape anteriorly being only slightly above the lower margin of the eye, and the maxillary (which is now well developed) reaches a little beyond the middle of eye. The pupil is nearly or quite round, as in smaller specimens, and the vent remains situated nearer the tip of the notochord than the tip of the snout. The bases of the soft dorsal and anal fins are evident and indications of rays are present. The notochord has become curved upward, and below it the caudal fin is partly developed with rather definite rays. The pectoral fins are short and broad, with indications of rays, and the ventral fins are not evident. The color has changed little since a length of 2.9 millimeters was attained. The dark markings about the mouth, along the ventral outline of the abdomen, and on the tail remain virtually as described in the smaller fish, except that the dark markings on the dorsal outline of the tail are a little more prominent and form a somewhat more defi-

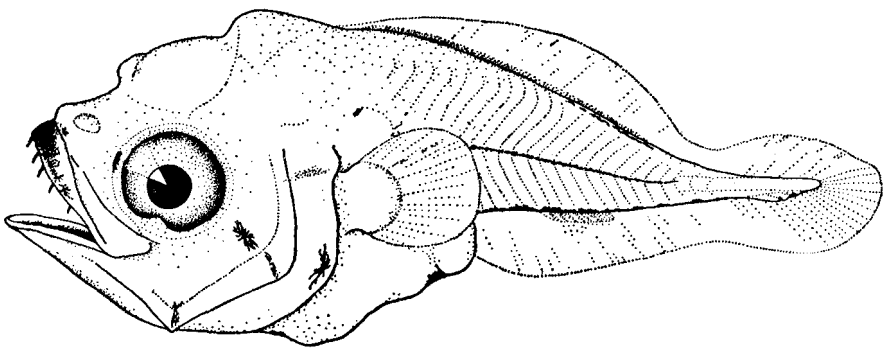

FIGURE 2.—*Menticirrhus americanus.* From a specimen 2.9 millimeters long.

nite stripe. Several indefinite dark markings now are present on middle of side, extending from the eye to opposite the vent (fig. 3).

The principal recognition marks are the same at this size as in 2.9 millimeter specimens previously described. The chief changes have taken place in the development of the tail, which has become much deeper posteriorly, the mouth is less strongly oblique, and some of the fins are becoming differentiated.

*Specimens about 5.8 millimeters long.*—The fish is much more shapely than it was when smaller. Yet, the body is quite unlike that of the adult, as it is deep and compressed. The break in the ventral outline, behind the vent, pronounced in smaller fish, is no longer prominent, and the caudal portion of the body has become proportionately much deeper. The greatest depth of the body is now scarcely equal to two-thirds of the preanal length and is contained about 2.75 times in the total length to the base of the caudal fin. Myomeres are indistinct anteriorly and again posteriorly, about 25 evident. The mouth remains moderately oblique, and the lower jaw is a little shorter than the upper. The gape is wholly below the level of the lower margin of the eye and the maxillary reaches nearly opposite the anterior margin of the eye. The vent is situated a little nearer the tip of the snout than the end of the caudal fin. Considerable advancement in the development of the fins has been made since a length of 3.8 millimeters was attained, most of the soft rays being fairly well

differentiated in the second dorsal and the anal, and a fairly accurate count of the anal rays may be made, the number being 7 or 8. The caudal fin is better developed than the dorsal and anal; it is round in outline and the longest rays are about equal to the depth of the body just posterior to the vent. The pectorals apparently have made little advancement and the ventral fins are not evident. The dark longitudinal stripes on the caudal portion of the body, described in smaller fish, generally are not evident. The stripes, having broken up into large chromatophores, remain in rather definite rows in some specimens, but are more scattered in others. In still other

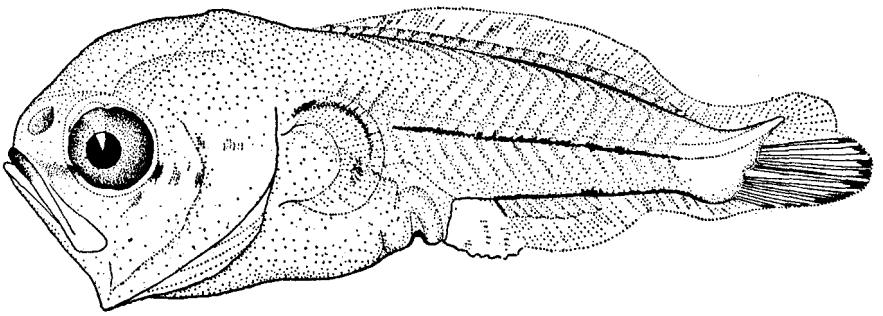

FIGURE 3.—*Menticirrhus americanus*. From a specimen 3.8 millimeters long.

specimens of this size, and even larger ones, the stripe along the lateral line, however, remains well defined. Considerable variation in color, that is, with respect to the number, intensity, and arrangement of the spots present, is evident. The distal portion of the tail remains pale and almost transparent (fig. 4).

The chief recognition marks at this size are the deep compressed body, the large oblique mouth, the short anal fin, and the rather large, dark markings on the caudal portion of the body. However, these markings are faint in some specimens, as shown in the foregoing description, while they are large and well defined in others.

*Specimens 8 millimeters long.*—The body is proportionately more slender than in specimens 5.8 millimeters long and the head is much broader. The rest of the body,

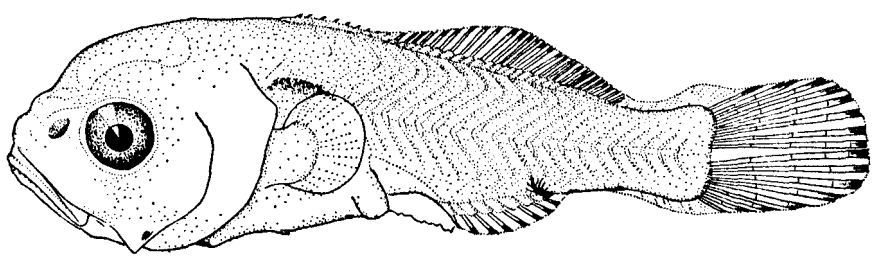

FIGURE 4.—*Menticirrhus americanus*. From a specimen 5.8 millimeters long.

however, remains quite strongly compressed. The greatest depth is contained about 3.0 times in the total length to the base of the caudal fin. The mouth is only slightly oblique, the lower jaw is a little shorter than the upper, and the maxillary reaches nearly to the posterior margin of the eye. Considerable advancement in the development of the fins has been made. The spinous dorsal is evident now, and the ventral fins are rather long and prominent. The pectoral fins have increased greatly in length and reach the vent. The caudal fin has become produced and pointed, the longest rays being nearly as long as the head. The middle portion of the body is largely spotted with dark chromatophores of various sizes, which are present also on

the head and nape. Dusky color is present around the mouth and across the middle of the mandible. The distal portion of the tail remains pale and more or less transparent, the upward curved notochord within it being plainly visible under the microscope with transmitted light. Slight dark color has appeared on the anal and on the margin of the spinous dorsal (fig. 5).

The fish at this size bears about the same recognition marks as in somewhat smaller specimens. However, the head is less strongly compressed, the mouth is less oblique, the spinous dorsal and ventral fins are now developed, the caudal fin has be-

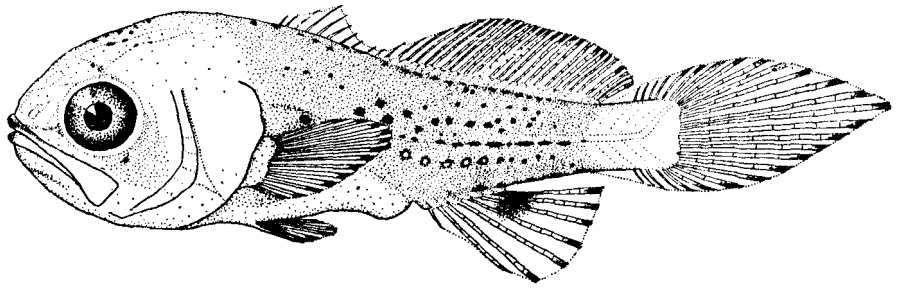

FIGURE 5.—*Menticirrhus americanus*. From a specimen 8 millimeters long.

come somewhat produced and pointed, and the dark markings on the body have increased greatly in number and cover a larger area.

*Specimens 10 millimeters long.*—The body is moderately deep, compressed, the greatest depth being contained about 3.6 to 3.8 times in the length to base of caudal fin. The head is moderately compressed, and its length is greater than depth of body, being contained about 2.75 to 3.1 in length to base of caudal. The interorbital is strongly convex; the eye is only a little longer than the snout, and it has a rather large, perfectly round pupil. The mouth is moderately oblique, the upper lip anteriorly being slightly below the level of the lower margin of the eye; the maxillary reaches nearly to posterior margin of eye; and the upper jaw projects beyond the lower

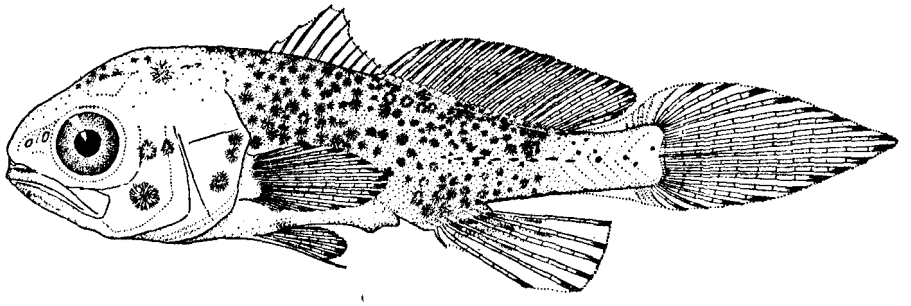

FIGURE 6.—*Menticirrhus americanus*. From a specimen 11 millimeters long.

one. The fins are all well developed, and the rays may be enumerated accurately. The longest dorsal spines reach only slightly past the origin of the second dorsal when deflexed; the caudal fin is nearly symmetrical and quite pointed; and the ventral and pectoral fins are long, generally coterminal, reaching nearly or quite to the vent. The fish has dark chromatophores almost everywhere, except on its ventral surface. They are most numerous on the side from opercular margin to end of base of anal, and few on the head and caudal peduncle. The spinous dorsal and the anal fin generally are partly black; the caudal fin has at most a few dark points on the base, and the other fins are without color (fig. 6).

The present species, at a length of 10 millimeters, is intermediate of the other local species of the genus in the shape of the body, that is, the body is deeper and more strongly compressed (especially the head) anteriorly than in *littoralis*, and less so than in *saxatilis*. It also has a larger and an almost perfectly round disk-shaped pupil, whereas the pupil is vertically elongate and somewhat eliptical in *littoralis* and *saxatilis*. (The shape of the pupil often becomes somewhat distorted during preservation and, therefore, the difference in shape is not always as plainly evident in preserved specimens as in fresh material.) The caudal fin is quite long and pointed and nearly symmetrical in *americanus*. In the other species this fin is quite broadly and asymmetrically rounded, the longest rays being in the lower half of the fin. In *americanus* the spinous dorsal often is partly black, while the ventral fins are colorless, or at most with only a few dark points. In *saxatilis* the spinous dorsal and the ventral fins are wholly black, whereas in *littoralis* these fins are colorless.

*Specimens 13 to 15 millimeters long.*—The body has become less strongly compressed since a length of 10 millimeters was reached and has become deeper in the region of the vent, causing a notably less pronounced tapering in the depth from the head to the vent. The length and greatest depth of the body, however, remains proportionately about the same as in the 10-millimeter fish. The head is less compressed; the mouth is more nearly horizontal, and the snout now projects slightly beyond the upper jaw. The caudal fin has become proportionately longer and more strongly pointed. No other changes in the fins that appear to be worthy of note are evident. The color has changed little. The general tendency is toward fewer large branching chormatophores and more numerous small dark points. The spinous dorsal and the anal are at least partly black; the second dorsal, the pectorals, and the caudal are unmarked, or the caudal at most may have a few dark markings on the base; and the ventral fins may have only a few dark dots or be solidly black at the base.

The fish obviously has made fair headway toward the adult form in the shape of the head, the body, and the mouth. This species at the size just described differs from *littoralis* about as in the smaller fish previously described, that is, the body is deeper, the pupil is round, the caudal is longer and more pointed, the spinous dorsal is at least partly black, the soft dorsal is unmarked, and the ventral fins have at least some dark points if not partly black. No specimens of *saxatilis* between 11 and 17 millimeters in length are at hand. Therefore, the exact differences between specimens of *americanus* and *saxatilis* of this size cannot be stated at this time.

*Specimens 18 to 20 millimeters long.*—The body has continued to grow rather more elongate and rounder. The head remains somewhat deeper than wide, however, and the greatest depth (which occurred at the posterior part of the head in smaller specimens, now falls under the spinous dorsal) is contained 3.6 to 3.8 times in the length to the base of the caudal fin. The mouth is nearly horizontal and inferior, and the conical projecting snout is only a little shorter than the eye. A slight knob has appeared at the tip of the lower jaw, which is the beginning of the development of the characteristic mandibular barbel of the adults of the genus. Scalation is nearly complete (although not shown in the illustration). The caudal fin remains long and pointed. The longest rays now definitely occur in the lower half of the fin, and are somewhat longer than the head. Pigmentation has progressed rather rapidly. While variation is evident among specimens, most usually the entire body is spotted with black or dark brown. The spinous dorsal and the anal fins are largely black, as in smaller fish; the ventral fins bear dark spots; and generally two dark blotches have appeared on the base of the caudal fin (fig. 7).

Considerable headway toward acquiring the shape and form of the adult has been made, and the conical projecting snout and the rudimentary mandibular barbel at once identify the fish as a Menticirrhus. The shape of the body in the present species remains intermediate of the other local species of the genus, that is, the body is slightly deeper than in *littoralis*, but not as deep as in *saxatilis*. The pupil, of course, remains round, whereas it is definitely elliptical in the other two species. The tail is longer and more strongly pointed, the longest rays being longer than the head, whereas in *littoralis* and *saxatilis* the longest rays are shorter than the head.

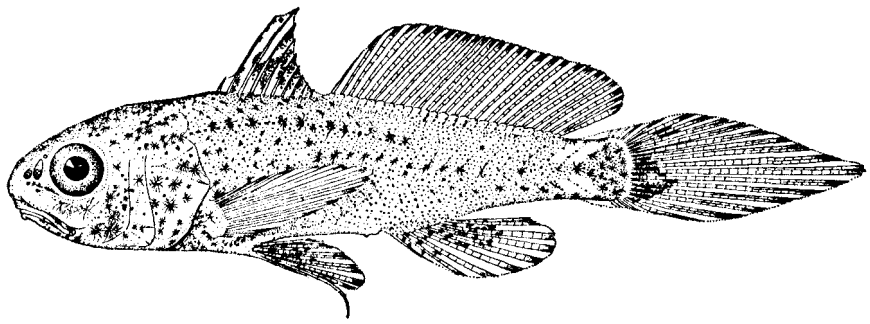

FIGURE 7.—*Menticirrhus americanus*. From a specimen 20 millimeters long.

*Specimens 30 to 35 millimeters long.*—The body has become somewhat rounder anteriorly since a length of 18 to 20 millimeters was attained, and the greatest depth now is contained in the length to the base of the caudal fin 3.8 to 4 times, which are proportions prevailing in the adult. The mouth is inferior and horizontal, and the snout projects rather prominently, as in the adult. The mandibular barbel is very short, a mere knob, and scalation is complete. None of the dorsal spine are produced and the longest ones reach to the origin of the second fin when deflexed. The caudal fin is long and pointed, the longest rays being slightly below the middle of the fin and

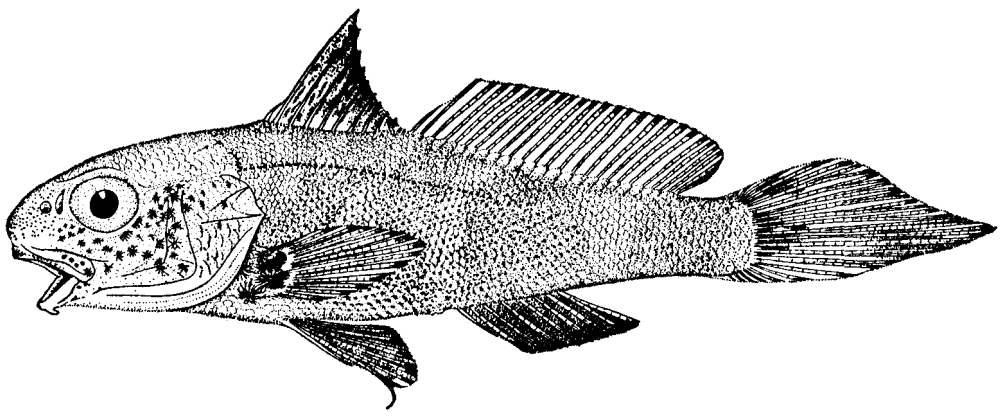

FIGURE 8.—*Menticirrhus americanus*. From a specimen 30 millimeters long.

quite as long as the head. The pectoral fins are long and reach almost to the tips of the ventrals, or nearly to the vent. The body is fully pigmented, some specimens being much darker than others. The lower parts generally are silvery and the upper parts brownish. The ground colors are overlaid with irregular dark specks or spots, which follow the rows of scales more or less definitely. Some specimens have dark blotches and others bear suggestions of dark cross bars. The spinous dorsal is largely

black. A large black spot generally is present on the base of the caudal, preceded by a pale crossline, the rest of the fin being plain translucent. The anal and ventral fins usually are dusky to black, and the pectoral fins generally are plain translucent, or sometimes with dusky points (fig. 8).

The round pupil and the long pointed tail remain as dominant characters in distinguishing the present species from the other two local species of the genus. The long pectorals and the large scales (which are not notably reduced on the chest) also aid in distinguishing the present species from *littoralis*, while it differs further from *saxalitis* in the more elongate body.

*Specimens 50 to 60 millimeters long.*—The fish has acquired virtually the shape of the adult, the body being only a little more strongly compressed anteriorly. The proportions of the depth to the length are the same as in fish 30 to 35 millimeters long, and these proportions also occur in the adults. The snout is more sharply conical, projects beyond the mouth more prominently than in smaller fish, and is now fully as long as the eye. The mandibular barbel is developed and is about half as long as the pupil. No important changes have taken place in the development of the

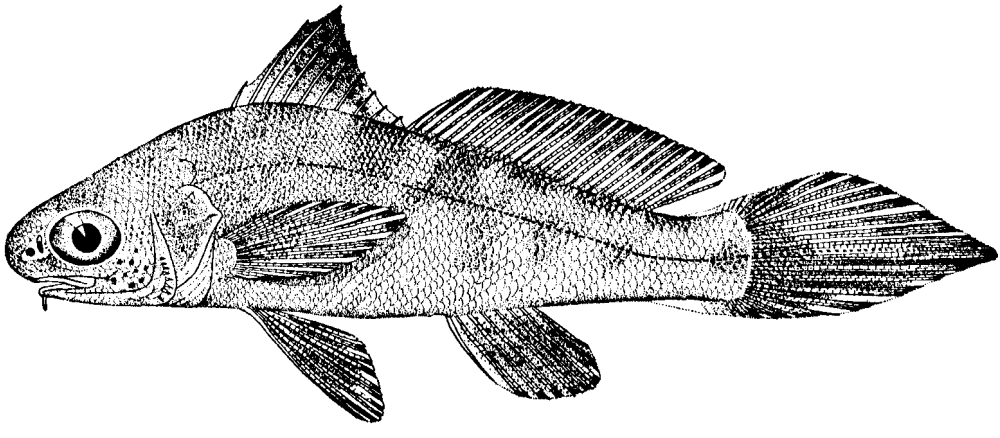

FIGURE 9.—*Menticirrhus americanus*. From a specimen 59 millimeters long.

fins. The spines in the first dorsal are somewhat shorter, and the lower lobe of the caudal remains notably more pointed and proportionately longer, than in the adult. The color remains about as in 35-millimeter fish. Some specimens retain indefinite dark blotches on the sides, and others have more or less definite oblique bars. In the majority of specimens at hand the base of the caudal is dusky, and this color extends on the lower lobe of the fin. The anal and ventrals are in part white, as in the adult (fig. 9.)

Specimens 50 to 60 millimeters long are enough like the adult to be recognized readily. Specimens of this size differ more strongly from full-grown fish in the shape of the caudal fin than in any other one character, and this member does not acquire the adult shape, namely, a slightly concave upper lobe and a moderately short, rather sharply rounded lower lobe, until the fish reach a length of about 100 millimeters. At a length of 50 to 60 millimeters the spinous dorsal has become quite pointed, though none of the rays are especially produced, nor do any of them reach far beyond the origin of the second dorsal. The fish may be distinguished from the other species of the genus at this size by about the same characters which identify the adults, namely, the rather small scales (86 to 90 vertical series above the lateral line), which are not

reduced on the chest; the short anal, which typically has only 7 rays; the long pectorals, which reach nearly or quite to the tips of the ventrals; and by the presence of obscure bars and blotches on the sides and back. The large roundish pupil remains conspicuous and readily distinguishes this species from the other local forms.

### DISTRIBUTION OF THE YOUNG

It has been shown elsewhere (p. 53) that the young under 20 millimeters in length were taken more abundantly off Beaufort Inlet than in the inside waters. The larger ones, however, were caught equally as often and in equally large numbers within the harbor and adjacent waters as off the inlet. This species was not taken in the surf along the outer shores of the "banks", which apparently is a favorite habitat of the young of the other local species of the genus. It seems evident, furthermore, that the young, like the adults, are chiefly bottom dwelling. Larvae under 10 millimeters in length appeared in the surface tow only 3 times, whereas in about an equal number of hauls on the bottom they were taken 22 times. Individuals over 10 millimeters in length were not taken at the surface with the gear used, namely, 1-meter tow nets, and only a few exceeding a length of 10 millimeters were taken with this apparatus on the bottom.

The failure to capture the larger young with meter tow nets on the bottom where they certainly were present, as shown by large catches made with an especially constructed otter trawl, no doubt was caused by their ability either to avoid the meter nets or to escape from them. It is unfortunate that no satisfactory net for catching fish, except small larvae, at the surface has become available. Since the surface of the waters could not be properly sampled for young of about 10 millimeters and upward in length, it cannot be stated definitely that these larger young do not occur there. However, according to the data secured (which may not be entirely reliable, as already shown) the habitat of the young is almost identical with that of the adult; that is, fish of nearly all ages inhabit both inside and off-shore waters and apparently are almost wholly bottom dwelling.

### GROWTH

While the measurements secured are not numerous, it is believed, nevertheless, that they show in a general way the growth of the young during the first several months of life. All the measurements made, both of young and adults, are tabulated by months in 5-millimeter groups in table 1. It is evident from this table that the young of the 0-class are readily distinguishable from the older fish until about the end of September. In October and November this class is less clearly distinct. During the winter months, that is, from December to March, an insufficient number of fish was taken to give reliable data. In table 2 the range in size of the 0-class and the arithmetical average of the specimens measure are shown for each month. The upper extreme may not be quite accurate for the fall months. However, the few larger specimens that may have been wrongly assigned to either year class would not affect the average length greatly.

It is evident from the tables presented that the range in size of the 0-class is very great toward the end of the summer and in the fall. In September, for example, when spawning probably has just ended, the range in length of the specimens of the 0-class measured extends from 2.5 to 156 millimeters. In November the difference in size of the specimens of this same class (if the data were correctly interpreted) is

even greater, as the range extends from 15 to 209 millimeters. This large range in size, no doubt, is caused in part by a difference in the rate of growth; more particularly, however, to the very long spawning season, which apparently extends from April through August.

TABLE 1.—*Length frequencies of 1,779 Menticirrhus americanus*

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

| Total length | April | May | June | July | August | September | October | November | December | January | February | March |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–4 | | | | | | | | | | | | |
| 5–9 | 1 | 2 | 9 | 5 | | 3 | | | | | | |
| 10–14 | 1 | 1 | 6 | 132 | 6 | 10 | | | | | | |
| 15–19 | | | 11 | 32 | 14 | 1 | | | | | | |
| 20–24 | | | 2 | 2 | 5 | 3 | | 1 | | | | |
| 25–29 | | | | 5 | 4 | 3 | 1 | | | | | |
| 30–34 | | | | 7 | 13 | 15 | 2 | 3 | | | | |
| 35–39 | | | | 9 | 35 | 8 | 4 | 1 | | | | |
| 40–44 | | | | 9 | 37 | 2 | 3 | 7 | | | | |
| 45–49 | | | | 15 | 41 | 4 | 7 | 7 | | | | |
| 50–54 | | | | 12 | 22 | 1 | 16 | 5 | | | | |
| 55–59 | | | | 18 | 29 | 4 | 15 | 7 | | | | |
| 60–64 | | | | 16 | 20 | 8 | 20 | 13 | | | | |
| 65–69 | | | | 14 | 26 | 12 | 16 | 11 | 1 | | | |
| 70–74 | | | | 4 | 24 | 22 | 8 | 9 | | | | |
| 75–79 | | | | 14 | 16 | 20 | 8 | 9 | | | | |
| 80–84 | | | | 10 | 20 | 15 | 10 | 4 | | | | |
| 85–89 | | | | 11 | 39 | 10 | 5 | 10 | | | | |
| 90–94 | | | | 6 | 7 | 9 | 2 | 3 | | | | |
| 95–99 | | | | 2 | 16 | 2 | 2 | 8 | 1 | | | |
| 100–104 | | | | 2 | 7 | 9 | 3 | 5 | | | | |
| 105–109 | | | | 1 | 7 | 6 | | 3 | 2 | | | |
| 110–114 | | | | | 4 | 3 | 2 | 1 | 1 | 3 | | |
| 115–119 | | | | | 5 | 3 | | 2 | | 3 | | |
| 120–124 | | | | | 1 | 1 | 1 | 5 | 3 | 2 | | |
| 125–129 | | | | | 3 | 2 | | 3 | 2 | 6 | 1 | |
| 130–134 | | 1 | 2 | | 2 | | 2 | 9 | 3 | 1 | | |
| 135–139 | | 1 | 2 | | | 2 | | 5 | 2 | 4 | | |
| 140–144 | | | 3 | | | | | 6 | 1 | 3 | | |
| 145–149 | | | 9 | | | | 1 | 10 | 2 | 3 | | |
| 150–154 | | | 14 | | 1 | 1 | 1 | 5 | 1 | | | |
| 155–159 | | | 13 | | 1 | 2 | 1 | 13 | 7 | 2 | | |
| 160–164 | | | 16 | | 1 | 2 | 1 | 12 | 3 | 2 | | |
| 165–169 | 2 | | 15 | | | | 2 | 17 | 3 | | | |
| 170–174 | 1 | | 21 | | | | 2 | 8 | 6 | 1 | | |
| 175–179 | 1 | | 13 | | | | | 17 | 8 | | | |
| 180–184 | | | 9 | | | | 2 | 30 | | 1 | 2 | |
| 185–189 | 1 | | 5 | | | 1 | 1 | 22 | 1 | | | |
| 190–194 | 1 | | 5 | | | 2 | | 13 | 2 | | 1 | |
| 195–199 | 2 | | 4 | | | 2 | 2 | 20 | | 1 | | 1 |
| 200–204 | | 1 | 2 | | 1 | | | 10 | | | | 4 |
| 205–209 | | | 2 | | | | | 8 | | | | 1 |
| 210–214 | | | | | 1 | | 1 | 5 | | | | |
| 215–219 | | | | 2 | | | 1 | 1 | | | 1 | 1 |
| 220–224 | | | | | 2 | | | 2 | | | | |
| 225–229 | | 1 | 1 | | 2 | 1 | | 1 | | | 1 | 1 |
| 230–234 | | 1 | | | 1 | 2 | 1 | 5 | | | | 3 |
| 235–239 | | | | 1 | 1 | | 2 | 1 | | | | 2 |
| 240–244 | 1 | | | | 3 | 2 | 2 | 1 | | | | 3 |
| 245–249 | | | | 1 | 1 | | 2 | 2 | | | | |
| 250–254 | 1 | | | | | 1 | | 1 | | | | 5 |
| 255–259 | 1 | | | 1 | 1 | 1 | 1 | 2 | 1 | | 1 | 1 |
| 260–264 | 1 | 1 | | | 1 | 1 | | 2 | | | | 1 |
| 265–269 | 1 | 1 | | | 1 | 4 | | 1 | | | | 2 |
| 270–274 | | | | | 1 | | | 1 | | | | |
| 275–279 | | | | | | | 1 | | | | | 1 |
| 280–284 | | | | 1 | | 4 | 2 | 2 | | 1 | | 1 |
| 285–289 | | | | | | | 1 | | 1 | | | 1 |
| 290–294 | | 1 | | | | | | | | | | |
| 295–299 | | | | | | | 1 | 2 | | | 1 | |
| 300–304 | | | | | | | | | | | 1 | |
| 305–309 | | | | | | | 1 | | 1 | | | |
| 310–314 | 1 | | | | | | | | | | | |
| 315–319 | | | | | | | | | | | | |
| 320–324 | | | | | | | | | | | | |
| 325–329 | | | | | | | | | | | | |
| 330–334 | | | | | | | | | | | | |
| 335–339 | | | | | | | | | | | | |
| 340–344 | | | | | | | | 1 | | | 1 | |
| 345–349 | | | | | | | | | | 1 | | |

The average rate of growth as shown by the tables, is quite regular and rapid during the first several months of life. The data are not sufficient to show how it progressed during the winter nor the second summer. However, since the average length during November of various samples taken over a period of several years, consisting of a total of 327 fish, is 135.01 millimeters (5⅜ inches) with an apparent maximum length of 209 millimeters (8⅛ inches), it seems evident that some of the earliest and fastest growing individuals of this year class reach a marketable size, and probably maturity, during their second summer. Others may require a year longer.

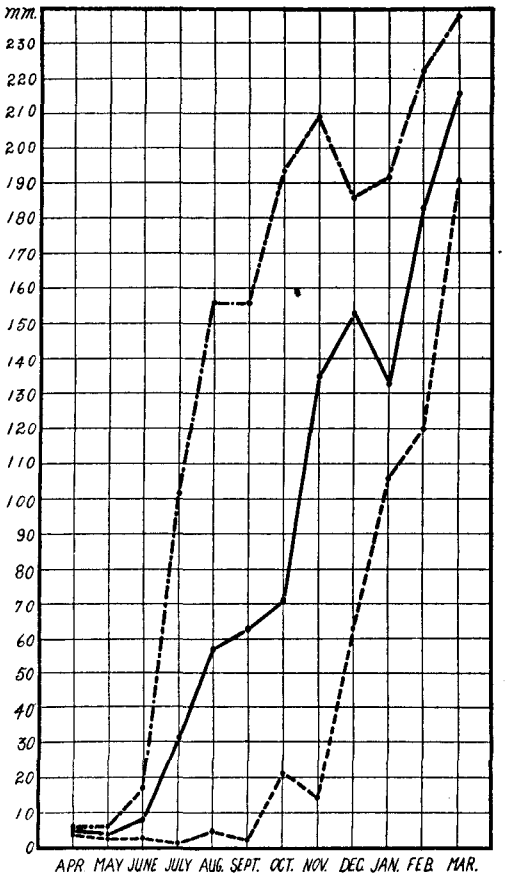


FIGURE 10.—Growth of *Menticirrhus americanus* during first year or so of life. Solid line, average size; dot and dash line, maximum size; broken line, minimum size. (Graph based on table 2.)

Welsh and Breder (1923, p. 188) produce limited data which they believed tended to show that the fish reached a length of only 140 to 240 millimeters (5½ to 9½ inches) at Fernandina, Fla., by the second winter, the modal length being around 170 millimeters (6¾ inches). In New Jersey the rate of growth was thought to be a little slower, as individuals apparently in their second winter averaged only about 160 millimeters (6¼ inches) in length. The authors conclude that maturity is reached in about 3 years. We agree that some individuals no doubt require 3 years to reach a marketable size and maturity. However, it seems certain, as already shown, that at Beaufort not an inconsiderable number becomes mature and marketable before an age of 3 years is attained.

TABLE 2.—*Monthly summaries of length measurements of 1,519 Menticirrhus americanus during their first year of life (based on table 1)*

| Month | Fish measured | Smallest millimeter | Largest millimeter | Average millimeter | Month | Fish measured | Smallest millimeter | Largest millimeter | Average millimeter |
|---|---|---|---|---|---|---|---|---|---|
| April | 2 | 4 | 5.5 | 4.75 | October | 140 | 21 | 194 | 71.2 |
| May | 3 | 2.75 | 6 | 3.91 | November | 328 | 15 | 209 | 135.01 |
| June | 28 | 3 | 17 | 8.0 | December | 49 | 63 | [1] 186 | 153.2 |
| July | 326 | 1.7 | 102 | 31.42 | January | 32 | 106 | [1] 192 | [1] 133.28 |
| August | 406 | 5 | 156 | 57.48 | February | 6 | 120 | 223 | 183.33 |
| September | 183 | 2.5 | 156 | 63.05 | March | 16 | 191 | 237 | 216.6 |

[1] The apparent decrease in length, of course, shows that the larger individuals of the year class either were not present or not properly represented.

## MENTICIRRHUS SAXATILIS (Bloch and Schneider)

The range of *Menticirrhus saxatilis* extends from Maine to Florida. Therefore, its range overlaps considerably that of *americanus* and also to a lesser extent that of *littoralis*. However, it ranges farther northward and apparently not as far southward as the other local species. In Chesapeake Bay and southward *saxatilis* is less numer-

ous than *americanus*, but northward (the northern limit of the range of *americanus* being New York) it is more numerous. This species occurs in the vicinity of Beaufort, generally in small numbers, virtually throughout the year. It is taken both in the sounds and estuaries and along the outer shores of the "banks." Its local commercial value, however, is rather small. It is reported to reach a maximum weight of 3 pounds, but it probably does not average over a half a pound in the markets of North Carolina. It is caught in the same way as, and often in company with, *americanus*.

### SPAWNING

Ripe fish were not obtained at Beaufort. It is possible, however, to determine the time and place of spawning in a general way from the collection of a rather small number of young fish. The smallest young of this species obtained were 10 millimeters long, and were caught on June 20 (1932). On this same date a total of 29 specimens, ranging from 10 to 62 millimeters in length, was caught. Two days later 2 specimens 91 and 93 millimeters long were taken. These specimens no doubt belong to the same year class and are the product of the current year's spawning. During July, of several years, 14 specimens, ranging more or less gradually from 20 to 116 millimeters in length, besides some larger ones, which quite certainly are older fish, were secured. During August, 5 young, ranging from 70 to 95 millimeters in length, were taken. Fish 91 to 93 millimeters long quite probably are a few months old, while specimens only 10 millimeters long may be only a few weeks old. The specimens collected in June, supported in a measure by those taken in July and August, appear to show that spawning begins not later than April and that it extends through May. Additional data quite probably would show that spawning extends over an even longer period of time.

The smaller specimens, 70 millimeters and less in length, were all taken in the surf on the outer shores of the "banks." The larger ones were taken there in part also and in part in the estuary of Newport River. The presence of the small fish on the outer shores of the banks suggests that spawning may take place near there, as it quite surely does in the other local species of the genus.

Spawning takes place about the same time in Chesapeake Bay as at Beaufort, beginning probably a little later, for Hildebrand and Schroeder (1928, p. 291) report the capture of fish 16 millimeters long in Chesapeake Bay late in June. These investigators also report the collection of specimens ranging from 35 to 154 millimeters in length late in September and others in October 50 to 185 millimeters long, all of which they believe to belong to the 0-class.

Welsh and Breder (1923, p. 190) state that spawning (presumably at Atlantic City, N.J., where they carried on investigations) commences in June and continues until August, and reaches its maximum in late June or early July. They took ripe fish in July which were stripped, and the eggs were incubated and hatched in the laboratory. The same authors report spawning early in June at Woods Hole, Mass. The information available, then, indicates that spawning begins a month or two later in New Jersey and Massachusetts than it does at Beaufort, and that it probably ends correspondingly later.

### DESCRIPTIONS OF THE EGGS AND YOUNG

*The egg and its development.*—The following account of the egg and its development is based on the description given by Welsh and Breder (1923, p. 190, figs. 46–49). The eggs are spherical, 0.76 to 0.92 millimeter in diameter, and lighter than sea water.

They are almost colorless, having only a slight yellowish tinge, and they contain from 1 to 18 oil globules. If only one globule is present it is larger than if several are present. During the development of the egg the oil globules become amalgamated until only one remains at hatching. The incubation period has a duration of 46 to 50 hours in water temperatures of 68° to 70° F. Segmentation and development proceeded as in Bairdiella (Kuntz, 1914). About 18 hours after fertilization grayish chromatophores appeared on the dorso-lateral aspects of the embryo and on the surface of the oil globule. Six hours later the chromatophores had become black on the oil globule, and the embryo was dotted with black. Some black chromatophores were scattered also over the yolk near the embryo.

*Newly hatched young.*—The following account of the newly hatched young is based on descriptions and figures by Welsh and Breder (1923, pp. 190–193, figs. 50–53). The fry are 2.0 to 2.5 millimeters long at hatching, and they float in an inverted position. The head is slightly deflected, the vent is notably in advance of midbody length, and the oil globule lies in the posterior part of the yolk sac. Pigmentation consists of three vertical bands, each consisting of black and dull gold chromatophores, the first one being above the vent and two posterior to it. A patch of chromatophores of the same colors lies in the dorsal finfold anteriorly, and similar ones are scattered over the yolk sac.

None of the larvae lived over 7 days. They lost the gold pigment by the second day and all markings had become less conspicuous. By this time the pectoral fins had become plainly visible. On the fourth day only traces of dark bands remained, and a row of black chromatophores had appeared along the ventral surface posterior to the vent. The blotch in the dorsal finfold remained conspicuous, the eye had become pigmented, the pectoral fins had become dotted with black and gold chromatophores, and the abdomen had a golden tinge. The yolk sac was almost completely absorbed, and the mouth was open. On the fifth day the larvae, when at rest, floated with the head downward. With the unaided eye the fry appeared dark brown anterior to the vent, and the tail was transparent. On the sixth day the eye had a steel-blue luster, and no trace of rudimentary fins was evident. On the seventh day, shortly before the longest survivors died, a few of the fry had attained a length of 2.8 millimeters. Therefore, very little growth had been gained.

The larvae described by Welsh and Breder were preserved, in part, and were compared by us with the smallest fry of *americanus* taken at Beaufort. Although specimens of the last-mentioned species, quite as small as the larvae described in the preceding paragraphs, were taken at Beaufort, the resemblance is very remote, as stated elsewhere (p. 55), which apparently is caused partly by a difference in age and partly by the differences of the two species.

The account of the development of this species must remain incomplete for the present, as the stages between the newly hatched young and specimens 10 millimeters in length have not been secured.

*Specimens 10 millimeters long.*—The body is rather deep, compressed, the greatest depth being contained about 2.8 to 2.9 in length to the base of caudal fin. The head is quite narrow, compressed, and its length is equal to or a little longer than the greatest depth of the body. The interorbital is convex. The eye is longer than the snout, and it has a very small vertically slightly elongate pupil. The mouth is large and moderately oblique, the upper lip anteriorly being nearly on a level with the lower margin of the pupil. The maxillary reaches somewhat past the middle of the eye, and the upper jaw projects beyond the lower one. The fins are all well developed,

permitting an accurate enumeration of the rays. The longest spines in the first dorsal reach past the origin of the second dorsal when deflexed; the caudal fin is asymmetrically rounded, the longest rays being in the lower half of the fin; and the ventral and pectoral fins are rather long and coterminal, not quite reaching vent. The body almost everywhere is dotted with prominent black chromatophores. An indefinite brownish band is present on the back below the base of the dorsal fins, and another one extends along the lateral ventral edge from the origin of the anal to the base of the lower rays of the caudal. The spinous dorsal is almost wholly black; the second dorsal is colorless, except for an indefinite elongate dark band on the base of about the middle third of the fin; the caudal fin is colorless, with a white base, and sometimes with one or a few large black chromatophores; the anal fin is colorless, except for dark dots on its base; the ventral fins are wholly black; and the pectoral fins are plain translucent (fig. 11).

All the specimens at hand were caught among black, partly suspended vegetable debris, which they resemble in color. It seems probable that these fish are darker than they would have been had they been taken in a different environment.

This species is characterized at this size chiefly by the deep, strongly compressed body; the narrow, well-compressed head; the small elliptical pupil; the broad, asymmetrically rounded caudal; and by the black spinous dorsal and ventral fins.

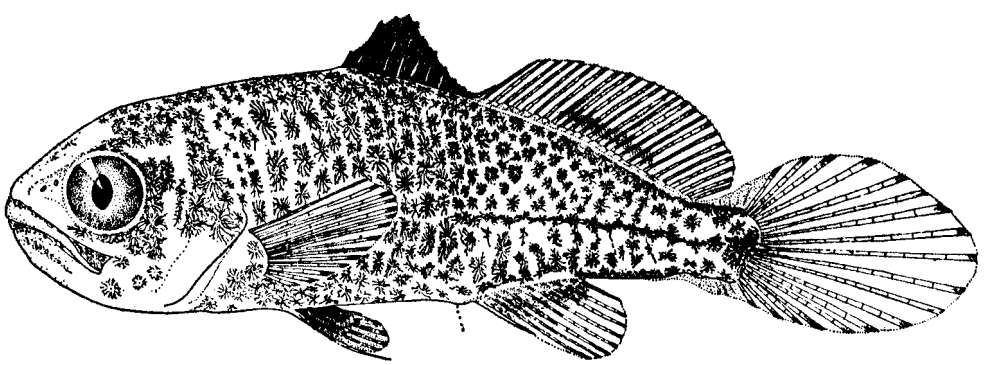

FIGURE 11.—*Menticirrhus saxatilis*. From a specimen 10 millimeters long. (Drawing by Miss Nell Henry.)

The specimens described in the foregoing paragraphs are the smallest ones taken. The confusion of this species with smaller specimens of the genus, identified and described as *americanus* is quite improbable, because of the rather pronounced differences among the species in specimens 10 millimeters in length, as shown by the descriptions and illustrations offered. Certainly some of the differences would be evident, also, in somewhat smaller specimens.

*Specimens 18 to 20 millimeters long.*—The body has become somewhat more slender since a length of 10 millimeters (no specimens between 10.5 and 17 millimeters in length having been collected) was attained, and it remains rather strongly compressed, the greatest depth being contained in the length to the base of the caudal about 3.25 to 3.4 times. The head has become broader, but it remains much deeper than broad. The mouth is slightly oblique and nearly terminal, the snout scarcely projecting beyond the upper jaw. A slight knob, the beginning of the characteristic barbel of the adult, is evident at the symphysis of the lower jaw. Scalation is nearly complete, and the lateral line is developed anteriorly to about the middle of base of second dorsal. The caudal fin is rather broadly pointed; the longest rays, which are shorter than the head, are in the lower half of the fin. The general color is

(of specimens taken in black vegetable debris) almost uniform dark brown, with a slight indication of a broad vertical bar, darker than the ground color, on the side under the spinous dorsal, and another one under the middle of the base of the second dorsal. The spinous dorsal and the ventral fins are black; the pectoral fins are colorless; the second dorsal and anal have at least a partly black base, the rest of these fins being colorless; and the caudal is colorless, except for a black blotch on the base (fig. 12).

The present species is deeper than either of the other two local species of the genus. Its elliptical pupil and rather bluntly pointed tail, which is shorter than the head, at once distinguish this species from *americanus*. The dark cross bars on the body, the black spinous dorsal, and the black ventral fins separate it from *littoralis*.

*Specimens 30 to 35 millimeters long.*—The body has continued to become more elongate and less strongly compressed. The depth remains proportionately a little greater than in the adult, it being contained in the length to the base of caudal 3.5 to 3.65 times. The mouth is nearly horizontal, inferior, and the snout projects moderately beyond it. The mandibular barbel is short, but plainly evident, and scalation is complete. None of the dorsal spines are produced, the longest reaching

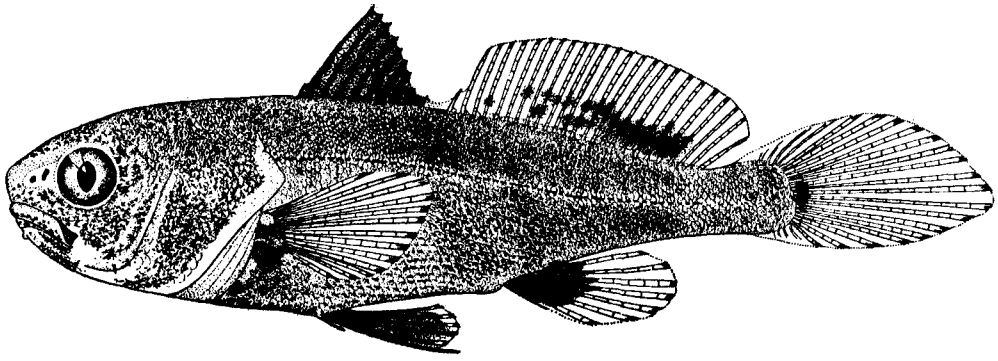

FIGURE 12.—*Menticirrhus saxatilis*. From a specimen 20 millimeters long. (Drawing by Miss Nell Henry.)

opposite the base of the first or second ray of the second dorsal when deflexed. The caudal fin is slightly angular, and the longest rays, which are in the lower half of the fin, are notably shorter than the head. The pectoral fins scarcely reach the tips of the ventrals, and the latter do not quite reach the vent. The body is quite fully pigmented; the ground color is silvery, brightest on lower parts of body, overlaid almost everywhere with dark brown dots. Dark bars are evident in the majority of the specimens at hand; the first one is on the posterior part of the head and runs obliquely downward and backward on the opercle; the second one crosses the nape and is parallel with the first one; the third one lies under the spinous dorsal and bends forward slightly, nearly or quite joining the second one on the middle of the side. The two together form a V, which is a recognition mark in the adult. Posterior to the bars described are dark blotches suggestive of bars. The spinous dorsal and the ventrals remain almost wholly black; the second dorsal and anal are black at the base or at least are dotted with black; the caudal fin bears two irregular dark spots on its base and is plain translucent elsewhere; and the pectoral fins are plain, more or less dotted with black at the base (fig. 13).

This species, like *littoralis*, continues to differ from *americanus* in the eliptical pupil and the short angulate caudal fin. It differs from both the other local species

in the deeper body; and from *littoralis* in the presence of large scales (which are not notably reduced) on the chest, and in the longer pectoral fins. This species, according to the specimens at hand, alone has definite dark bars (on anterior part of the body) at this size.

*Specimens 50 to 60 millimeters long.*—The body has continued to grow less compressed and somewhat more elongate, the depth now being contained in the length 3.8 to 4.1 times, which are the dominating proportions in the adult. The

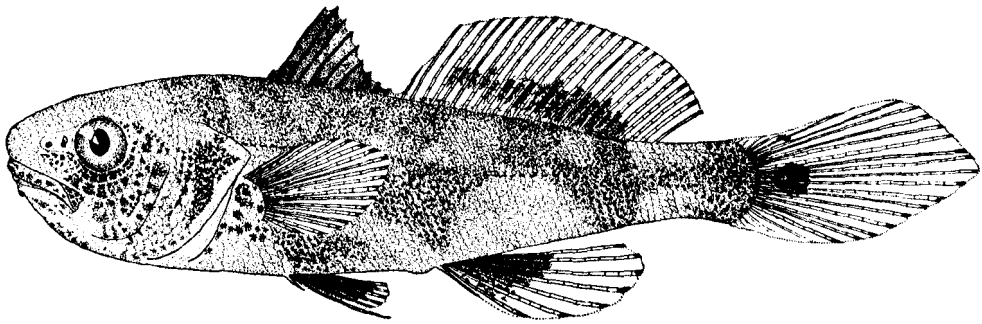

FIGURE 13.—*Menticirrhus saxatilis*. From a specimen 30 millimeters long. (Drawing by Miss Nell Henry.)

snout is conical, it projects much more strongly than in the smaller fish described in the foregoing section, and is somewhat longer than the eye. Although none of the dorsal spines are notably produced, the longest one reaches well past the origin of the second dorsal. The caudal fin has a slightly concave margin and the lower lobe remains notably longer and somewhat angulate. The color varies greatly among specimens. Some are dark brown, others silvery gray. However, all have rather definite oblique dark bars on the anterior part of the body and a few blotches poste-

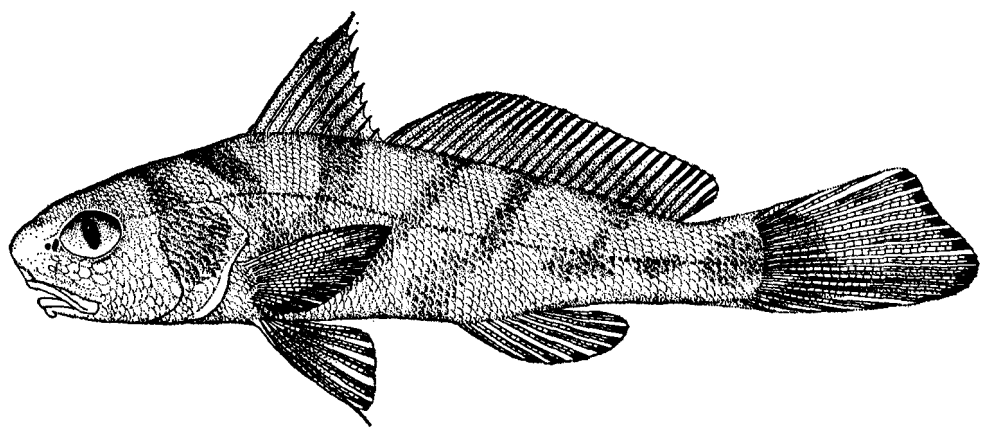

FIGURE 14.—*Menticirrhus saxatilis*. From a specimen 63 millimeters long.

riorly. The spinous dorsal and the ventrals remain almost wholly black in the darker specimens, but are only partly dusky in the lighter ones (fig. 14).

The characters of the adult are perhaps less fully developed in this species than in the other local forms at the length described. The third dorsal spine becomes notably produced when the fish reaches a length of about 85 millimeters, although not yet as long as in larger specimens. The caudal fin does not acquire fully the shape it has in full-grown fish until a length of about 120 millimeters is attained. However,

the fish resemble the adult sufficiently to be recognized readily. The characters that distinguish the species at this size are largely the same as those used in identifying the adult; namely, the small scales (91 to 96 vertical series above the lateral line), which are not notably reduced in size on the chest; the rather high spinous dorsal (the third ray later becoming conspicuously produced) with the longest spines reaching well past the origin of the second dorsal; the longer anal, typically with 8 soft rays; the moderately long pectorals, which usually reach to tips of ventrals; and the presence of rather definite black bars on the back and sides, the one crossing the nape and the one under the spinous dorsal nearly or quite meeting on the side to form a V above the pectoral. The small, vertically elongate, eliptical pupil remains conspicuous, as in smaller specimens, and readily distinguishes this species from *americanus*, although not from *littoralis*.

### DISTRIBUTION OF THE YOUNG

Young under 10 millimeters in length were not taken. Those from 10 to 70 millimeters in length were all collected in the surf along the outer shores of the "banks." The larger ones were also taken there in part and in part in the estuary of Newport River. So far as known, the young dwell on or near the bottom like the adults.

### GROWTH

The measurements obtained are inadequate to cast much light upon the rate of growth. However, specimens of the 0-class, 113 to 116 millimeters long, taken in July when very probably not over 3 months old, suggest rapid growth.

Hildebrand and Schroeder (1928, p. 291) report specimens, 35 to 154 millimeters in length, from Chesapeake Bay taken late in September, and others 50 to 185 millimeters long taken in October. If the larger fish are correctly assigned to the 0-class, a phenominally rapid growth must take place.

Welsh and Breder (1923, p. 192) state, "The growth of *Menticirrhus saxatilis* the first summer is exceedingly rapid." These authors record specimens of the 0-class from Woods Hole, Mass., as much as 100 millimeters long on September 1; others from Cape May, N.J., 90 millimeters long on August 8; and still others from Chesapeake Bay, 140 millimeters long on September 12. All the data that are available, therefore, point to a very rapid growth in this species during the first summer.

Very little is known about the growth after the first summer. The present investigation, being concerned almost wholly with the development of the young, has yielded virtually nothing on this phase of the life history. Welsh and Breder (1923, p. 194) state that from the examination of the scales of a small series of examples from New Jersey it appeared that a modal length of about 120 millimeters was attained by the first winter, the majority of the fish being 100 to 150 millimeters long. In the second winter the modal length was about 250 millimeters, and the third winter 350 millimeters. Then, the writers conclude that maturity is reached during the third or fourth summer. The earlier spawning season and the very rapid growth during the first summer further south, that is, in Chesapeake Bay and at Beaufort, suggests that maturity may be attained there a year earlier.

## MENTICIRRHUS LITTORALIS (Holbrook)

*Menticirrhus littoralis* ranges from Chesapeake Bay southward to the Gulf coast, the exact limits of its southern distribution being undetermined. Its range northward does not extend as far as that of either of the other two local species of the

genus. Southward it probably extends further than that of *saxatilis* and equally as far as *americanus*. This species as a whole is of much less commercial importance than the others. At Beaufort it is much less numerous than *americanus* and about equally as common as *saxatilis*, its commercial value being small. This species evidently seldom enters Beaufort Inlet, as only one record (Bird Shoal, 1906) of its capture in the inside waters is at hand. The writers did not find it in the more or less enclosed waters of the vicinity. The young, ranging upward of about 15 millimeters, are common during the summer in the surf along the outer shores of the "banks" where they may be taken with small collecting seines in company with young pompano, spot, and occasionally with its congener, *saxatilis*.

### SPAWNING

Smith (1907, p. 324) says, "At Cape Lookout spawning fish were found by the writer in June, and at Beaufort ripe eggs have been taken on several occasions between June 1 and 10." Unfortunately, the eggs are not described. If the eggs were taken in the tow during the present investigation, they were not recognized, and ripe fish were not seen. Neither did the larvae appear in the tow. The smallest specimens secured are 9 and 10 millimeters long, and were taken on June 20 (1932) with a bobbinet seine in the surf on Bogue Banks, opposite Fort Macon. Fish ranging from 15 to about 120 millimeters long are abundant there throughout the summer. Some of the fish taken in June that certainly belonged to the 0-class had attained a length as great as 75 to 80 millimeters. Examples evidently of the 0-class, caught during July, ranged from 11 to 58 millimeters (the larger individuals of the class being missing), those taken during August ranged from 15 to 98 millimeters, and those caught in September from 15 to 120 millimeters.

A collection made on June 10 includes specimens 53 to 57 millimeters long, and one made on June 20 contains specimens 75 to 80 millimeters long. It seems reasonable to assume that these rather large, well-developed specimens are 6 to 8 weeks old. If that be true then spawning probably begins not later than the 1st of May. Young only 15 millimeters long were taken as late as September 14. Fish of such a size probably were hatched in August. Although these data are not as complete as desirable, they do indicate rather strongly that spawning begins not later than the 1st of May and that it continues into August.

Although the eggs and small fry under 9 millimeters in length were not taken, it seems almost certain that spawning occurs only in the open outside waters. This conclusion is arrived at for the reason that the adults rarely enter the inside waters about Beaufort and, furthermore, the young of 9 millimeters and upward in length were found only in the surf.

### DESCRIPTIONS OF THE YOUNG

*Specimens 10 millimeters long.*—The body is quite elongate, compressed, the greatest depth being contained about 3.6 to 4.0 in the length to base of caudal fin. The head is rather broad, more or less quadrate in cross section. Its width is equal to about three fourths its depth, and its length is somewhat greater than the depth of the body, being contained about 3.2 in the length to base of caudal. The interorbital is rather flat and broad. The eye is longer than the snout, and it has a very small, vertically slightly elongate pupil. The mouth is moderately large and oblique, the upper lip anteriorly is about on a level with the lower margin of the eye, and the

upper jaw projects beyond the lower one. The fins are all well developed and an accurate enumeration of the rays is obtainable. The longest spines in the first dorsal reach somewhat beyond the origin of the second dorsal when deflexed; the caudal fin is asymmetrically rounded, the longest rays being in the lower half of the fin; the ventral and pectoral fins are rather long and coterminal, not quite reaching the vent. The body is densely dotted with dark chromatophores, pigmentation in some specimens being almost general, and dark brown in color as seen with the unaided eye. The spinous dorsal, the ventrals, and the pectorals are colorless. The caudal fin, too, is colorless or at most with one to a few dark dots on the base. The posterior half of the base of the soft dorsal and most of the base of the anal are black, the amount of black present varying among specimens, the rest of these fins being plain colorless (fig. 15).

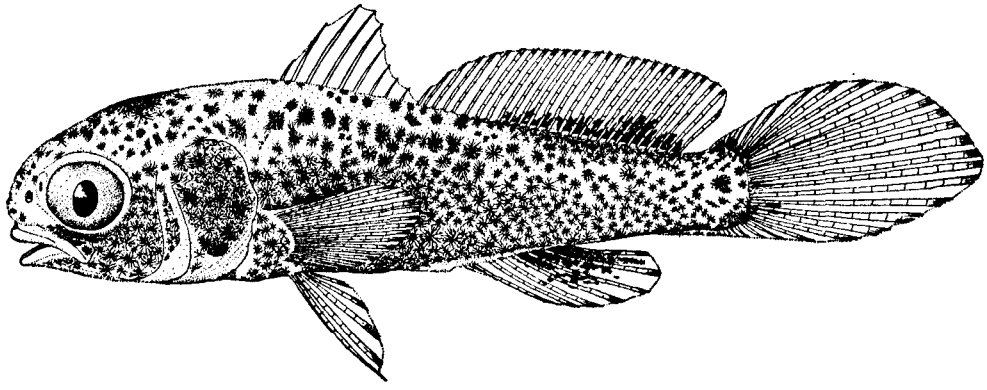

FIGURE 15.—*Menticirrhus littoralis*. From a specimen 11.9 millimeters long.

All specimens at hand of the size described were taken among black, partly suspended vegetable debris, which they resemble in color. Somewhat larger specimens caught in the same environment, too, are black, while specimens taken on white sand are pale silvery. It seems probable, therefore, that small fish, if caught in a different environment, too, would be paler in color.

This species is recognized, when about 10 millimeters long, chiefly by the slender body; the broad head, which is somewhat quadrate in cross section; the small elliptical pupil; the broad asymmetrically rounded caudal; and by the absence of black on the spinous dorsal and ventral fins.

The smallest specimen of this species at hand is 9 millimeters long. It does not differ noticeably from the 10-millimeter ones described in the foregoing paragraphs. It is quite unlikely that a confusion of this species has taken place with the smaller specimens of the genus identified and described as *americanus*. The very evident differences, existing at a length of 10 millimeters, as shown by the descriptions and illustrations offered, surely would be evident also in part in smaller specimens.

*Specimens 13 to 15 millimeters long.*—The body has become rather deeper and heavier posteriorly, although the length and the greatest depth remain proportionately about the same as in 10-millimeter fish. The head is more compressed and less evidently quadrate in cross section. The mouth is only slightly oblique, and the snout projects somewhat beyond the upper jaw. No pronounced changes in the fins have taken place. The caudal fin apparently has become slightly more pointed, but retains an asymmetrical shape. The body in the specimens at hand remains dark

brown. The spinous dorsal, the ventral, and pectorals remain colorless. The amount of black on the base of the soft dorsal and on the anal varies among specimens from a small spot on the base of each fin to a long band or blotch involving a considerable portion of each fin. The caudal fin is colorless, except for a pair of more or less triangular-shaped black spots on its base. The specimens described were taken among black vegetable debris and, therefore, may be generally darker in color than others would be if taken in a different environment.

In this species, as in *americanus*, moderately pronounced headway has been made toward acquiring the adult form, especially in the shape of the head, body, and mouth. The slender body, the elliptical pupil, the asymmetrically rounded caudal, and the absence of black on the spinous dorsal and the ventral fins serve to characterize *littoralis*, as in the 10-millimeter fish previously described.

*Specimens 18 to 20 millimeters long.*—The body has become only slightly more rounded and elongate since a length of about 15 millimeters was attained, the greatest

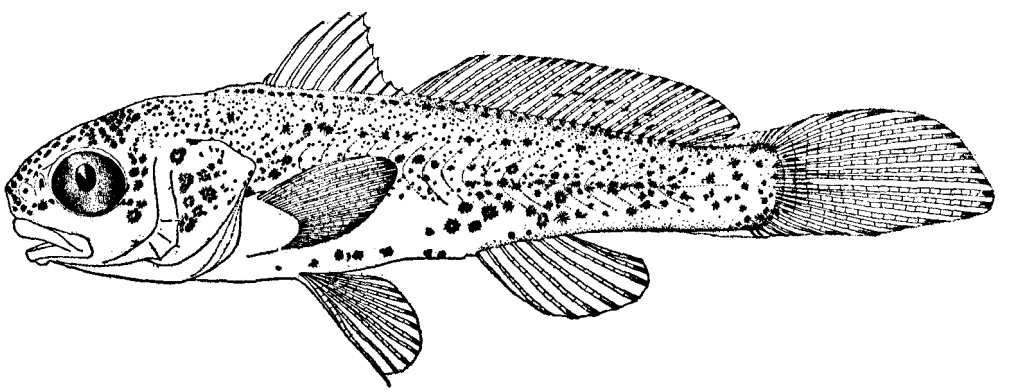

FIGURE 16.—*Menticirrhus littoralis*. From a specimen 19 millimeters long.

depth being contained in the length to the base of the caudal about 3.75 to 4.2 times. The head remains low and wide, its depth being only a little greater than its width. The mouth is nearly horizontal and inferior, and the rather conical snout, which is scarcely shorter than the eye, projects slightly. The development of the characteristic barbel of the adult at the symphysis of the lower jaw is indicated by a minute knob. Scalation is nearly complete (although not shown in the illustration), and the lateral line is developed anteriorly, extending to middle of base of soft dorsal. The caudal fin has become rather more broadly asymmetrically rounded, and the longest rays are shorter than the head. Pigmentation is very variable, depending upon the environment in which the specimens were taken. Some specimens are almost uniformly brown, while others are silvery with scattered brownish chromatophores. The spinous dorsal (except for a few black dots), the pectorals, and the ventrals in all specimens at hand remain plain translucent. The caudal fin is void of color except for a pair of dark blotches on the base, which may be separate or united. The dorsal and anal are largely black at the base in some specimens, whereas they bear only comparatively few dark points in others (fig. 16).

Specimens of *littoralis* of the size described remain more slender than either of the other two local species of the genus. The difference in this respect, however, is slight between *littoralis* and *americanus*, but comparatively great between *littoralis* and *saxatilis*. The strongly eliptical pupil and the short asymmetrically rounded caudal fin at once separate *littoralis* from *americanus*, although not from *saxatilis*. The

almost total absence of black on the spinous dorsal and ventral fins, also, aids in distinguishing *littoralis* from the other local species.

*Specimens 30 to 35 millimeters long.*—The body has become more rounded and has acquired virtually the form of the adult, the depth being contained in the length to the base of the caudal 4.05 to 4.3 times, which are the proportions found also in the adult. The mouth is inferior and horizontal, and the conical snout, which is now a little longer than the eye, projects notably beyond it. The mandibular barbel, although plainly visible, still has the appearance of a knob. Scalation is complete, and the scales on the chest are smaller than those on the sides and on the abdomen. The dorsal spines are short, the longest ones failing to reach the first soft ray of the second dorsal when deflexed. The caudal fin is slightly angular and the longest rays, which are in the lower half of the fin, are notably shorter than the head. The pectoral fins are short, failing by fully an eye's diameter to reach the tips of the ventrals, and the latter do not quite reach the vent. The ground color is silvery, overlaid on sides and back with grayish dots. Indications of dark blotches are present on the sides of some specimens, while others appear uniform silvery gray. The dorsal, caudal, and anal fins are more or less dotted with black, while the paired fins usually are plainly translucent (fig. 17).

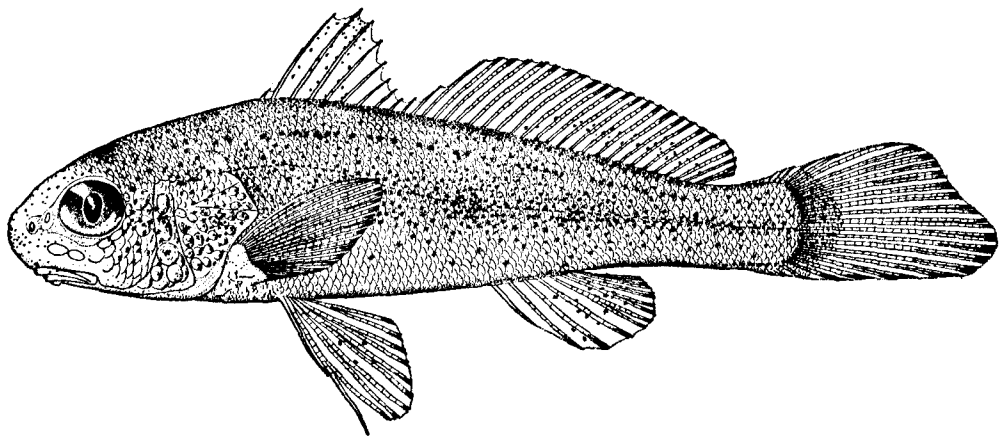

FIGURE 17.—*Menticirrhus littoralis.* From a specimen 30 millimeters long.

The attainment of virtually the adult form at so small a size is quite striking. While the body remains somewhat more slender than in the other two local species of the genus, the difference is slight between the present species and *americanus*. However, the eliptical pupil and the short angulate caudal fin have been retained and are useful in separating this species and *americanus*. The very short pectorals and the reduced scales on the chest distinguish the present species from both *americanus* and *saxatilis*.

*Specimens 50 to 60 millimeters long.*—The differences between specimens of this size and those described in the preceding section are not pronounced. The body has continued to become more rounded anteriorly and apparently proportionately not quite as deep, the greatest depth being contained in the length to the base of the caudal 4.3 to 4.4 times. These proportions are, also, common to the adult. The caudal now is shaped virtually as in the full grown fish, that is, its margin is concave and the lower lobe is longer and somewhat more sharply rounded than the upper one. The color is plain silvery gray, as seen with the unaided eye. Under magnification

dark points are evident on the sides and back, but they have become smaller and less numerous since a length of 35 millimeters was attained (fig. 18).

Specimens of the size described are virtually young adults and are readily recognized. The body remains slightly more compressed, however, and the caudal fin is less deeply concave and the lower lobe is more sharply rounded.

The principal characters that distinguish the adults of this form from the other local species of the genus are developed at this size, and are usable in making identifications. They are the rather large scales (72 to 74 vertical series above the lateral line), which are conspicuously reduced in size on the chest; the low dorsal spines, none being produced; the short anal, which typically has only 7 soft rays; the very short pectorals, which fail conspicuously to reach the tips of the ventrals; and the plain silvery gray coloration. The small, vertically elongate pupil still is conspicuous and readily distinguishes this species from *americanus*, although not from *saxatilis*.

### DISTRIBUTION OF THE YOUNG

Young under 9 millimeters in length were not taken. Their habitat and distribution, therefore, remain unknown. Young ranging upward of 9 millimeters were

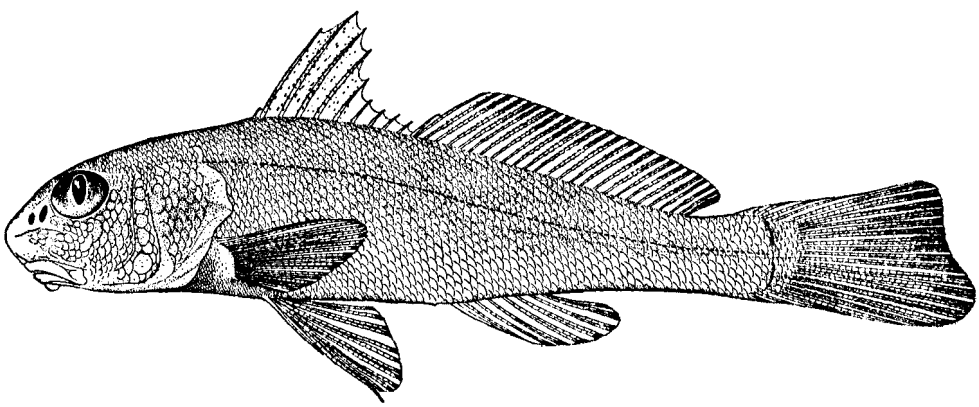

FIGURE 18.—*Menticirrhus littoralis*. From a specimen 60 millimeters long.

found only in the surf, at Cape Lookout and on the outer shores of the "banks." So far as known the young, like the adults, dwell on or near the bottom.

### GROWTH

The measurements of 180 young taken during June, July, August, and September are entirely inadequate to cast much light upon the rate of growth. However, specimens of the 0-class, 98 millimeters long taken in August, and others 120 millimeters in length caught in September, when probably only about 3 or 4 months old, suggest rapid growth. Nothing is known concerning the rate of growth after the first several months.

## STAR DRUM (Stellifer lanceolatus (Holbrook))

This small drum has no common name at Beaufort. The two names, "star drum" and "bullhead" occur in the literature. The species ranges from Chesapeake Bay to Texas and possibly to Mexico, its southern range of distribution not having been definitely determined. The species is recorded from Chesapeake Bay (Hildebrand and Schroeder, 1928, p. 282) from a single specimen. It is recorded

from North Carolina (Beaufort) by Smith (1907, p. 315), who refers to it as a "rare drum." However, during recent years it has proven to be rather common off Beaufort Inlet in water ranging from about 2 to 7 fathoms in depth. Here the star drum is sometimes taken in considerable numbers in trawls. Since specimens have been taken almost throughout the year, it obviously is a permanent resident, although quite evidently more numerous during the summer than during the winter. Only 3 small specimens were secured in the inside waters throughout several years of intensive collecting, indicating that this drum seldom crosses Beaufort Bar. It is reported as very common on the South Atlantic and Gulf coasts from South Carolina southward.

The species has no direct commercial value because of its small size, the maximum length attained being only about 165 millimeters (6½ inches). It no doubt enters into the food of other fishes to some extent, as it occupies areas frequented by such predatory species as the bluefish, weakfish, croaker, king whitings (or "sea mullet"), and flounders.

The star drum is the only species of the genus Stellifer recorded from the coast of the United States. The genus is represented by several species in tropical America. The adult star drum is recognized readily by the rather low head, broad interorbital, blunt snout, the slightly concave dorsal outline of the head, and the terminal or slightly inferior mouth. The spongy skull, with bony ridges and large caverns (readily perceptible to the touch), also is quite distinctive. The body is rather robust and elongate, the depth being contained in the standard length 3.0 to 3.3 times, and the length of the head is about equal to the depth. The caudal fin is pointed at all ages. The dorsal has X or XI–I, 21 or 24 rays, and the anal II, 7 or 8. The scales in the lateral series number about 47 to 50. The color is plain bluish gray above and silvery below.

## SPAWNING

The star drum spawns during the summer. Young under 5 millimeters in length were taken at Beaufort in July, August, and September. The largest specimens of the 0-class taken in July (on the 25th day of the month) are 60 to 69 millimeters long. These large young quite probably are more than a month old. Only one ripe fish, a female taken August 4, 1914, was observed. It seems reasonable to assume from these data that spawning begins certainly not later than June, and probably as early as May, and that it extends through August. The eggs have not been studied.

The larvae were taken from Beaufort Inlet to Cape Lookout, that is, along Shackleford Banks, some rather near the shore and others several miles off shore, in the general vicinity inhabited more or less permanently by the adults. Besides the off-shore collections only one small lot of larvae was caught in the inside waters where they may have been carried by winds and tides. The indications, therefore, are that the young are hatched on the grounds regularly occupied by the adults and that no migration for the purpose of spawning takes place.

## DESCRIPTIONS OF THE YOUNG

*Specimens 1.8 to 2 millimeters long.*—The head and trunk are short and moderately deep, compressed, and the tail is long and slender, an abrupt decrease in depth occurring at the vent. The distance from the snout to the vent is contained in the length to the end of the notochord about 2.4 times, distance posterior to vent (without finfold) 1.6 times, and the greatest depth about 3.1 times. The mouth is moderately large and oblique, and the snout is very short. The myomeres are too indistinct to enumerate accurately; about 25 can be counted, and only about 5 of them are in

advance of the vent. A small black spot is present on the median line of the abdomen immediately in advance of the vent, generally another elongate black spot is situated on the ventral outline of the tail at about midcaudal length. However, sometimes several small black spots occur on the ventral outline of the tail. The inner surface of the base of the primitive pectoral is black, and dark points are present on the sides along the upper margin of the abdomen. Three dark dots also are situated on the dorsal outline. The first is placed slightly in advance of the anterior margin of the eye, the next one is somewhat behind the posterior margin of the eye, and the third one is fully a half an eye's diameter behind the second one (fig. 19).

Specimens of this size differ notably from somewhat larger ones in the long slender tail, which becomes proportionately much shorter and stouter quite abruptly. The deep body, the moderately large oblique mouth, and the color markings are useful in identifying these small larvae with somewhat larger ones.

*Specimens 2.5 millimeters long.*—The fish has increased greatly in depth since a length of about 1.8 to 2.0 millimeters was attained, and the tail has become proportionately much shorter and stockier. The distance from the snout to the vent is contained 1.75 to 1.9 times in the length to end of the notochord, distance posterior to vent (without finfold) 2.0 to 2.3 times, and the greatest depth 2.3 to 2.5 times. The cavernous nature of the skull, characteristic of the adult, already is indicated by

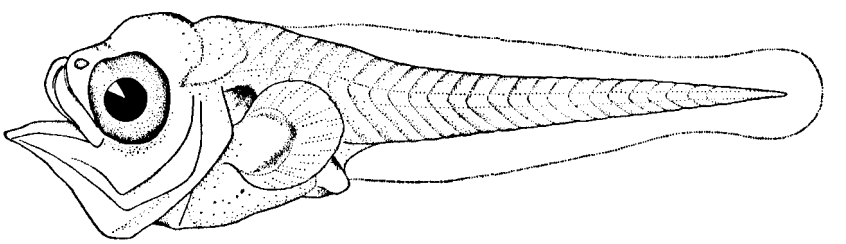

FIGURE 19.—*Stellifer lanceolatus*. From a specimen 1.8 millimeters long.

an apparently vacant space over the brain. (The outline of the brain is plainly visible because of the transparency of the coverings of the head.) The mouth is moderately large and oblique; the gape anteriorly is about on a level with the middle of the eye and the maxillary reaches under the pupil. Distinct teeth are present on the jaws, and a few spines have appeared on the preopercular margin. The myomeres are partly indistinct; about 8 can be counted in advance of the vent and about 17 behind it. A slight thickening of the vertical finfold is noticeable in those places where the soft dorsal, the caudal, and anal fins are developing. Slight indications of rays are present in the caudal fin (that is, below the end of the tail). The color markings of the smaller specimens described remain, though somewhat modified. A few dark points (more distinct in some specimens than in others) persist on the median line of the abdomen. The dark spot at about midlength of the ventral outline of the tail has become more distinct and quite elongate, and some specimens have a smaller spot in front of this one and another one behind it. The inner surface of the base of the primitive pectoral remains black. A few dark points persist along the upper margin of the abdomen, ending in a small dark spot dorsally of the base of the pectoral. These dark markings, in part at least, consist of dark membranes, visible through the body wall. The three dark markings on the head, noticed in smaller specimens, now have the appearance of dark cross partitions, lying below the surface of the skull (fig. 20).

The indications are that the fish when about 2.0 millimeters long (preserved specimens) virtually ceases to increase in length for a while. During the time it fails to grow in length it appears to increase greatly in robustness, and the caudal portion of the body becomes proportionately much shorter, as shown by the proportional measurements given in the foregoing description and by figures 19 and 20. Specimens 2.5 millimeters long have the appearance of being considerably older than those 2.0 millimeters long.

*Specimens 3.0 to 3.5 millimeters long.*—The fish has increased further in depth, the tail particularly having become much deeper, and the body, although rather robust, is compressed throughout. The decrease in depth immediately behind the vent, abrupt in younger fish, has become much less pronounced. The distance from the snout to the vent is contained 1.55 to 1.65 times in the length to the end of the notochord, distance posterior to vent (without finfold) 2.0 to 2.2 times, and the greatest depth 2.2 to 2.5 times. The notochord remains nearly straight in a specimen 3.0 millimeters long, but is bent upward quite sharply distally in a fish 3.3 millimeters long. A large vacant space exists between the brain and the cranium, and a few rather prominent spines are present on the preopercular margin. The mouth remains moderately oblique, the gape anteriorly being only a little higher than the lower

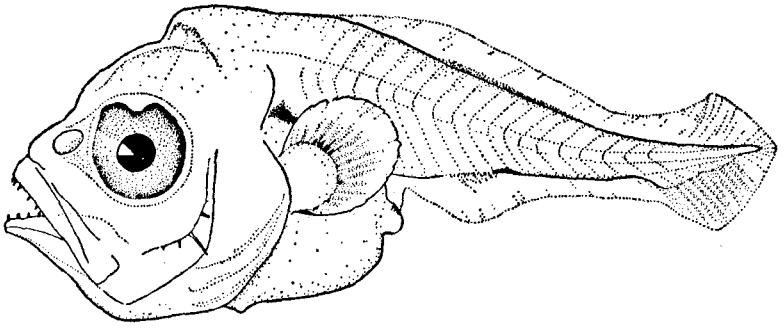

FIGURE 20.—*Stellifer lanceolatus*. From a specimen 2.5 millimeters long.

margin of the eye, and the maxillary reaches nearly opposite the middle of the eye. The caudal and pectoral fins contain well developed rays; the soft dorsal and anal bases are rather well outlined, but the rays are not fully differentiated; the spinous dorsal is not evident; and the ventral fins if present appear as mere tufts of membrane. Color markings on the chest and abdomen have increased in number and intensity. A short dark cross line, preceded by a median black spot, usually is present on the chest; a few indistinct dark points appear at the base of the ventrals; and a rather distinct short dark bar (sometimes consisting of a few dark points only) crosses the abdomen behind the ventrals. The elongate dark spot at about midlength on the ventral outline of the tail, mentioned in descriptions of smaller larvae, now is situated at or near the end of the base of the anal fin, and occasionally a black point is present directly over it on the dorsal outline. In some specimens, at least, a small dark spot has appeared also at the origin of the anal. The inner surface of the base of the pectorals remains black, and a dark shoulder spot is present as in the younger fish (fig. 21).

The most prominent advancement in the development since a length of about 2.5 millimeters was attained consists in the further deepening of the body, especially the caudal portion, causing a less pronounced break in the ventral outline at the vent.

*Specimens 4.5 to 5.5 millimeters long.*—The fish has become much more shapely than it was at a length of about 3.5 millimeters. It is quite deep and strongly compressed throughout, and the break in the ventral outline at the vent has almost disappeared, a space exceeding in length the diameter of the eye between the vent and origin of the anal being occupied by a transparent membrane. The distance from the snout to the vent is contained 2.0 to 2.3 times in the length to the base of the caudal, distance from vent to base of caudal 1.9 to 2.1 times, and the greatest depth 2.6 to 2.8 times. The cavernous nature of the skull is quite evident from the large vacant spaces occurring above the brain and around the snout. The eye and snout are of

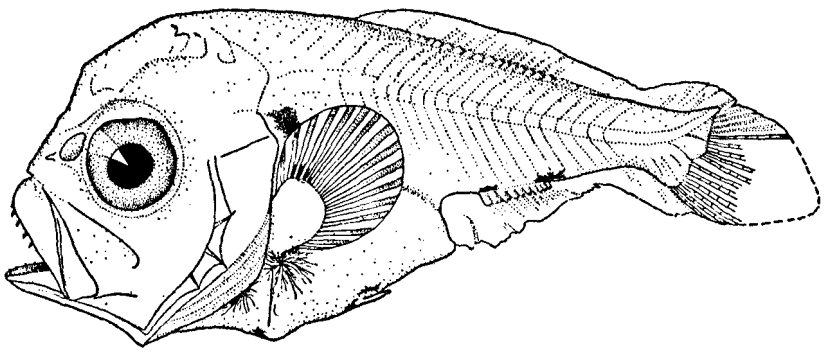

FIGURE 21.—*Stellifer lanceolatus.* From a specimen 3.3 millimeters long.

about equal length. The preopercular margin has several prominent spines at its lower angle. The mouth is oblique, the gape anteriorly is about on a level with the lower margin of the pupil, and the maxillary reaches below the middle of the eye. The fins, exclusive of the spinous dorsal and the ventrals which remain rudimentary, are quite well developed. About 22 rays can be counted in the soft dorsal and 10 in the anal (the spines and the soft rays not being differentiated in the latter). The caudal fin is moderately long and somewhat pointed. A few dark points remain on the median line of the chest and abdomen, but are less evident than in younger fish. The elongate black spot at the end of the base of the anal persists and is variable in

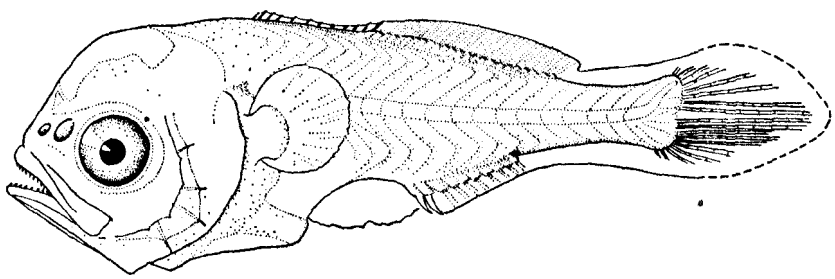

FIGURE 22.—*Stellifer lanceolatus.* From a specimen 5.6 millimeters long.

size and intensity among specimens. A slight dark spot remains evident at the origin of the anal in some individuals, though missing in others. The black on the inner surface of the base of the pectoral, prominent in the younger stages described, has disappeared entirely according to the specimens at hand. A slight shoulder spot and a few dark markings behind it, which extend to the vent, still persist. It is evident that the last-mentioned color markings are below the surface of the body, and apparently consist of a dark membrane on the dorsal wall of the abdominal cavity. A faint dark bar has appeared at the base of the caudal fin (fig. 22).

*Specimens 7 to 8 millimeters long.*—No pronounced changes in the proportions of the body have taken place since a length of about 4.5 to 5.5 millimeters was attained. The distance from the snout to the vent is contained 2.0 to 2.2 times in the length to the base of caudal; distance from vent to base of caudal 1.8 to 2.1 times; and the greatest depth 2.65 to 2.8 times. A slight concavity remains in the ventral outline of the body between the vent and origin of anal, which is occupied by a thin membrane, apparently a remanent of the finfold. Above this concavity in the ventral outline, the body is very thin and semitransparent. The snout remains short and narrow, its length being equal to the diameter of eye, and the profile ascends abruptly from its tip. Considerable advancement has been made in the development of the fins. The spinous dorsal is fairly well differentiated, although rather more closely connected with the soft dorsal than in the adult. About 12 spines and 24 soft rays may be counted. The anal fin consists definitely of 2 spines and 7 or 8 soft rays. The caudal fin is frayed in the specimens at hand, but it evidently is long and pointed. The ventral fins remain small. The dark markings present vary in size and number among specimens. Generally a few dark dots are present on the median line of the chest and abdomen. The spot at the end of base of anal, present in all the smaller larvae at hand, persists. Some specimens now have two spots at and behind the anal base, and each one may have a narrow vertical projection. Some specimens also

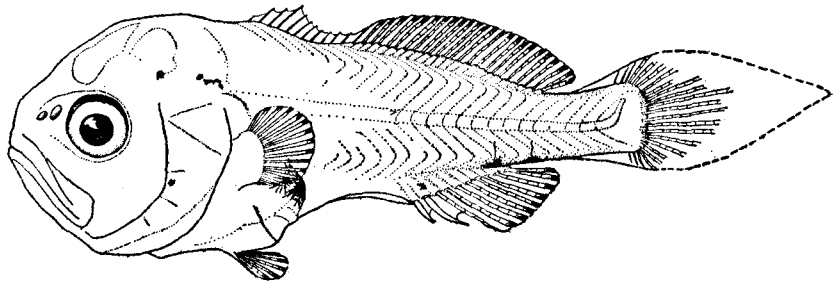

FIGURE 23.—*Stellifer lanceolatus.* From a specimen 9 millimeters long.

have a small black spot near the origin of the anal. A rather prominent dark spot is present above the vent, which often is more or less connected with other spots, reaching to an elongate, finely branched shoulder spot. A narrow dark bar at the base of the caudal is evident (fig. 23).

*Specimens 10 to 13 millimeters long.*—The proportions of the body remain about as in somewhat smaller specimens. The distance from the snout to the vent is contained 1.85 to 2.0 times in the length to the base of the caudal fin, distance from vent to base of caudal 2.05 to 2.15 times, and the greatest depth 2.6 to 2.75 times. A slight concavity remains evident in the ventral outline between the vent and the origin of the anal (which is occupied by a thin membrane as in smaller fish), and the distance between these two points exceeds the diameter of the eye. The snout has become broader and rounder; the mouth is less oblique and wholly below the lower margin of the eye; and the maxillary reaches nearly or quite to the posterior margin of the eye. In all the characters about the head, just mentioned, the fish is approaching the shape and form of the adult. The eye is unusually small. The cavernous nature of the skull, with its bony ridges, is quite prominent. The preopercular spines are smaller and more numerous than in younger fish. The fins are all well developed, the dorsal formula is X or XI–I, 23 or 24, and that of the anal II, 7 or 8. The caudal remains long and pointed, the longest rays being longer than the head. Little

advancement in pigmentation has taken place. The few dark markings usually present are shown in figure 24. Some specimens, however, have a series of 3 to 7 (instead of 1) dark spots on the side below the spinous dorsal, as well as several on the posterior part of the head and on the nape (fig. 24).

*Specimens 18 to 20 millimeters long.*—The fish has made considerable headway toward acquiring the form of the adult. Although the head has increased in width, it remains proportionately much more compressed than in the adult, its length is contained 2.55 to 2.75 in the total length without the caudal fin. The interorbital space has become relatively broad and is about 1.5 times as wide as the small eye. The snout is slightly longer than the eye and is contained 4.6 to 5.5 times in the head. The preopercular margin has 3 or 4 small spines, and 3 bony stays are partly embedded in the interopercle. A row of bony serrae are present at the shoulder. A slight concavity remains present between the vent and the anal fin, the membrane (remanent of the finfold) which occupied the concavity in smaller fish has disappeared, and the distance between the vent and origin of anal is now scarcely as long as the

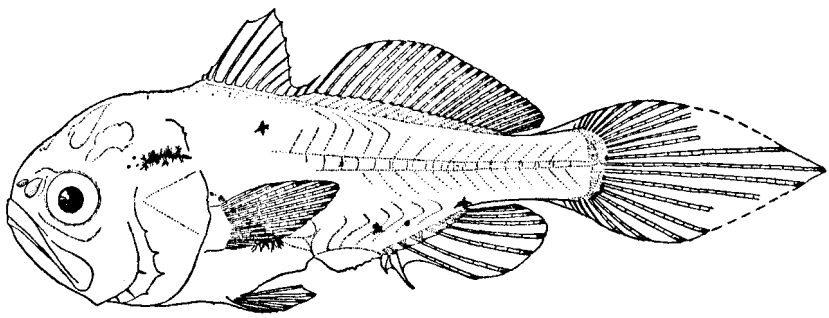

FIGURE 24.—*Stellifer lanceolatus*. From a specimen 13 millimeters long.

eye. The proportionate depth of the body remains the same as in fish 10 to 13 millimeters long. Much advancement in pigmentation has taken place. The dark spot near the end of the base of the anal, present in all younger fish, remains evident and is preceded (along the base of the anal) as well as followed (on the ventral outline of the peduncle) by a row of dark dots and spots. The characteristic elongate, slightly arched spot on the opercle, immediately in advance of the upper angle of the gill opening, remains prominent. The mouth is margined with black and numerous dusky markings occur on the head and nape, and on the upper parts of the sides. The markings are variable in size and intensity among specimens. One row of spots follows the base of the dorsal and another one parallels it about an eye's diameter lower on the side. Other scattered markings are present, and a dark bar is situated on the base of the caudal.

*Specimens 25 to 30 millimeters long.*—Although advancement toward the adult form has been rather rapid since a length of 18 to 20 millimeters was attained, the fish remains more compressed anteriorly and the snout is more pointed. The head is contained 2.8 to 2.9 times in the length to the base of the caudal, and the depth 2.7 to 3.1 times. These proportions are close to those of adult fish. The small eye is surrounded by a ridge which is not yet fully ossified, its longest diameter is contained 4.5 to 5.2 in the head; snout 4.25 to 4.5 times; interorbital 2.7 to 3.2 times; maxillary 1.8 to 1.95 times. The concavity between the vent and the anal, present in younger fish has disappeared, and the body in this region has thickened and no longer is semitransparent. Outlines of scales are present on most of the body. If scales

actually were developed they have been lost. Pigmentation has advanced rather rapidly. The chief color markings are shown in the accompanying illustration (fig. 25).

*Specimens 40 to 50 millimeters long.*—The head is lower and notably broader than in fish about 30 millimeters long. Although the snout is more rounded than in younger fish, it still remains narrower and rather more pointed than in the adult. The small eye, though lateral, is near the dorsal outline; the interorbital is broad, its width being contained 2.4 to 2.8 times in the head. Several bony ridges are present on the head among which caverns occur. The preopercle has a few small spines at the angle and the interopercular margin is strongly serrate, the spines at the angle being largest. The scapular spines have become much smaller. The caudal fin apparently remains rather longer and more pointed than in the adult, the longest rays being more than an eye's diameter longer than the head. Pigmentation is general. The

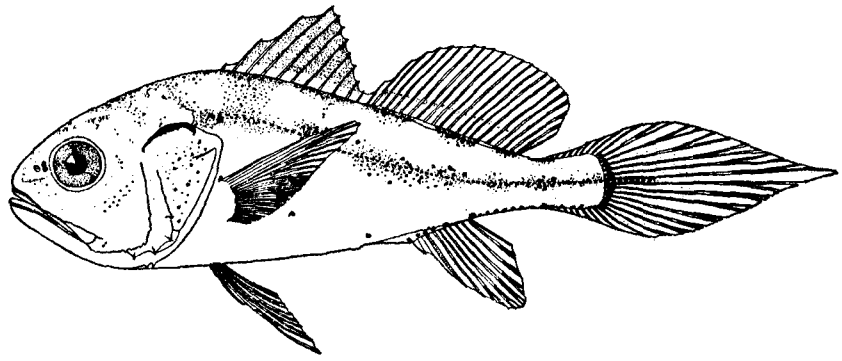

FIGURE 25.—*Stellifer lanceolatus*. From a specimen 29 millimeters long. (After Welsh and Breder.)

back of preserved specimens is light brown and the lower parts are silvery. The elongate dark spot on the upper part of the opercle and the dusky color around the mouth remain as in smaller specimens. Dark blotches, present in somewhat younger fish, along the back generally persist, but are less distinct, the color being more generally distributed as dusky points. The spinous dorsal is dusky, and all the other fins have dark dots, being very few, however, on the ventrals and pectorals. A dusky bar remains present on the base of the caudal fin.

*Specimens 75 to 85 millimeters long.*—Fish of this size are young adults, having the body proportions of full-grown fish. The head is somewhat depressed and its dorsal outline is slightly concave over and behind the posterior margin of the eye, as in the adult. The snout is broad, bluntly conical, and almost as broad as deep at anterior margin of the eye. The mouth is oblique, but wholly below the level of the lower margin of eye; the maxillary reaches about under posterior margin of the pupil. The small eye is shorter than the snout, and not as wide as the interorbital, its diameter being contained 4.4 to 4.8 times in the head. The preopercular spines are small, and those on the interopercle are strong, as in full grown fish. The scapular spines, described in younger fish, are now represented as serrations on an enlarged scale. The caudal fin remains rather pointed and is about as long as the head. The pectoral fins are long, being only a little shorter than the head. The color remains about the same, as in 40 to 50 millimeter fish. The dark points on the fins have become more numerous, however, and the anal and the tips of ventrals are quite dusky.

Specimens of this size have virtually all the characters of the adult and are easily recognized. Figure 26 illustrates the adult without indicating the scales.

## DISTRIBUTION OF THE YOUNG

It has been shown (p. 76) that the young of the star drum in the vicinity of Beaufort apparently are hatched and live on the grounds occupied by the adults as a permanent residence, that is, the larvae were taken from Beaufort Inlet to Cape Lookout, as far as 7 to 12 miles off shore, and only one small lot was caught in the inside waters. Furthermore, all the young collected were taken on the bottom, showing that the young, like the adults, dwell on the bottoms. The star drum, therefore, appears to dwell at or near the bottom throughout life.

## GROWTH

The number of young taken is insufficient to determine accurately the rate of growth even during the first several months of life. During July 122 young of the 0-class were caught, ranging in length from 2.5 to 69 millimeters, having an average length of 21.3 millimeters. Although no young were taken earlier in the season, it is believed that the larger specimens, as already explained (p. 76), are more than a month old and probably were hatched in May or June. In August 617 young were caught, ranging in length from 2.3 to 90 millimeters, with an average length of 49.3

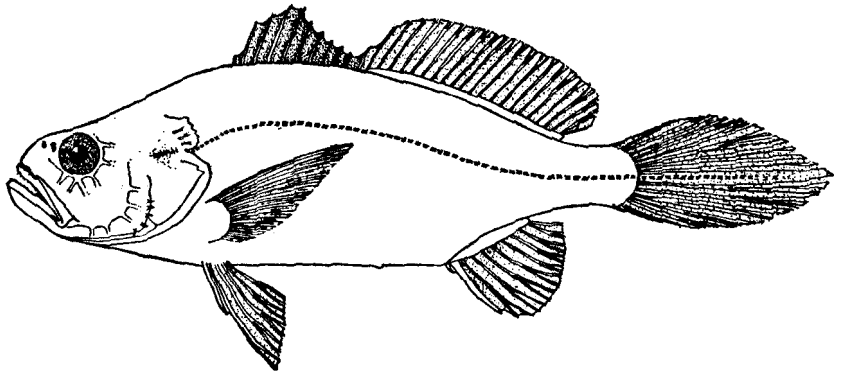

FIGURE 26.—*Stellifer lanceolatus*. From a specimen 164 millimeters long. Scales not indicated. (After Welsh and Breder.)

millimeters. Only 11 larvae, all less than 10 millimeters in length, were taken in September. During October 62 young, ranging in length from 38 to 112 millimeters, averaging 90.4 millimeters, were caught. The smaller young of the season obviously are missing in this catch, as the smallest specimen taken next month is 26 millimeters long. The largest one in the 0-class caught in November is only 91 millimeters, and the average length of 34 specimens taken is only 58 millimeters. It is obvious, therefore, that although the smaller ones are present the larger ones of the 0-class are missing in the catch for November. The number of specimens taken during the other months is too small to be worthy of consideration. From the data presented it is evident that some of the young reach a length as great as 100 to 125 millimeters (4 to 5 inches) during their first summer. Since the maximum length attained by the star drum is only about 6 inches, it seems probable that the fastest growing individuals reach maturity when about 1 year old. Others may require a year longer to reach that stage.

The foregoing analysis of the rate of growth is in general agreement with the data presented by Welsh and Breder (1923, p. 175), who found individuals of the 0-class varying from 10 to 40 millimeters in length (the smallest larvae of the season evi-

dently being missing) in a collection of fish made in Winyah Bay, S.C., in July (1915). From a collection from Fernandina, Fla., these writers determined that the fish reach a length of 50 to 90 millimeters by the first winter. These writers state that the 1-year-old fish are 70 to 100 millimeters long in July and that the same year class reaches a length of 80 to 140 millimeters by the second winter, and they conclude that maturity is reached at the age of 1 year.

## BANDED DRUM (Larimus fasciatus Holbrook)

The banded drum, also known as "bastard drum", "bastard perch", and "chub", ranges from Cape Cod to Texas. According to published records, it occurs only as a straggler from Virginia northward, and is common from Cape Hatteras southward. The limit of its southward range apparently has not been determined definitely. The species is common off Beaufort Inlet, where it is a year-round resident, and where it sometimes is taken in large numbers in shrimp trawls in water ranging from a few to several fathoms in depth. According to the records at the Fisheries laboratory at Beaufort, the species does not enter the harbor nor adjacent sounds. Neither has it appeared in collections made with seines along the outer shores of the "banks."

The banded drum was first recorded from North Carolina by Smith (1907, p. 314), who reported it from "several specimens" with the notation, "It is not common anywhere." However, Welsh and Breder (1923, p. 170) state "* * * although stragglers have been taken as far north as Woods Hole, it is not found in abundance north of Cape Hatteras. South of this point and on the shores of the Gulf of Mexico it is one of the most abundant fishes, being taken in large numbers in the trawls of the shrimp fishermen." The species evidently did not appear often in the collections at Beaufort until the otter trawl came into use in about 1913 or 1914. We have no record of its capture with seines, probably because it does not frequent areas near Beaufort in which such nets commonly are operated.

The banded drum does not grow large enough to be of much direct commercial value. Comparatively few individuals attain a length as great as 8 inches. The largest one seen at Beaufort was 206 millimeters (8¼ inches) long. The species probably enters into the food of other fishes to some extent, as it occupies areas frequented by such predatory species as the bluefish, weakfish, croaker, king whiting ("sea mullet"), and flounder.

The banded drum is the only species of the genus occurring north of Florida. The adult is readily recognized by the deep compressed body (depth in standard length 2.6 to 2.8), the strongly oblique mouth, long dorsal fin (X–I, 24 to 27), short anal fin (II, 6 to 8), and by the 7 to 9 black crossbars. The skull is firm, without conspicuous caverns, and no barbels are present about the mouth.

### SPAWNING

The banded drum evidently spawns throughout the summer. Young under 5 millimeters in length were taken in July, August, September, and October, and one specimen 12 millimeters long was taken on May 29 (1930). This specimen, according to measurements made of collections, belongs to a new year class. Furthermore, the largest young of the 0-class taken in July, as shown elsewhere (p. 91), were as much as 70 millimeters long and the average length of 87 specimens measured was 34 millimeters. Unless the rate of growth in this species were unusually rapid, the larger individuals certainly would be as much as 2 months old. It seems quite probable,

therefore, that spawning begins as early as May, even though no larvae were taken in June, and it extends through October, as some of the smallest larvae (1.9, 2.1, and 3.0 millimeters long) in the collection were taken on October 22 (1928).

The eggs, if taken, were not recognized. The larvae were caught in the tow in the same general vicinity where the adults are found throughout the year, that is, from Beaufort Inlet to Cape Lookout and as much as 12 miles offshore, beyond which collecting was not extended. It seems improbable, therefore, that a migration for the purpose of spawning takes place.

## DESCRIPTIONS OF THE YOUNG

*Specimens 1.9 to 2.0 millimeters long.*—The body is moderately deep and robust for such a small fish, and the decrease in depth at the vent is not abrupt. The caudal portion is rather shorter than the rest of the body, the distance from vent to tip of notochord being contained 2.25 times in length without caudal fin membrane, and the greatest depth of body 4.15 times. Myomeres are partly indistinct; about 25 may be counted. The mouth is moderately large and oblique, the gape anteriorly being at or slightly above middle of eye, and the maxillary reaches about to the pupil. The eye is moderately small for such a young fish and does not exceed the snout in length. The color markings of preserved specimens consist principally of a dark spot at the vent, a larger and more distinct one at midcaudal length, and a third and smaller one about half-way between the last-mentioned spot and the tip of the notochord.

The smaller larvae of this species differ from related forms quite notably in having the caudal portion of the body rather deep anteriorly, thereby eliminating an abrupt decrease in the depth at the vent.

*Specimens 2.3 to 2.6 millimeters long.*—The head and trunk are deep, compressed, and the decrease in depth just posterior to the vent is less abrupt than in related species. The caudal portion of the body remains somewhat shorter than the rest of the fish, being contained in the total length without the caudal fin membrane 2.1 to 2.6 times, and the greatest depth is contained in the length 2.8 to 3.2 times. The mouth is moderately large, oblique, with the lower jaw projecting in advance of the upper one, the gape anteriorly being on or above the level of lower margin of pupil, and the maxillary reaches nearly or quite under anterior margin of pupil. Slight indications of rays are discernible in the vertical fin membranes, as well as in the pectorals. The color of preserved specimens is brownish. The air bladder may be seen as a small clear area, with a dark margin, situated above the base of the pectorals. The ventral outline of the abdomen is slightly dusky, with a small black spot just behind the gill membranes and another one usually present just behind the vent. Two or three black spots occur on the ventral outline of the tail. The first one, if present, is a short distance behind the vent; the second and more distinct one (sometimes quite elongate) is near midcaudal length, and the third one is about midway between the last-mentioned spot and tip of notochord. The inner surface of the base of the pectoral is black (fig. 27).

The head and trunk become abruptly deeper while the fish grows in length from about 1.9 to 2.5 millimeters.

*Specimens 3 to 3.5 millimeters long.*—The fish has become proportionately deeper and more robust, the greatest depth now being contained in the total length without the caudal fin membrane about 2.3 times. Although the tail remains much

more slender than the rest of the body, it has become proportionately deeper and rather shorter, its length being contained in the length of the body about 2.3 times. The mouth remains strongly oblique and the maxillary reaches about under the middle of the orbit. The eye is small, scarcely longer than the snout. The cranium is very transparent, permitting the lobes of the brain to be seen clearly. The fin membranes remain about as in the younger fish already described. A slight thickening of the membranes is discernible, however, in the places that will be occupied by the bases of the dorsal and anal fins. The color markings have not changed per-

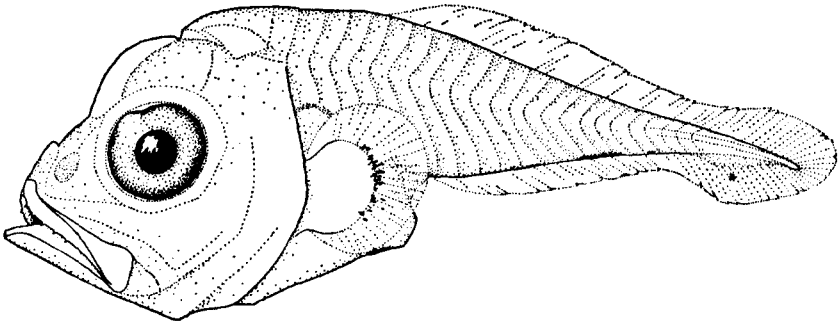

FIGURE 27.—*Larimus fasciatus*. From a specimen 2.5 millimeters long.

ceptibly, the most prominent ones being the dark spot on about midlength of the ventral outline of the tail, and the black inner surface of the base of the pectorals (fig. 28).

The dark color markings described, together with the very deep compressed body, serve as the principal diagnostic characters in the smaller larvae of this species.

*Specimen 4.5 millimeters long.*—The body is very deep and moderately compressed anteriorly, tapering rapidly behind the head. The break in the ventral outline behind the vent, very abrupt in the smaller specimens, is no longer pronounced. The caudal

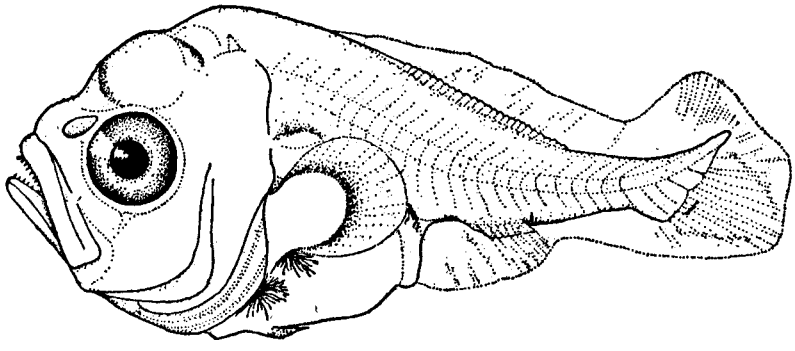

FIGURE 28.—*Larimus fasciatus*. From a specimen 3.4 millimeters long.

portion is notably shorter than the rest of the body, its length being contained about 2.6 times in the total length without the caudal fin, and the greatest depth is contained about 2.15 times in the length. The mouth remains strongly oblique, and the maxillary reaches under the middle of the orbit. The eye is comparatively small, being only a little longer than the snout, and is situated somewhat nearer to the dorsal than the ventral outline. The fins are fairly well developed, all of them, exclusive of the ventrals, having fairly well-developed rays. About 36 rays may be counted in the dorsal, and 7 in the anal. A structural differentation is not evident

between spines and soft rays. However, the rays in the anterior part of the dorsal, which will form spines, are shorter than the others. The color in spirits remains dark brown. The anterior part of the abdomen is dusky and the dark spot on the ventral outline of the tail, described in smaller specimens, is situated immediately behind the base of the anal. The inner surface of the base of the pectorals remains black, as in the smaller larvae (fig. 29).

The very deep compressed body, moderately large oblique mouth, the black spot behind the base of the anal, and the black inner surface of the base of the pectorals are the principal recognition marks.

*Specimen 7 millimeters long.*—The head and trunk remain deep and compressed, as in smaller specimens. The tail has become deeper, causing the fish to appear more shapely. It has decreased still further in proportionate length, the distance from the vent to the base of the caudal fin being contained in the total length without the caudal fin 3.8 times, and the greatest depth of the body is contained 2.35 times in the length. The mouth remains strongly oblique, the gape anteriorly being about on a level with the middle of the eye, and the maxillary reaches slightly beyond the middle of the orbit. The fins remain about as in the 4.5-millimeter fish already

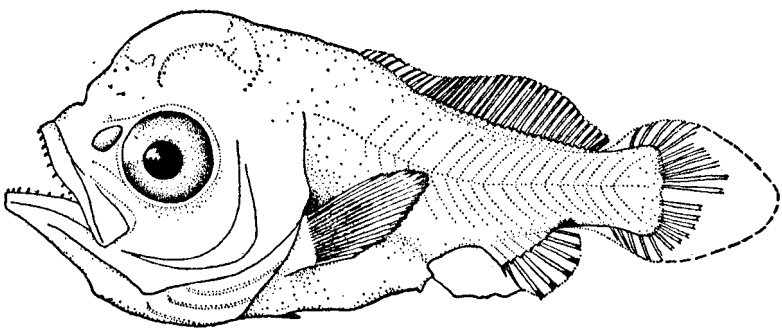

FIGURE 29.—*Larimus fasciatus.* From a specimen 4.5 millimeters long.

described, except that some of the anterior rays of the dorsal and the first one of the anal now resemble spines somewhat. The caudal fin is quite fully developed, but the exact shape cannot be determined as it is frayed at the tip in the single specimen of this size at hand. However, it very probably is pointed, as indicated in the accompanying illustration. The pectoral fins are long and reach the origin of the anal. Many black chromatophores are now present, as shown in figure 30. The characteristic black spot just posterior to the base of the anal, present in all the smaller specimens examined, persists. The inner surface of the base of the pectoral remains black, and the base of the ventral is dusky (fig. 30).

*Specimens 9 to 10.5 millimeters long.*—The body has become somewhat deeper, its greatest depth being contained about 1.9 times in the length. The dorsal outline is much more strongly curved than the ventral one. It ascends sharply anteriorly and descends strongly posterior to the origin of the dorsal. The mouth has become less strongly oblique, as the gape anteriorly is only a little above the lower margin of the eye. The spines and soft rays in the vertical fins are fully differentiated. The first dorsal consists of 10 spines, the second one (which is scarcely separated from the first one) has 1 spine and 26 or 27 soft rays, and the anal has 2 spines and 6 soft rays. The caudal fin is nearly as long as the head and is pointed. The ventral fins reach

almost to the origin of the anal, and the long pectorals reach to or past the middle of the anal base. Black pigment spots have increased greatly in number, as shown in figure 31. However, the spots vary in size and number among individuals, some examples having more and larger spots than the one illustrated. The black spot immediately behind the anal, present in the smallest specimens taken, persists, though it has become much more elongate and branched. The basal half of both the ventrals and pectorals is black (fig. 31).

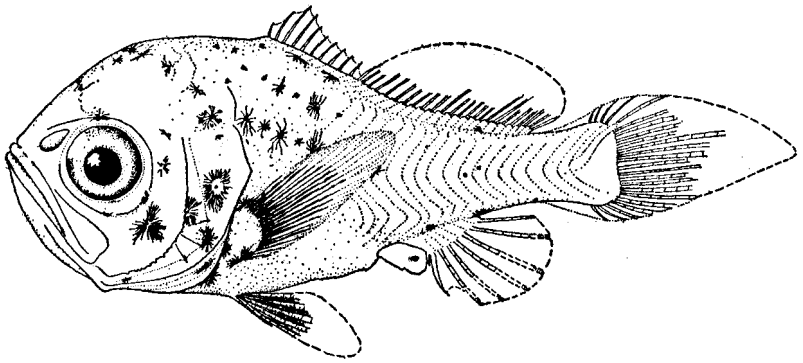

FIGURE 30.—*Larimus fasciatus*. From a specimen 7 millimeters long.

The deep compressed body, oblique mouth, the number of rays in the dorsal and anal fins, and the prominent black spots on the body distinguish specimens of this size from other local forms.

*Specimens 15 to 17 millimeters long.*—The body remains deep and compressed, although proportionately more slender than at a length of about 10 millimeters. The greatest depth, which falls under the origin of the dorsal, is contained about 2.4 times in the length. The vent is well posterior to midbody length, the tail (without

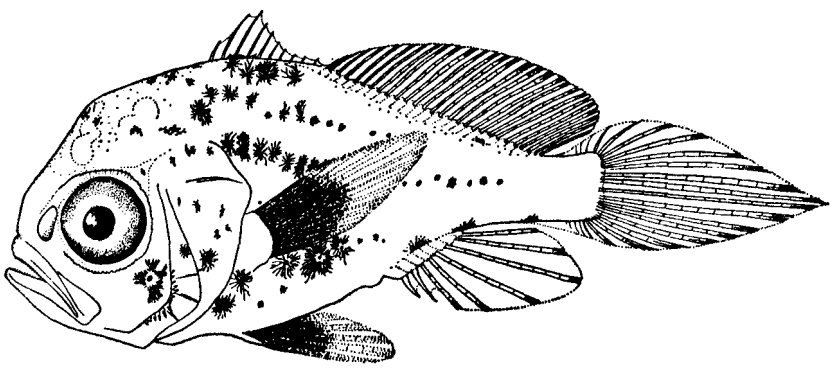

FIGURE 31.—*Larimus fasciatus*. From a specimen 10.5 millimeters long.

the fin) being contained in the length of the body about 3.15 times. The head is large and compressed. The preopercular margin has small serrae and three long spines at the angle. The eye is small, being scarcely longer than the short snout. The gape anteriorly is about on a level with the lower margin of the eye, and the maxillary reaches nearly opposite the posterior margin. Scales are present on most of the body, although not shown in figure 32. The dorsal and anal fins are rather high, the longest rays of the former reaching past the base of the caudal when deflexed, and those of

the latter about opposite it. The caudal fin is long and pointed (not round as shown by Welsh and Breder, 1923, p. 171, fig. 22), being longer than the head. The ventral fins, which have a strong spine, reach to or a little beyond the vent, and the pectorals reach opposite the anal base. Black pigment spots have increased in number as shown in figure 32. A concentration of spots, suggesting a broad black band, has taken place on the side below the base of the spinous dorsal. The black spots extend on the spinous dorsal, and the ventrals and pectorals are mostly black. A black spot at the end of the anal base, which serves as a recognition mark in the younger stages, is not evident in some specimens, though it persists in others (fig. 32).

*Specimens 20 to 25 millimeters long.*—The body is slightly more elongate than in the smaller fish described in the foregoing section, and has acquired proportions near those prevailing among adult fish, the depth being contained in the standard length 2.5 times. The head remains rather longer than in adults and is contained 2.7 times in the length. The eye is small, lateral, near the dorsal profile, and is a little longer than the very short snout, being contained in the head 3.2 to 3.6 times. The mouth virtually has the position it occupies in the adult; the gape anteriorly is a little above the level of the lower margin of the eye; and the maxillary reaches nearly to a vertical

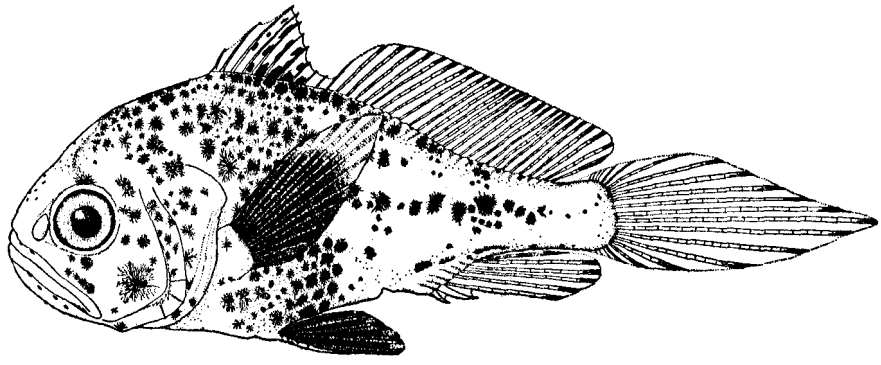

FIGURE 32.—*Larimus fasciatus*. From a specimen 17 millimeters long.

from the posterior margin of the eye, its length being contained 2.0 to 2.2 times in the head. The margin of the preopercle remains strongly serrate, but the long spines at the angle, present in somewhat smaller fish, have disappeared. The body is now fully covered with large scales. The fins remain about as in the smaller fish described in the preceding section. The caudal fin is notably longer than the head, and remains strongly pointed. The ventral and pectoral fins are long, the former reach a little beyond the vent and the latter opposite the anterior part of the anal base. Pigmentation has increased greatly, as shown in figure 33, although it is not yet general and complete. Indications of three dark crossbars are present. The anterior one, situated under the spinous dorsal, is broad and moderately distinct. The second one is situated under about the end of the anterior third of the soft dorsal, and the third one is under the posterior third of that fin. The posterior bars are narrower and much less distinct than the anterior one. A concentration of dark chromatophores occurs near the base of the caudal, forming a dark blotch. The ventral fins are almost wholly black, and the inner surface of the basal two-thirds of the pectorals also is black (fig. 33).

Fish about 20 to 25 millimeters long resemble the adults sufficiently to make identification comparatively easy. The chief diagnostic characters are the rather

short compressed body, the blunt head, short snout, strongly oblique mouth, the fin formulae (D. X–I, 24 to 27; A. II, 6 or 7), and the dark crossbars. Although only 3 bars are developed, whereas adults have 7 to 9, they are an aid in distinguishing the species.

*Specimens 35 to 40 millimeters long.*—The most evident advancement in the development since a length of about 25 millimeters was attained is in color. Pigmentation is general, and about seven dark crossbars are present. The broad one under the base of the spinous dorsal, present in smaller fish, shows indications of dividing into two narrower bars. The caudal fin remains nearly as long and pointed as in fish 25 millimeters long. The second anal spine has become very strong, as in the adult, and is only a little shorter than the snout and eye. The pectoral fins have become proportionately shorter and extend only to the tips of the ventrals, which scarcely reach the origin of the anal. The serrations on the preopercular margin have decreased in size, but remain somewhat more prominent than in the adult.

*Specimens 60 to 65 millimeters long.*—The proportionate depth (2.6 to 2.8 in the length) is about the same as in the fully matured fish, but the body remains more

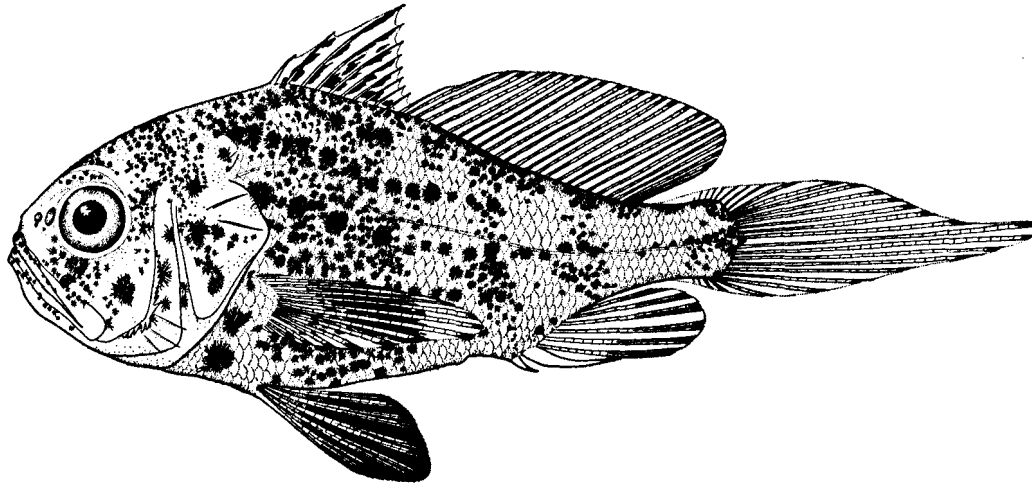

FIGURE 33.—*Larimus fasciatus.* From a specimen 24 millimeters long.

compressed. Specimens of this size differ from the adult conspicuously in the long pointed tail, the longest rays of which exceed the length of the head by at least an eye's diameter. The color pattern of the adult is quite fully developed. The ground color is silvery, the back in preserved specimens being slightly brownish. The sides have from about 7 to 9 dark bands. The spinous dorsal, the anal, ventrals, and pectorals are largely dusky to black, and the other fins are plain or somewhat punctulate with dusky.

The caudal fin generally does not acquire the characteristic shape it has in the adult (the upper lobe slightly concave and the lower one rounded) until the fish reaches a length of about 100 millimeters. In the adult, as in the young, the middle rays are the longest, but they do not exceed the head in length. When the fish reaches a length of about 100 millimeters the body has increased considerably in robustness, and this increase continues until the fish is full grown.

### DISTRIBUTION OF THE YOUNG

It has been shown elsewhere (p. 85) that the young were taken in the general vicinity where the adults are permanent residents. The larvae, like the adults, apparently dwell at or near the bottom, for no young were taken in towings at the surface, whereas they appeared in bottom hauls 9 times (16 specimens, 1.9 to 15 millimeters long), notwithstanding that many more surface than bottom hauls were made. The eggs, although not taken, probably are pelagic, as in other sciaenids so far as known. If that be true the larvae must descend to the bottom very early, as already indicated. The banded drum, therefore, appears to be bottom dwelling almost throughout life.

### GROWTH

The number of young fish measured is too small to cast much light upon the rate of growth. The range in length of 87 specimens of the 0-class, taken in July is from 3 to 70 millimeters, the average length being 34 millimeters. The range of 54 specimens taken in August is from 3 to 77 millimeters, with an average length of 54 millimeters. The only other month for which a considerable number of measurements is available is November. However, the larger young of the season obviously are missing, as the 215 fish measured range in length from 15 to only 63 millimeters, with an average length of 44.5 millimeters. The largest specimen, which evidently belongs to the 0-class, taken in October is 91 millimeters long, the largest one in February (no large ones of the 0-class having been taken in November, December, and January) is 113 millimeters, and the largest one in March is 123 millimeters long. While the data are quite incomplete, they do suggest a fairly rapid rate of growth, indicating that the largest young may reach a length of 120 to 125 millimeters (4¾ to 5 inches) when 1 year of age, although the average must be much smaller.

## THE WEAKFISHES OR SEA TROUTS (Cynoscion nebulosus, C. regalis, and C. nothus)

Three species of sea trouts, namely *Cynoscion nebulosus*, *C. regalis*, and *C. nothus* occur on the coast of North Carolina. The two species named first are very important food fishes, as shown in the subsequent pages, whereas the last-mentioned one is of little value. The adults may be distinguished as shown by the following key.

### KEY TO THE SPECIES

*a.* Soft dorsal and anal scaleless; gill rakers short, 8 on lower limb of first arch; body with round black spots ..... *nebulosus*

*aa.* Soft dorsal and anal covered with small scales; body without round black spots.

*b.* Anal fin usually with 12 soft rays, sometimes 11, infrequently 13; lower limb of first arch most frequently with 17 gill rakers, often with 16 or 18, infrequently with 15 or 19; caudal fin definitely emarginate in specimens 300 millimeters (12 inches) and more in length; upper parts of sides usually with dark greenish wavy oblique stripes or reticulations. *regalis*

*bb.* Anal fin usually with 9 soft rays, sometimes with 8 or 10; lower limb of first arch usually with 13 gill rakers, sometimes 12 or 14; caudal fin never definitely emarginate, the upper lobe in large specimens somewhat concave and the lower one rounded, pointed in fish under 200 millimeters (8 inches) in length; coloration generally plainer, seldom with dark wavy oblique lines or reticulations ..... *nothus*

The distinguishing characters of young *C. nebulosus* and *C. regalis* are pointed out in a separate paragraph following the descriptions of the different stages in the

development of *C. nebulosus*. Similarly, the distinguishing characters of *C. regalis* and *C. nothus* are shown in a paragraph following the descriptions of the various stages in the development of *C. nothus*.

### CYNOSCION NEBULOSUS (Cuvier and Valenciennes)

### SPOTTED TROUT; SPECKLED TROUT; SPOTTED WEAKFISH

The spotted trout ranges from New York to Texas and is commercially an important fish from Virginia southward to Texas. According to the statistical records [7] of this Bureau, the following catches were made by States: Virginia, 198,000 pounds; North Carolina, 694,309; South Carolina, 10,900; Georgia, 48,450; Florida, 2,790,566; Alabama, 105,981; Mississippi, 125,112; Louisiana, 387,101; and Texas, 1,043,353. This weakfish reaches a fairly large size. Individuals weighing 5 to 10 pounds are not unusual on the coast of North Carolina. The maximum weight attained, so far as known to the writers, is 16 pounds (Hildebrand and Schroeder, 1928, p. 298).

The spotted trout is a fish of superior flavor, and it always commands a good price. Its importance in North Carolina is greatly increased because it is caught in the shallow waters of the estuaries and sounds throughout the year. The catches made during the winter are of particularly great importance to the fishermen who depend on haul-net fishing. A catch of speckled trout during the winter, which is a very lean season with the haul-seine fishermen, often is a real "life saver." In fact, the speckled trout is of first importance to these fishermen in the vicinity of Beaufort. Even though the total annual catch is smaller than for the gray trout, the annual money value is greater, because of the higher price it commands in the market. Furthermore, much of the return, as already indicated, comes during the winter when it is badly needed.

Although the fish inhabit the shallow waters of the sounds and estuaries during the winter, they do at times become numb from the cold. For example, on January 7, 1926, fishermen are reported to have made good wages picking up numb and floating fish in North River. The weather had been rather unusually cold for a week or more, the air temperature having dropped to 12° F. on December 28. The water temperature at 4:30 p.m. at the laboratory pier, just off a moderately deep channel where the water undoubtedly was not as cold as in the shallow estuary of North River, was 55°, 57°, 53° F., respectively, on January 5, 6, and 7. Again on January 4, 1928, many numb floating speckled trout were seen in the vicinity of Beaufort. The senior author picked up several along the shores of Pivers Island, and commercial fishermen found it profitable to "gather" the fish. Perhaps many more fish were eaten by water fowl than were gathered by man. At least, the activities of the sea gulls were great around Pivers Island. January 4 was preceded by several days of exceptionally cold weather (for that vicinity), the air temperature reaching the low mark of 14° F. on January 2. The water temperature at 4:30 p.m. was 42°, 41°, and 39° F., respectively, on January 2, 3, and 4.

The numbed fish became quite active upon being taken into a heated room. It is thought, therefore, that they might have revived in nature with the return of warmer weather, if they had been left unmolested.

[7] Fisheries Industries of the United States, 1931. By R. H. Fiedler. Appendix II, Report, Commissioner of Fisheries, 1932 (1933), pp. 97–440.

Sometimes during cold weather the trout, although not numb enough to float, became quite helpless. The fish school more or less and if once found they are easily surrounded by a net. Fisherman often make large catches at such times.

According to Coker (in Smith, 1907, p. 313) speckled trout have not always been present in the shallow waters around Beaufort, N.C., during the winter. However, they have occurred there with a fair degree of regularity since 1914 when the senior author first began to make observations at Beaufort.

Pearson (1929, p. 190) reports that speckled trout in Texas mostly depart from the grassy areas during cold weather and seek the deeper holes and channels. At Beaufort the movement seems to be in the reverse direction.

It appears to be of interest to report a remarkable case of recovery from a very serious injury. This case is of special interest, as the speckled trout and other species of the genus Cynoscion in some localities are known as weakfish, presumably because they do not stand handling well and die quickly when caught. On June 27, 1927, a specimen of speckled trout that had had its tail severed from the body slightly behind the anal fin, was caught off Pivers Island. The wound had healed completely, and the stump of the tail, which was entirely without a fin, had become scaled over in part. The fish appeared to be healthy and in a well-fed condition.

The descriptions of the young fish, under 10 millimeters in length, that follow are based on specimens from Beaufort. In drawing up those of the larger fish, collections from the Gulf coast, made by Isaac Ginsburg and John C. Pearson, were used in addition to the specimens from Beaufort.

## SPAWNING

Ripe fish, or fish with well-developed gonads, were not seen during this study Yarrow (Smith, 1907, p. 312) observed females with large roe in April at Beaufort. J. H. Potter, a local fish dealer of long experience, reported to the senior author that he saw a ripe female, from which eggs were "running", on June 10, 1915, the first and only fish of the genus he had ever seen with "roe of any size." Pearson (1929, p. 180), working on the coast of Texas says, "The spawning season of the trout begins in early spring (not before March) and continues as late in the summer as October. The spotted trout * * * are found in all stages of development throughout the spring and summer and probably spawn for weeks. The height of the spawning season occurs in April and May, however."

The young apparently are not numerous at Beaufort. Only 47 specimens 80 millimeters and less in length were secured during several years of rather intensive collecting, and generally only one to several specimens were taken at a time. Only 17 individuals under 5 millimeters in length were secured, and of these 6 were taken during June of 4 different years, namely, 1927, 1928, 1931, and 1932, and the other 11 were caught in one haul on August 26, 1929. No specimen less than 10 millimeters in length was caught during July. The largest specimen of the 0-class taken in June is 11 millimeters long, the largest secured during July is 71 millimeters, and the largest one taken in August is 150 millimeters in length. The size range of the limited number of specimens taken at Beaufort, therefore, suggests that spawning probably begins there in May and extends into August.

Pearson (1929, p. 180) has stated: "The spotted trout spawns largely, if not entirely, within the bays and lagoons along the coast of Texas * * *." Twelve of the 17 specimens under 5 millimeters in length, caught at Beaufort, are from stations

5 and 6 miles offshore, 1 was taken in the bight at Cape Lookout, and the remaining 3 were caught in the estuary of Newport River. Such small, comparatively helpless, young almost certainly had not voluntarily traveled far. However, they may at times be carried comparatively long distances by wind and tide. It is impossible to determine the exact spawning ground or grounds from the limited material secured at Beaufort. It seems probable that spawning may take place both in the inside and outside waters. The general scarcity of the young suggests that there is no important spawning ground in the vicinity of Beaufort.

### DESCRIPTIONS OF THE YOUNG

*Specimens 1.8 millimeters long.*—The head and trunk are deep, and the caudal portion of the body is very slender, an abrupt break in the ventral contour of the body occuring at the vent. The vent in these small specimens is situated in advance of midbody length, the preanal distance being contained in the length to the tip of the notochord, 2.1 to 2.4 times, and the postanal distance 1.75 to 1.9. The greatest depth of the body is contained in the length about 3.1 times, and the depth behind the vent is scarcely greater than the diameter of the eye. The mouth is moderately

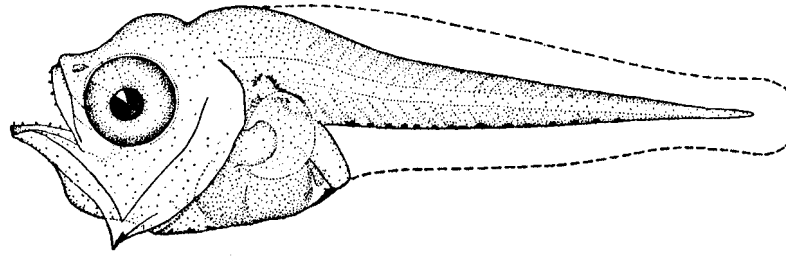

FIGURE 34.—*Cynoscion nebulosus*. From a specimen 2.0 millimeters long.

large and strongly oblique, the gape anteriorly being somewhat above the level of middle of eye, and it extends backward somewhat under the eye. The myomeres are indistinct anteriorly and posteriorly; about 25 may be counted. The vertical finfold is uninterrupted and is without indications of fin rays. The pectoral fin membranes are prominent, but the ventrals are not evident. Dark markings are present on the ventral outline of the chest and abdomen, with a prominent spot immediately in advance of the vent. A series of close-set black spots occupies the anterior half to two-thirds of the ventral outline of the tail. A few indefinite dark, probably subsurface, markings also are present above the abdominal mass (fig. 34).

The specimens described in the foregoing paragraph were taken in the same tow-net haul in which the somewhat larger ones, described in the next section were taken. The identification is somewhat uncertain because insufficient specimens are available and because of the darkened condition of some of the preserved ones, obliterating color markings. However, the larvae of nearly all the other local species of sciaenids are known. Therefore, the identification may be fairly definitely established through elimination.

The larvae of *C. nebulosus* at a length of 1.8 millimeters differ from those of *C. regalis* of the same length, so far as can be judged from the material available, in the rather deeper head and trunk, and apparently more slender tail, the decrease in depth at the vent being greater and more abrupt. The greatest depth of the body is contained in the total length to the tip of the notochord about 3.1 times in *C.*

*nebulosus*, whereas the greatest depth is contained about 4.0 to 4.5 times in the length in *C. regalis*. Another difference apparently exists in color, as the dark spots on the ventral outline of the tail are more prominent and in a much closer set series in *C. nebulosus* than in *C. regalis*.

*Specimens 2.5 millimeters long.*—The head and trunk are rather deep, and the caudal portion of body, although proportionately deeper than in specimens 1.8 millimeters long, remains moderately slender. The vent now is situated almost exactly at midbody length, and the greatest depth (measured somewhat behind the head) is contained about 2.6 times in the length to the tip of the notochord. The depth immediately behind the vent now is notably greater than the diameter of the eye. The mouth is large and strongly oblique, the gape anteriorly is only slightly below the level of the middle of eye, and the maxillary reaches nearly to the vertical from the posterior margin of the pupil. The myomeres are indistinct posteriorly, about 27 may be counted. The finfold remains continuous. However, a thickening of the tissues has taken place below the distal part of the notochord, and also farther forward, constituting respectively the primitive bases of the caudal and anal fins. The pectoral fin membranes are prominent, but the ventrals are not yet evident.

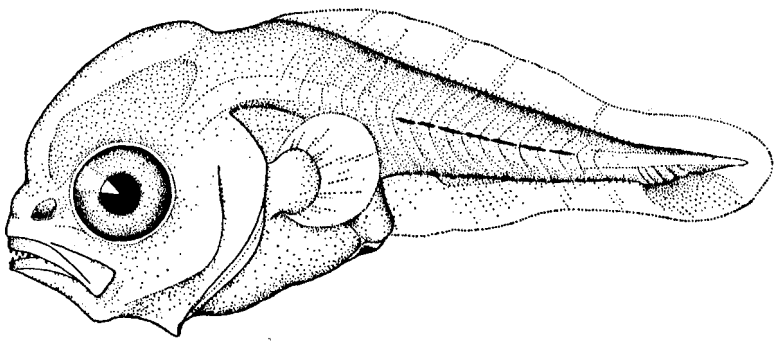

FIGURE 35.—*Cynoscion nebulosus*. From a specimen 2.5 millimeters long.

A black lateral stripe, consisting of nearly connected dashes, begins about at the vertical from the vent and extends nearly half the distance to the tip of the tail. The closely approximated dots, forming an almost continuous dark stripe along the ventral outline of the tail, although somewhat less distinct than in smaller specimens, remain present. Dark dots also remain evident on the ventral outline of the chest and abdomen (fig. 35).

The body proportions, according to the specimens at hand, are almost identical in *C. nebulosus* and *C. regalis* at this size. The chief diagnostic character is the dark lateral stripe, present in *C. nebulosus*, but wanting in *C. regalis*. The first-mentioned species, also, has more numerous and more closely approximated black spots of nearly uniform size, on the ventral outline of the tail. In *C. regalis* the spot at about midcaudal length already is somewhat larger than the others, a distinction that becomes more pronounced in somewhat larger specimens.

*Specimens 3.0 to 3.6 millimeters long.*—The body is quite elongate and compressed, the break in the ventral outline at the vent, abrupt in smaller specimens, no longer remains pronounced. The head and trunk now exceed the rest of the body in length, the preanal distance being contained in the length to the tip of the notochord 1.75 to 1.8 times, and the postanal distance 2.2 to 2.3 times, and the greatest depth is contained 3.4 to 3.6 times in the length. The large mouth remains strongly oblique,

the gape anteriorly being about at the level of the middle of the eye and the maxillary reaches to middle of pupil. The notochord is curved slightly upward distally, and rather definite rays (caudal fin) are present below the curved portion. The bases of the soft dorsal and the anal fins are rather definitely shown by the thickening of the tissues, though no rays are present. The pectoral fin membranes remain rather prominent as in smaller specimens, but no ventrals are evident. The black lateral stripe already present at a length of 2.5 millimeters, has become more prominent, and it extends from the shoulder nearly to the base of the primitive caudal fin, which (as already stated) is situated under the ventral side of the distal part of the notochord. The stripe is rather more continuous than in smaller specimens, but the dashes of which it is composed still are visible in some specimens. Furthermore, the line has slight vertical projections, making its edges somewhat ragged. The line extends forward faintly across the opercle and on the snout. Both the upper and lower lips are dusky. More or less black is present over the abdominal mass, which probably is subsurface. The dark markings along the ventral outline of the tail, distinct in the smallest specimens at hand, remain, and are nearly uniform in size. A few very small and indefinite dark points are evident on the ventral surface of the head and trunk (fig. 36).

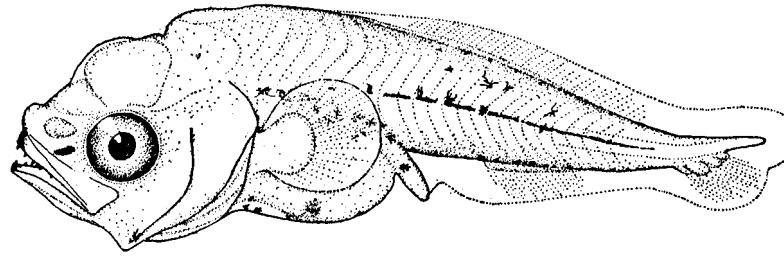

FIGURE 36.—*Cynoscion nebulosus*. From a specimen 3.2 millimeters long.

This species, at the length described, is distinguished from *C. regalis* principally by the black lateral line, which *C. regalis* does not possess. The first-mentioned species also has much more numerous black markings along the ventral outline of the tail, none of which are especially enlarged, whereas in *C. regalis* the spot lying at the posterior end of the base of the primitive anal is considerably larger than the others. *C. nebulosus*, at the size described, appears to be somewhat more slender, the greatest depth being contained 3.4 to 3.6 in length, compared with about 2.7 to 3.0 in *C. regalis*. Insufficient specimens are available, however, to determine definitely the relationship in this respect.

*Specimen 7 millimeters long.*—The body is quite elongate, compressed, and shapely for such a small fish. The dorsal profile anteriorly ascends rather gently and is moderately convex. The vent is situated much nearer the base of the caudal than the tip of the snout (preanal distance 1.6 times in standard length; postanal distance to base of caudal, 2.6 times), and the greatest depth is contained 3.3 times in the standard length. The snout is rather pointed and longer than the eye. The mouth is large, less strongly oblique than in smaller specimens; the gape anteriorly is almost on a level with the lower margin of the pupil; and the maxillary reaches about to the vertical from the posterior margin of the pupil. Although the caudal fin is well developed and apparently rather sharply rounded (the rays are broken in part and the exact shape cannot be determined), the upward curved tip of the notochord

remains visible. The anal and the soft dorsal are quite fully developed, but the spinous dorsal remains rudimentary. The anal consists of 11 soft rays, and the soft dorsal has 26 rays, formulae prevailing in adults. The pectoral fins, too, are developed, and have differentiated rays, but the ventrals are very rudimentary, that is, mere tufts of membrane less than half the length of the eye. A black lateral stripe persists, although rather less distinct than in smaller fish. A definite black band is present on the snout in advance of the eye, and indefinitely on the opercle behind the eye. Both lips are black. The black on the ventral outline, described in smaller specimens, now is confined almost wholly to the ventral surface of the caudal peduncle. Subsurface dark markings over the abdominal mass remain visible, although less distinct than in younger fish. Small dusky spots are scattered over the cranium, and a row of more or less definite black spots is present on the back and extends along the base of the dorsal fins (fig. 37).[8]

Only one specimen of the size described is at hand. This species is more slender and more shapely than *C. regalis* at this size (depth in standard length 3.3 times in the former and 2.8 in the latter), and the snout is more pointed. *C. regalis* is much

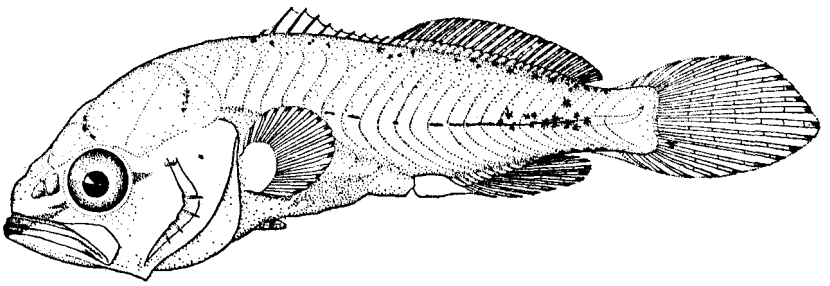

FIGURE 37.—*Cynoscion nebulosus*. From a specimen 7 millimeters long.

plainer in color, as it has no lateral stripe and no black markings on the head or back, and only a few on the ventral outline. The enlarged black spot near the middle of the base of the anal is quite distinctive, as no such spot is present in *C. nebulosus*. The enlarged spot on the anal base in *C. regalis* is present at a length of about 3.5 millimeters, and it serves as a mark of distinction in specimens ranging from that length to 7 millimeters and upward.

*Specimens 10 to 12 millimeters long.*—The fish is moderately slender, compressed, and shapely. The head is rather low, and pointed, its length is contained 2.7 to 2.85 times in the standard length, and the greatest depth 3.8 to 4.2 times. The snout is rather long, its length to tip of upper jaw being contained 3.5 times in the head, and the eye 4.2 to 4.4 times. The mouth is large, moderately oblique; the lower jaw projects rather prominently; the gape anteriorly is about on a level with the lower margin of the pupil; and the maxillary reaches slightly past middle of eye, its length being contained 2.25 to 2.9 times in the head. Small spines are present on the margins of the preopercle and interopercle. Two stained and cleared specimens have respectively 25 and 26 vertebrae. The fins are all developed, but the spinous dorsal remains quite low, the longest spines being shorter than the eye, and the ventrals, although having rays, also remain short, being equal to or scarcely longer than the eye. The

[8] The figure by Pearson (1929, p. 179, fig. 24) based on a specimen 7.8 millimeters long, presumably taken on the coast of Texas shows the body as being much more compressed and less shapely than in the Beaufort fish. Furthermore, the mouth is shown as less strongly oblique and the caudal fin as much more broadly rounded. Marked differences in color, also, are evident. If the figure is correct, much variation must exist among specimens. The figure certainly does not agree as to the shape of the body with a faded specimen from Texas examined by us.

caudal fin is moderately long and somewhat pointed, the longest rays being in the lower half of fin and much shorter than the head. Pigmentation has advanced little since a length of 7 millimeters was attained. A few additional dusky markings have appeared along the black lateral stripe, and the dusky markings on the head and back have increased somewhat in number and intensity (fig. 38).[9]

This species remains notably more slender than *C. regalis*, and the head is lower, and the snout more pointed (the depth in the former is contained 3.8 to 4.2 in the length and in the latter 2.95 to 3.0 times). The caudal fin is less sharply pointed and the rays are shorter than in *C. regalis*. The differences in color remain about as in 7-millimeter specimens. Although *C. regalis* now has a few dusky spots on the side and the back, they are not arranged in definite series. The characteristic dusky spot near the middle of the base of the anal remains in that species, and in some specimens a smaller one precedes it and another one follows it. No black spots occur on the base of the anal in *C. nebulosus*.

*Specimens 16 to 20 millimeters long.*—The body is quite slender and moderately compressed, the shape being close to that of the adult. The head is long and low, its length being contained 2.7 to 3.0 times in the standard length, and the greatest depth of the body 3.9 to 4.15 times. The snout is rather long and pointed, its length is contained 3.5 times in the head, and the eye 4.0 to 5.0 times. The mouth has ac-

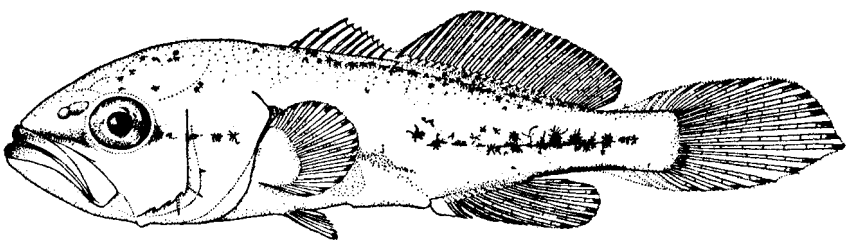

FIGURE 38.—*Cynoscion nebulosus*. From a specimen 11 millimeters long.

quired virtually the shape and position it has in adult fish. It is somewhat oblique, the gape anteriorly is scarcely above the lower margin of the pupil, and the maxillary reaches nearly opposite the posterior margin of the eye, its length being contained 2.2 to 2.8 times in the head. Scales are evident on the middle of the side from the shoulder nearly to the base of the caudal at a length of 16 millimeters; at a length of 20 millimeters the body is almost fully scaled. The spinous dorsal has increased greatly in height since a length of 12 millimeters was attained, and the longest spines are as long as the snout, therefore, proportionately about as long as in the adult. The caudal fin remains somewhat pointed and the longest rays are about as long as the head without the snout. The ventral fins have increased greatly in length since the fish attained a length of 12 millimeters, and now are fully twice as long as the eye. When the fish reach a length of about 16 millimeters the black lateral line, present in smaller fish, disappears or becomes laid over gradually by an indefinitely outlined dark band composed of numerous minute brownish or dark markings which extend forward on the side of the head and snout (quite indefinite on the head in some specimens), and backward on about the basal half of the caudal fin. Dark dots on the head and back have become much more numerous and those on the back form more

[9] The criticisms pertaining to Pearson's figure 24 (1928, p. 179), set forth in footnote 8, in general apply to his figure 25, with the addition that the origin of the spinous dorsal, which is shown as having its origin over the pre-opercular margin, actually has its origin slightly behind the vertical from the base of the pectoral, according to specimens from North Carolina as well as from Texas, which the writers were able to examine.

or less definite longitudinal bands than in smaller specimens. At a length of about 19 millimeters dark dots sometimes develop on the spinous dorsal (fig. 39).

This species continues to differ notably from *C. regalis* in the much more slender body (depth in standard length 3.9 to 4.15 times in *C. nebulosus*, 3.3 to 3.4 times in *C. regalis*), much lower head and more pointed snout, and in the much more prominently projecting lower jaw. The species also differ notably in color, as *C. nebulosus* is marked chiefly by dark longitudinal bands, whereas *C. regalis* has no longitudinal bands, but is marked anteriorly with indefinite broad dusky crossbars on the back, and posteriorly with lateral quadrate blotches. It is obvious that *C. nebulosus* acquires the shape and form of the adult at a smaller size than *C. regalis*.

*Specimens 25 to 30 millimeters long.*—No change of importance has taken place in the proportions of the body since a length of 16 to 20 millimeters was attained. The head is contained 2.7 to 2.9 times in the standard length and the depth 3.95 to 4.2 times.[10] The eye is small, being contained 4.25 to 5.0 in the head, the snout 3.25 to 4.5, and the maxillary 2.25 to 2.4 times. Gill rakers are well developed, 8 on lower limb of first arch. The body is fully scaled, and a sheath of scales is evident along

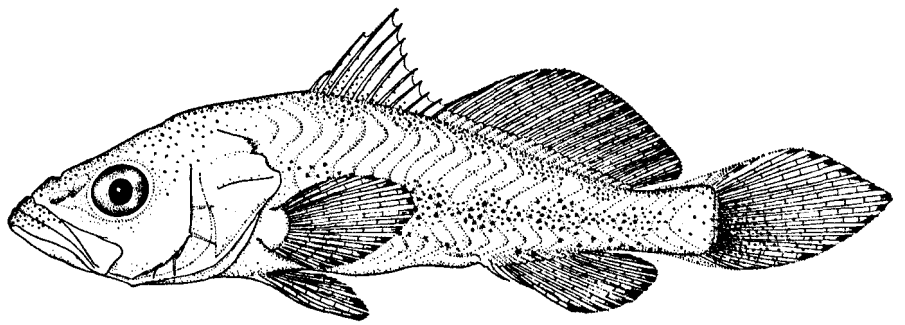

FIGURE 39.—*Cynoscion nebulosus*. From a specimen 20 millimeters long.

the bases of the dorsal and anal. The dorsal fins are moderately high, the longest rays and the longest spine being nearly equal in length and each is contained in the head about 2.5 to 2.8 times. The shape of the caudal remains unchanged, and the longest rays are about as long as the head. The ventral and pectoral fins are virtually equal in length and are contained 2.15 to 2.4 times in the head. A definite dark brownish band, with broken edges, extends from the snout along the side and on the caudal fin. The band is broken from the eye to the opercular margin where it forms more or less disconnected blotches. At the base of the caudal it is crossed by a pale line, and on the base of that fin it is darker and becomes somewhat pointed posteriorly. It is not definitely outlined, however, as most of the fin bears dark dots. The upper surface of the head is mostly brownish, and this color extends on the back as two indefinite bands, one on each side of the base of the dorsal fins. Posterior to the spinous dorsal the bands are more or less broken up into blotches. In some specimens the bands are more nearly continuous than in others. A few dark dots are present on the dorsal fins, being most numerous on the anterior margin of the spinous dorsal. Indications of scattered dark points also are present on the anal, but the pectorals and ventrals remain unmarked (fig. 40).

[10] Attention is called to figure 15 in Welsh and Breder (1923, p. 167) which is based on a specimen 28 millimeters long. This illustration appears to have been drawn from an abnormally deep fish. At least the body is shown as much deeper than in any of the specimens now at hand. Furthermore, the lower jaw projects too prominently, and the caudal fin has the longest rays in the lower half of the fin, and not in the middle as shown in the figure.

*C. nebulosus* remains more slender than *C. regalis* (depth in standard length of the former 3.95 to 4.2 and the latter 3.3 to 3.5), the head is lower and more pointed, and the mouth is less strongly oblique (the gape in *C. nebulosus* being wholly below the eye, whereas in *C. regalis* it is only a little below the middle of the eye anteriorly). The caudal fin is rather short and only moderately pointed in *C. nebulosus*, the longest rays being about as long as the head, whereas in *C. regalis* the fin is long, sharply pointed, the longest rays being notably longer than the head. The differences in color remain about as indicated for specimens 16 to 20 millimeters long.

*Specimens 35 millimeters and upward in length.*—The larger young of this species have been described adequately by Welsh and Breder (1923, pp. 164 to 169) and the descriptions by these authors were augmented with remarks on smaller fish by Pearson (1929, pp. 178 and 179). It does not appear essential, therefore, to draw up further descriptions. However, it does seem desirable, in the light of the study of large series of specimens, to include a discussion of the relationship of this species and *C. regalis*, as development proceeds.

The species are most readily separated by color, as the patterns are very different. However, evident structural differences also are present. In *C. nebulosus* the dark

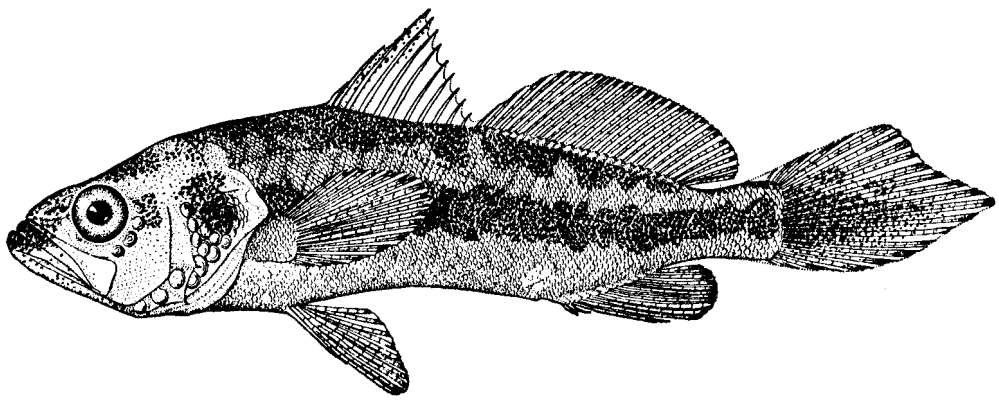

FIGURE 40.—*Cynoscion nebulosus*. From a specimen 27 millimeters long.

longitudinal bands, present in smaller specimens, begin to break up into spots when the fish are about 30 millimeters long. At a length of 35 to 40 millimeters, the band on the back is divided into more or less definite quadrate blotches, but the lateral band remains almost continuous. When the fish reach a length of about 60 to 70 millimeters the lateral band also becomes divided into spots, and the caudal fin, which previously was almost solidly black at the base, has become spotted. At about the same size spots develop between the bands, and at a length of 70 to 80 millimeters the entire upper half of the side bears indefinitely outlined spots, which are irregular in shape and variable in size. The spots (in preserved specimens) are rather more brownish in color than in younger fish. At a length of 110 to 120 millimeters, the characteristic small, roundish black spots of the adult, which occupy the upper two-thirds of the sides as well as the dorsal and caudal fins, are quite fully developed.

Specimens of *C. regalis*, 35 to 40 millimeters long, on the other hand, have broad dark crossbands on the upper part of the side, which extend to or somewhat below the lateral line. These bars disappear when the fish reach a length of about 70 to 80 millimeters. Specimens ranging from about 80 to 100 millimeters in length are almost plain grayish above and silvery below. The characteristic dark wavy lines

or reticulations of the adult begin to appear when the fish reach a length of about 100 millimeters, and at a length of about 120 to 130 millimeters the fish have acquired almost fully the color pattern of the adult.

*C. nebulosus* is more slender and more shapely than *C. regalis* throughout the younger stages. However, at a length of about 175 millimeters the differences in the shape of the body virtually have disappeared. It is evident from table 3 that *C. nebulosus* acquires the proportionate depth of the adult very early, that is, at a length of about 10 to 12 millimeters, whereas *C. regalis* is much deeper throughout the younger stages and does not have the proportionate depth of the adult until a length of about 175 millimeters is attained.

The shape of the caudal fin differs quite notably in the two species throughout the younger stages, that is, from a length of about 20 to 125 millimeters. During this entire period of development this fin, although pointed in both species, is notably longer in *C. regalis* than in *C. nebulosus*, the longest rays in the former being the middle ones, which are more or less filamentous in the younger stages, and equal to or longer than the head, whereas the longest rays in the latter are in the lower half of the fin and are not longer than the head. For some time during the course of development the upper lobe of the caudal fin in both species is slightly concave and the lower lobe more or less roundish. Although the fin must undergo a greater change in *C. regalis* to acquire the broadly concave outline which obtains in adults of both species, it is acquired somewhat earlier, that is, at a length of about 250 to 280 millimeters (there being much variation in the development among specimens), whereas this shape is not acquired by *C. nebulosus* until the fish is about 300 millimeters long.

The two species differ also in the number of gill rakers, *C. regalis* having 11 or 12 on the lower limb of the first arch, whereas *C. nebulosus* has only 7 or 8. The gill rakers are developed and can be counted readily when a length of about 26 millimeters is attained.

The species differ, furthermore, in that *C. nebulosus* has no scales on the fins throughout life, whereas *C. regalis* has minute scales on about the basal half of the soft dorsal, the caudal and the anal fins. The scales first appear when the fish are about 45 to 55 millimeters long.

TABLE 3.—*Proportionate depths of specimens of various size of Cynoscion nebulosus and C. regalis*

| Total length in millimeters | C. nebulosus | | C. regalis | | Total length in millimeters | C. nebulosus | | C. regalis | |
|---|---|---|---|---|---|---|---|---|---|
| | Depth in standard length | Number of specimens measured | Depth in standard length | Number of specimens measured | | Depth in standard length | Number of specimens measured | Depth in standard length | Number of specimens measured |
| 7 | | | 2.8 | 1 | | | | | |
| 10–12 | 3.3 | 1 | 2.95–3.0 | 3 | 70–90 | 3.7–4.0 | 7 | 3.4–3.6 | 7 |
| 16–20 | 3.8 –4.2 | 3 | 3.3 –3.4 | 3 | 120–130 | 3.8–4.1 | 5 | 3.5–3.6 | 5 |
| 25–30 | 3.9 –4.15 | 3 | 3.3 –3.5 | 6 | 150–175 | 3.9–4.25 | 4 | 3.5–4.1 | 4 |
| 40–50 | 3.95–4.2 | 6 | 3.3 –3.4 | 6 | 210–240 | 4.1–4.3 | 6 | 4.1–4.4 | 6 |
| | 4.0 –4.25 | 6 | | | | | | | |

## DISTRIBUTION OF THE YOUNG

It has been stated elsewhere (p. 93) that the young under 5 millimeters in length, in the collection mostly were taken at off-shore stations. The larger ones of the same year class, ranging from 5 millimeters upward, however, were all caught in inside waters. The indications are, therefore, that the young, if actually hatched in part off shore, enter the inside waters soon afterward.

Only a few of the smaller larvae at hand were caught in surface towings, and all the larger ones were taken in bottom hauls. Therefore, the indications are that the young of this species are chiefly bottom dwelling.

### GROWTH

The number of young of the 0-class, consisting of only 126 specimens taken and measured, is entirely too small to cast much light on the rate of growth. However, the measurements parallel those of *C. regalis* rather closely, and indicate that the fish grow rapidly during the first summer of life, attaining a modal length of about 170 millimeters (6¾ inches) when 7 or 8 months old. The size at which sexual maturity is reached remains unknown.

### CYNOSCION REGALIS (Bloch and Schneider) GRAY TROUT; GRAY WEAKFISH

The gray trout ranges from Massachusetts to the east coast of Florida[11]. It is a commercially important species from Rhode Island to Florida. The States having the largest catches are New Jersey, with an average annual catch from 1928 to 1930 inclusive of 9,160,346 pounds;[12] Virginia, 12,710,389 pounds; and North Carolina, 4,415,059 pounds. This trout is reported to reach a maximum weight of 30 pounds. In Chesapeake Bay fish weighing 10 pounds are not particularly uncommon. However, at Beaufort fish weighing 6 pounds are considered large ones and 9-pound fish are exceptional.

The gray trout is a well-flavored fish and always commands a good price. This species and the spotted trout constitute the chief support of the haul-seine fishermen who generally go in pairs and fish the shallower inside waters in the vicinity of Beaufort. Their equipment consists of a small motor boat, which generally has a small cabin forward over the engine, a rowboat, and a 300 yard straight dragnet. Frequently two crews "pair", that is, they unite their gear and power by lashing their nets together and making long drags, using the power of their motor boats.

The gray trout is taken commercially at Beaufort from about March to December, the length of the fishing season varying according to the annual fluctuation in the mildness, or severity, and duration of winter weather, for the large fish leave when cold weather comes and return as early in the spring as the temperature of the water again becomes agreeable. The large fish evidently are more sensitive to temperature than the smaller ones. Whereas, the larger ones leave the shallow waters, as already stated, upon the approach of cold weather, the smaller individuals remain there, except during the brief cold snaps that occur locally. Small gray trout were taken many times during the winter in Newport River, for example, during the several years of the present investigation. They were common also off Bogue and Shackleford Banks in a few to several fathoms of water. However, they presumably withdraw to deeper and warmer water during cold snaps, but return within a few days after the temperature rises. Therefore they may make several migrations during one winter. The large fish, on the other hand, make only one migration

[11] In a study of the sea trouts of the Gulf coast, Ginsburg (1929, p. 83) found that the fish from that coast, formerly considered identical with the gray trout of the Atlantic coast, is a distinct species, which he named *C. arenarius*. Therefore, the range of the gray trout, previously thought to extend to Texas, is now restricted to the Atlantic coast.

[12] The statistics offered are taken from "Fisheries Industries of the United States", for the years 1929, 1930, and 1931. The "average annual catch" is the arithmetical average for the 3 years, 1928, 1929, and 1930. The gray trout and the spotted trout are listed separately only for 1930. The spotted trout is unimportant, from a statistical standpoint, in all the States named, exclusive of North Carolina in which this species constituted 22.7 percent of the catch in 1930. However, to make the figures comparable the entire catch of trout is considered for each State.

as already indicated, leaving the shallow waters in the autumn or early in the winter and returning early in the spring when low temperatures are not likely to recur.

Although the smaller gray trout generally migrate away from the shallow waters during cold snaps, they apparently do not always go early enough, for on January 14, 1927, quite a few dead and numb fish were seen along the shores of Pivers Island. A sample of 6 fish was gathered having a range in length of 122 to 182 millimeters. Several days of rather unusually cold weather preceded January 14. The water temperature at the laboratory pier, taken daily at 4:30 p.m., dropped to 41° F. on January 9, and it remained there until January 14 when it came up to 48° F. A temperature of about 41° F., therefore, probably is close to lethal.

### SPAWNING

The spawning season of the gray trout is a moderately long one. Fish with well-developed roe (although not ripe) were observed as early as April 16 (1914), and as late as August 17 (1914). The young were taken first on May 25 (1932). However, they are rather large ones, ranging from 6.5 to 9 millimeters in length, and therefore may have been a few weeks old when caught. Larvae under 5 millimeters in length were caught during June, July, and as late as August 27 (1930). According to these data the spawning season at Beaufort begins in May and extends through June, July, and August.

The conclusion relative to the spawning period at Beaufort is in general agreement with statements by Welsh and Breder (1923, pp. 150–158), who say that the season is a protracted one, commencing in May and continuing until September. The great majority of the fish are reported, however, to spawn between the middle of May and the middle of June. These authors state, furthermore, that the spawning season is little affected by the latitude and that it occurs at about the same time from Cape Cod to the Carolinas. Higgins and Pearson (1927, p. 57) found virtually all mature females taken in pound nets in Pamlico Sound, N.C., in a spawning condition in the second week of June (1925) when they began their investigation, and by August 10 spawning had been completed.

It was noticed at Beaufort that the large fish develop roe earlier than the smaller ones. Among thousands of fish examined only large ones had gonads in an advanced state of development in April, whereas in August those fish that still contained roe were small ones, generally 15 inches and somewhat less in length.

In the vicinity of Beaufort spawning apparently takes place principally, if not wholly, at sea. This conclusion is arrived at from a study of the movements of adult fish and from a study of the distribution of the young. It has been stated elsewhere that the large fish return to the inside waters early in the spring from as yet a relatively unknown winter home. For a time these fish are quite abundant. However, within a month or two after their arrival, or about the latter part of May, the large fish become scarce and remain so until about July when they again increase in abundance. During two seasons (1914 and 1915) of almost ceaseless effort no females quite ripe were found among thousands of fish examined. Virtually all contained roe early in the spring. Later, when the large fish returned after a period of absence they had spawned. The explanation appears to be that the fish go out to sea to spawn and return to the estuaries and sounds when the process is completed.

The foregoing explanation of the scarcity of large fish in the inside waters during a period, which undoubtedly is the height of the spawning season, is substantiated in

a measure by the distribution of the young 10 millimeters and less in length, as shown by the collections. Young 5 millimeters and less in length were taken quite sparingly, as only 25 were secured, including 17 taken outside. The young ranging upward of 5 millimeters in length were taken much more abundantly. The collection contains 270 specimens 6 to 10 millimeters long, including 253 individuals taken off Bogue and Shackleford Banks and only 17 from Beaufort Harbor and adjacent waters. In explanation it may be stated that the foregoing results were secured, notwithstanding that many more hauls, using identical gear, were made in the inside than in the outside waters. It seems to be evident, therefore, that the young, 10 millimeters and less in length, are much more numerous off Bogue and Shackleford Banks than within the harbor and adjacent sounds and estuaries.

The bulk of the young undoubtedly remain in the general vicinity where they are hatched until the power to swim is developed. Occasionally the floating eggs and the helpless larvae no doubt are carried considerable distances by the wind and tide. It is possible that the comparatively few larvae taken in the inside waters were carried there involuntarily. The fins are entirely undeveloped until a length of about 6 millimeters is attained, and imperfectly until a length of at least 10 millimeters is reached. Prior to the rather full development of the fins the young fish probably cannot swim far, nor in a definite direction. Therefore, the majority of the young 10 millimeters and less in length would be expected to be found chiefly near the spawning ground.

The conclusion that in the vicinity of Beaufort spawning takes place principally, if not wholly, at sea, therefore, seems to be justified from the information given relative to the movements of the adults during the spawning season, and from the data presented concerning the distribution of the young.

## DESCRIPTIONS OF THE EGGS AND YOUNG

The reader is referred to Welsh and Breder (1923, pp. 150–153) for descriptions of the eggs and their development, as well as for accounts of the newly hatched young. Descriptive notes and illustration of the development of the young are offered by Pearson.[13] They have been compared with specimens of similar sizes in our collection and found to be essentially correct. Accordingly, descriptions and illustrations are omitted in this paper. However, the diagnostic characters are shown in the accompanying keys.

Some remarks relative to the eggs of the gray trout seems to be in order, because of the extremely great variation in their diameter shown by Welsh and Breder and also by Pearson. It is believed that the eggs were taken numerous times off Beaufort Inlet, but were confused with those of the white perch, *Bairdiella chrysura*. However, near the close of the investigation it was noticed that the larger eggs, identified as perch eggs, had more numerous pigment spots on the yolk and these were particularly prominent on the embryo. It was noticed, also, that the newly hatched fish not only were larger as would be expected, but contained more pigment spots than those hatched from the smaller eggs. Furthermore, the larvae hatched from the larger eggs have two bars composed of dots slightly greenish in color in life on the caudal portion of the body; one of the bars being at about midcaudal length, and the other one, which is rather less distinct, about midway between the vent and the bar already described. The larvae hatched from the smaller eggs, on the other hand, have only one bar which is situated at about midcaudal length.

[13] Unpublished manuscript in the files of the Bureau of Fisheries.

The numerous dots on the egg and embryo are in general agreement with the illustrations given by Welsh and Breder (1923, p. 152) of the eggs of *C. regalis*, and the illustrations of the recently hatched young presented on page 155 of the work already cited contain suggestions of two crossbars on the caudal portions of the body, though less distinct than in the specimens observed by us.

Insufficient eggs of the larger type were secured, after the differences in pigmentation were noticed, to obtain a sufficiently large series of measurements to show the exact relationship in size. A sample of 205 eggs was taken at random from a towing made on June 3, 1930. Among this lot 25 eggs of the type described were found. These eggs ranged in diameter from 0.8 to 0.92 millimeter and the average was 0.84 millimeter. The smaller eggs, namely, those of the white perch, *Bairdiella chrysura*, had a range in diameter of 0.66 to 0.76 millimeter and an average of 0.69 millimeter. The last-mentioned proportions quite certainly are correct for Bairdiella, as the range of 97 eggs, spawned in the aquarium on 2 different dates, ranged in diameter from 0.66 to 0.72 millimeter and averaged 0.68 millimeter. Although the number of the larger eggs measured is quite limited, enough of the smaller ones were measured to show that two distinct groups were present.[14]

Kuntz (1914, pp. 4–10) states that the diameter of the eggs of Bairdiella ranges from 0.7 to 0.8 millimeter, thereby indicating that he may have measured eggs of two species. However, his description and illustrations of the development appear to be correct for Bairdiella.

Welsh and Breder (1923, p. 151, table 3) give measurements of eggs taken from 2 specimens of *C. regalis*, which show, as already stated, a comparatively large difference in the size of the eggs produced by the 2 examples. One of the fish had eggs ranging in diameter, according to 8 eggs measured, of 0.98 to 1.03 millimeters and, therefore, all larger than any measured at Beaufort. The other one had eggs ranging in diameter, according to 10 eggs measured, from 0.8 to 0.84 millimeter and, therefore, near the size of the eggs taken at Beaufort.

Pearson (MS.) working with specimens collected at the entrance of Chesapeake Bay, found even a larger range among eggs which he believed to be those of *C. regalis*. He remarks, however, that the eggs fall into two groups as to size. One of the groups ranged in diameter from 0.7 to 0.9 millimeter, with a mode at 0.83 millimeter, and the other one had a range in diameter of 0.9 to 1.13 millimeters, with a mode at 1.0 millimeter. Therefore, the range of the two groups of eggs combined is greater even than that given by Welsh and Breder (loc. cit.), as it extends from 0.7 to 1.13 millimeters.

The time during which Pearson took the eggs of both groups (the larger ones from April 24 to May 23 and the smaller ones from May 6 to July 24) quite probably covers nearly the entire spawning period of *C. regalis*. However, the pigfish, *Orthopristis chrysopterus*, and the perch, *Bairdiella chrysura*, too, spawn during this period, and their eggs fall into the range of the eggs measured, and are extremely similar in appearance. It has been stated already that the eggs of Bairdiella measured at Beaufort ranged in diameter from 0.66 to 0.76 millimeter and that they are similar in appearance during the cleavage stages to somewhat larger eggs believed to be the eggs of the gray trout. The eggs of the pigfish, according to Hildebrand and Cable (1930, p. 399), range in diameter from 0.7 to 0.8 millimeter, and therefore are more or

[14] The oil globule, too, was measured in each egg. There is definite overlapping and only an average difference appears to exist, the average in 100 perch eggs being 0.18 millimeter and in 25 trout eggs 0.2 millimeter.

less intermediate in size of the perch and the trout, but overlap somewhat with both species.

At Beaufort the eggs of the three species named often were taken in the same towing, assuming of course that the largest ones were trout eggs. The pigfish eggs, like those of the gray trout, are very similar to the perch eggs and are scarcely distinguishable (although their average size is larger), until the embryos become well developed. In the advanced embryonic stages the oil globule in the perch egg acquires greenish specks, whereas the oil globule generally remains clear in the pigfish, or at most it acquires only a few minute specks. Furthermore, the position of the oil globule in relation to the embryo is characteristic. In the perch (also the trout) it lies far behind the head, whereas in the pigfish it lies at or near the ventral surface of the head. The newly hatched fish, too, may be distinguished by the location of the oil globule within the yolk sac, as it retains the approximate position it has in the embryo, that is, it lies in the posterior part of the yolk sac in the perch (and trout), and in the anterior part of the yolk sac or under the head in the pigfish.

Pearson's (MS.) measurements, in the absence of descriptions of color marking and statements in regard to the position of the oil globule with respect to the embryo, suggest that he may have grouped the eggs of the pigfish, the white perch (also known as the yellow-tail perch), as well as those of the gray trout, all under *C. regalis*. All three species no doubt spawn in Chesapeake Bay or off the month of the bay during the period in which the eggs were taken by Pearson, as Hildebrand and Schroeder (1928, pp. 258 and 280) took spawning pigfish during June, and ripe perch during May in Chesapeake Bay, and Radcliffe (in Welsh and Breder, 1923, p. 151) took trout eggs there during the spring. Since Pearson does not list the eggs of the pigfish and the perch (both very common species in Chesapeake Bay), although they most probably were present among the trout eggs, lends support to the supposition that they may not have been distinguished.

Too much faith apparently should not be placed in the measurements of eggs, unless it is known definitely that the eggs were spawned in water of about even density. If preserved eggs are measured, it would seem necessary to use one preservative of uniform strength. Delsman (1931, p. 403) has shown that a comparatively large difference in size exists in the eggs of one species (*Cybium guttatum*), depending upon the density of the water in which they are taken. Eggs collected in the mouths of rivers where the water was brackish were larger, varying in diameter from 1.24 to 1.36 millimeters, than those taken in salt water, which had a range in diameter of 1.05 to 1.26 millimeters. Delsman concludes:

> So we easily came to the conclusion that the size of the egg depends on the salinity of the water, increasing or decreasing in proportion to the latter getting lower or higher. The same phenomenon has been observed in other pelagic eggs, the eggs of the Baltic Sea fishes, e.g., being bigger than the corresponding eggs of the North Sea.

Kuntz (1914, pp. 4–10), presumably Welsh and Breder (1923, p. 151), and the present writers measured live eggs, whereas Pearson measured preserved eggs. The present investigators are not aware of data that show how the eggs are affected by the commonly used preservatives. Pearson apparently assumes that some shrinkage takes place and, therefore, left the eggs "in preservative at least 6 months in order to obtain nearly the minimum shrinkage." However, he does not name the preservative, nor the strength at which it was used. The measurements made by Pearson and the other investigators, therefore, may not be directly comparable, although in general they are in agreement, as already stated.

The measurements made by us, which are shown in preceding pages, were all made in the laboratory with an eyepiece micrometer and are based on eggs taken at sea (exclusive of some perch eggs spawned in a tank, as stated in the text) and brought to the laboratory alive in water dipped up where the towings were made. The water used in the tank in which some of the perch eggs were spawned was pumped from underneath the laboratory pier at high tide when the salinometer readings generally average about 1.025, as compared with 1.03 off Beaufort Inlet. Therefore, all the measurements made at Beaufort are based on eggs spawned in salt water of rather high density.

It has been shown that the eggs of two examples of gray trout measured by Welsh and Breder (1923, p. 151) differed markedly in size. The writers assume that some fish simply have larger eggs than others, and do not state whether the eggs of both fish were spawned in water of about even density. According to our measurements, the eggs of any one species, when spawned in strictly salt water, are quite uniform in size. Our experience, and the information gained by Delsman (1931, p. 403) and others, relative to the difference in the size of the eggs of one species according to the density of the water in which the eggs are spawned, suggest that Welsh and Breder may have used water of very unequal density in which the eggs of the two samples of trout mentioned presumably were artificially spawned. Certainly we must consider the large variation in the diameter of the trout eggs given by the writers mentioned as unusual. In fact such a wide variation, under identical conditions, would suggest the presence of two races.

## DISTRIBUTION OF THE YOUNG

It has been stated in the section of this paper dealing with the spawning (p. 104) of this species that the young, 10 millimeters and less in length, are much more numerous off Beaufort Inlet than in the harbor and adjacent sounds and estuaries. Somewhat larger fish, too, appear to be rather more numerous in the outside than the inside waters, although they tend to congregate and become abundant in certain restricted areas in the estuaries. For example, the young ranging from about 15 to 100 millimeters in length are very numerous above "cross rock" in Newport River during the summer or after the middle of June. The water is only a foot or two deep above cross rock at low tide and the bottom is very muddy. The water generally is brackish, but the density fluctuates greatly, depending upon the stage of the tide and the rainfall, as this mud flat is only a short distance from the mouth of the narrow channel of Newport River where this stream discharges fresh water into its estuary.

Pearson (MS.), too, found that young gray trout when about 8 to 10 millimeters long "settle on the bottom" in Chesapeake Bay in coves and creeks at Lynnhaven Roads and elsewhere.

Soft or muddy bottom seems to be preferred by the young during the first summer. Those that remain in the ocean, as well as those that enter the harbor, seem to seek muddy bottom. For that reason, presumably, the young are numerous in the vicinity of the sea buoy off Beaufort Inlet where the bottom is soft. It is presumed that the young fish find food abundant on the mud. However, the food requirements of the young under about 40 millimeters in length have not been studied. Larger ones, according to Welsh and Breder (1923, pp. 159–164), feed on a variety of forms, including copepods, amphipods, isopods, shrimps, crabs, worms, and fish.

The number of larvae, 5 millimeters and less in length, in the collection is too small to show the vertical distribution. Since the eggs are pelagic, the larvae would be expected to remain at or near the surface, at least, until the yolk is absorbed. The yolk sac contains an oil globule which persists until virtually all the yolk is absorbed (Welsh and Breder, 1923, p. 153, fig. 10). The oil globule almost certainly would keep the newly hatched fish at or near the surface. However, the indications are that the young fish in part, at least, go to the bottom very early, as the 25 specimens at hand having a range in length of 1.5 [15] to 5.0 millimeters were all taken in bottom hauls. The larger ones undoubtedly stay principally on the bottom, as all except 2 of a total catch of 270 specimens, 6 to 10 millimeters long, were caught in bottom hauls.

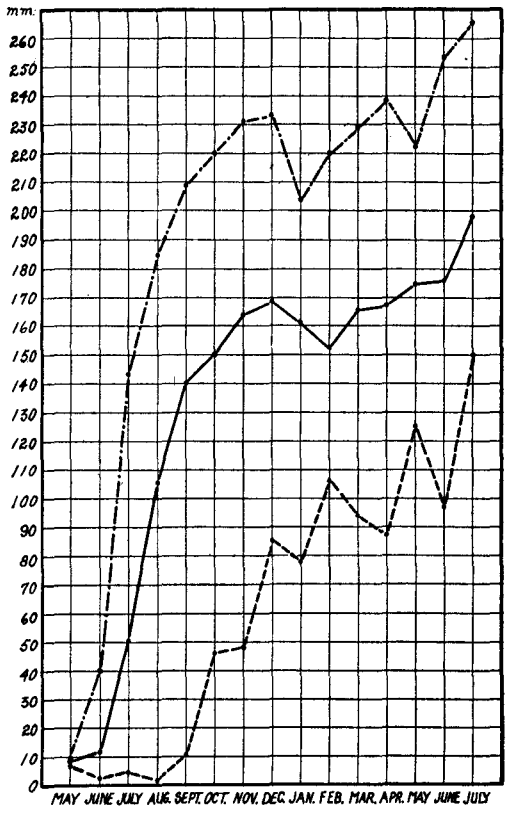


FIGURE 41.—Growth of *Cynoscion regalis* during first year or so of life. Solid line, average size; dot and dash line, maximum size; broken line, minimum size. (Graph based on table 5.)

It is stated elsewhere (p. 102) that the large fish leave the shallow waters during cold weather, whereas the smaller ones are more apt to remain. The young of the 0-class were taken throughout the winter. It seems significant, however, that the larger individuals are missing during the coldest months (see table 5), indicating that the largest young of the year probably follow the adults to a more agreeable habitat.

## GROWTH

The study of the rate of growth was limited chiefly to the 0-class. The tables and graph presented herewith show quite conclusively that the rate of growth is very rapid during the first summer. The distinction between the 0-class and the 1-class is not very distinct after July, as some overlapping takes place, and it is probable that a few specimens may have been wrongly assigned in table 5. However, the specimens improperly placed are so few that the averages cannot be affected importantly, and therefore may be accepted as approximately correct.

The largest individuals of the 0-class, as shown by the accompanying tables and graph, already had attained a length of 215 to 220 millimeters (8½ to 8¾ inches) in October, and the average length of 914 fish measured was 150.4 millimeters (6 inches). In December a few individuals, apparently belonging to the 0-class, had attained a length as great as 220 to 233 millimeters (8¾ to 9¼ inches), and the average

[15] Specimens only 1.5 millimeters long in the present collection do not retain a yolk sac. Much shrinkage takes place in larval fishes during the hardening process if alcohol and formalin is used, as with the specimens at hand. Judging from the degree of shrinkage known to occur in some other species, as in the pigfish (*Osthopristes chrysopterus*), for example, it seems probable that the specimens of trout 1.5 millimeters long may have had a length of 2.5 millimeters before preservation. Welsh and Breder (1923, p. 153, fig. 10) show that the yolk sac is very small in live or fresh larvae when 2.2 millimeters long, and it would be expected to disappear very soon afterward.

length of 464 specimens measured was 168.8 millimeters (6¾ inches). The larger fish of the 0-class appear to be missing in the catches made during the winter, as the maximum and the average lengths of the specimens caught during January, February, and March were less than for December. (See table 5.) In April the largest individuals were 225 to 238 millimeters (9 to 9½ inches) long, and the average length of 1,455 fish measured was 167.2 millimeters (6¾ inches). Therefore, the fish caught in April were about the same size as those taken in December.

The data presented appear to show that some of the larger individuals of the 0-class, like virtually all the adults, leave the shallower water, in which the collections were made, during cold weather. The data appear to show, also, that fish grow little, if at all, during their first winter, for in April even the adult fish have returned, and the samples taken should represent the class correctly. After April growth appears to be fairly rapid, for in June (when many of the fish were a year old) the average length of 615 examples measured was 175.8 millimeters (7 inches) and the extremes in length extended from 97 to about 253 millimeters (4 to 10 inches). The length attained in June shows that some of the fish undoubtedly reach a marketable size [16] during their second summer.

The size attained by the young fish at Beaufort, as shown by the accompanying tables, is not in disagreement with published accounts. Eigenmann (1901, p. 47), working with fish at Woods Hole, Mass., states, "It seems very probable that the fish reaches a marketable size in about a year from birth." Welsh and Breder (1923, p. 157) have calculated the average length of fish hatched on June 1, based on "measurements of 10 large samples of young fish, taken at various times from July to March" to be 30, 80, 130, 170, and 180 millimeters (1¼, 3⅛, 5⅛, 6¾, and 7⅛ inches), respectively, on July 1, August 1, September 1, October 1, and November 1. These writers unfortunately do not name the localities in which the fish were caught. Therefore, the data cast no light on the rate of growth in different localities. No calculations were made by us that are directly comparable. However, the lengths given by the authors cited, in general, fall in with the larger individuals of the 0-class caught at Beaufort, N.C., on approximately the same dates.

TABLE 4.—*Length frequencies of 8,382 gray trout (Cynoscion regalis) under 380 millimeters in length*

| Millimeters | May | June | July | August | September | October | November | December | January | February | March | April |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–4 | | | | | | | | | | | | |
| 5–9 | 1 | 4 | 5 | 10 | | | | | | | | |
| 10–14 | 8 | 25 | 164 | 25 | | | | | | | | |
| 15–19 | | 10 | 123 | 20 | 1 | | | | | | | |
| 20–24 | | 7 | 29 | 5 | | | | | | | | |
| 25–29 | | 3 | 14 | 8 | | | | | | | | |
| 30–34 | | 1 | 23 | 10 | | | | | | | | |
| 35–39 | | | 12 | 14 | 2 | | | | | | | |
| 40–44 | | | 11 | 7 | | | | | | | | |
| 45–49 | | 2 | 14 | 2 | 1 | | | | | | | |
| 50–54 | | | 17 | 2 | 3 | 3 | 1 | | | | | |
| 55–59 | | | 24 | 4 | | 1 | | | | | | |
| 60–64 | | | 30 | 2 | 2 | 2 | | | | | | |
| 65–69 | | | 29 | 1 | 4 | 7 | | | | | | |
| 70–74 | | | 27 | 5 | 6 | 9 | | | | | | |
| 75–79 | | | 34 | 11 | 6 | 12 | | | | | | |
| 80–84 | | | 55 | 11 | | 2 | | | 2 | | | |
| 85–89 | | | 38 | 24 | 4 | 1 | | | 1 | | | |
| 90–94 | | | 47 | 23 | 12 | 3 | 1 | 1 | 1 | | | 1 |
| 95–99 | | | 38 | 47 | 9 | 2 | | 1 | 2 | | 1 | |
| 100–104 | | 1 | 33 | 51 | 19 | | 1 | 1 | | | 2 | |
| 105–109 | | | 32 | 54 | 21 | 6 | 1 | 6 | 1 | | 2 | 1 |
| 110–114 | | 1 | 21 | 81 | 11 | 9 | 6 | 2 | 2 | 1 | 3 | 1 |
| 115–119 | | | 18 | 58 | 30 | 21 | 9 | 5 | 2 | 2 | 2 | 3 |
| 120–124 | | | 11 | 49 | 34 | 16 | 3 | 3 | 1 | 6 | 1 | 13 |
| | | 1 | 12 | 31 | 37 | 16 | 9 | 6 | 1 | 11 | 1 | 26 |

[16] The legal minimum size limit in North Carolina in 1925 is given as 9 inches by Higgins and Pearson (1927, p 49, fig. 8).

TABLE 4.—*Length frequencies of 8,382 gray trout (Cynoscion regalis) under 380 millimeters in length*—Continued

| Millimeters | May | June | July | August | September | October | November | December | January | February | March | April |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 125–129 | 1 | 1 | 5 | 37 | 33 | 17 | 8 | 8 | 1 | 7 | 2 | 29 |
| 130–134 | | 3 | 4 | 25 | 42 | 19 | 13 | 12 | 4 | 11 | 1 | 32 |
| 135–139 | 3 | 4 | 1 | 16 | 30 | 22 | 25 | 13 | 9 | 11 | 2 | 32 |
| 140–144 | 3 | 14 | 2 | 25 | 33 | 62 | 34 | 13 | 25 | 25 | 2 | 60 |
| 145–149 | 2 | 21 | | 29 | 28 | 102 | 63 | 11 | 38 | 26 | 9 | 76 |
| 150–154 | 7 | 41 | 3 | 21 | 24 | 139 | 76 | 30 | 60 | 32 | 27 | 125 |
| 155–159 | 5 | 23 | 5 | 20 | 22 | 121 | 87 | 26 | 68 | 26 | 19 | 181 |
| 160–164 | 4 | 47 | 23 | 34 | 18 | 109 | 75 | 41 | 75 | 40 | 33 | 228 |
| 165–169 | 9 | 40 | 18 | 26 | 21 | 66 | 76 | 38 | 57 | 21 | 30 | 184 |
| 170–174 | 14 | 55 | 18 | 18 | 20 | 42 | 73 | 56 | 42 | 26 | 32 | 147 |
| 175–179 | 9 | 46 | 12 | 6 | 11 | 21 | 33 | 43 | 28 | 27 | 25 | 110 |
| 180–184 | 7 | 43 | 8 | 5 | 23 | 27 | 23 | 40 | 18 | 16 | 26 | 82 |
| 185–189 | 4 | 42 | 12 | 3 | 14 | 15 | 23 | 28 | 26 | 12 | 17 | 40 |
| 190–194 | 4 | 47 | 19 | 5 | 14 | 16 | 20 | 28 | 11 | 3 | 19 | 32 |
| 195–199 | 4 | 53 | 14 | 4 | 6 | 6 | 10 | 10 | 7 | 6 | 9 | 11 |
| 200–204 | 5 | 41 | 21 | 3 | 4 | 6 | 3 | 20 | 4 | 3 | 8 | 14 |
| 205–209 | 2 | 25 | 25 | 14 | 3 | 6 | 5 | 10 | | | 3 | 3 |
| 210–214 | 4 | 19 | 23 | 9 | 3 | 2 | 2 | 4 | | | 4 | 10 |
| 215–219 | 1 | 17 | 25 | 6 | 6 | 4 | 2 | 5 | | | 1 | 7 |
| 220–224 | 2 | 13 | 17 | 6 | 8 | 2 | 1 | 2 | | 2 | 1 | 3 |
| 225–229 | | 5 | 17 | 7 | 13 | | 1 | | | | 1 | 2 |
| 230–234 | | 4 | 7 | 3 | 10 | 5 | 1 | 1 | | | | 1 |
| 235–239 | | | 5 | 4 | 10 | 2 | | | | | | 1 |
| 240–244 | | 3 | 2 | 9 | 10 | 2 | | 1 | | | | 5 |
| 245–249 | | 1 | 1 | 9 | 7 | 3 | 1 | | | | | 2 |
| 250–254 | | 3 | 1 | 9 | 7 | 5 | 1 | 1 | | | | 2 |
| 255–259 | | | 2 | 9 | 6 | 1 | | | | | | 2 |
| 260–264 | | | 2 | 10 | 6 | 3 | | 1 | | | | 1 |
| 265–269 | | | 1 | 2 | 4 | 2 | | | | | | |
| 270–274 | | 1 | 4 | 6 | 3 | 1 | | | | | | |
| 275–279 | | | 2 | 4 | 1 | 4 | 1 | | | | | 1 |
| 280–284 | | | 10 | 5 | 2 | 3 | | | | | | 1 |
| 285–289 | | | | 1 | | | | | | | | |
| 290–294 | | | 10 | 2 | 2 | 1 | | | | | | |
| 295–299 | | | 4 | 4 | 1 | 2 | 1 | 1 | | | | |
| 300–304 | | | 16 | 6 | 1 | | | | | | | |
| 305–309 | | | 1 | 9 | | | | | | | | |
| 310–314 | | | 12 | | 1 | | | | | | | |
| 315–319 | | | 12 | 9 | 2 | 2 | | | | | | |
| 320–324 | | | 15 | 1 | | | | | | | | |
| 325–329 | | | | 3 | | 1 | 1 | | | | | |
| 330–334 | | | 13 | 1 | | | | | | | | |
| 335–339 | | | | 5 | | | | | | | | |
| 340–344 | | | 12 | 3 | | | | | | | | |
| 345–349 | | | | 2 | | | | | | | | |
| 350–354 | | | 7 | 3 | | | | | | | | |
| 355–359 | | | 1 | 2 | | | | | | | | |
| 360–364 | | | 13 | 1 | | | | | | | | |
| 365–369 | | | 5 | 3 | | | | | | | | |
| 370–374 | | | 16 | | | | | | | | | |
| 375–379 | | | 3 | | | | | | | | | |

TABLE 5.—*Monthly summaries of length measurements of 7,883 gray trout (Cynoscion regalis) during the first 12 to 14 months of life (based on table 3)*

| Month | Fish measured | Smallest | Largest | Average | Month | Fish measured | Smallest | Largest | Average |
|---|---|---|---|---|---|---|---|---|---|
| May | 8 | 6.5 | 9 | 8.1 | January | 486 | 78 | 204 | 161.5 |
| June | 52 | 2.3 | 40 | 11.5 | February | 311 | 106 | 220 | 152.5 |
| July | 873 | 4.4 | 143 | 50.4 | March | 281 | 94 | 229 | 165.5 |
| August | 820 | 1.7 | 185 | 105.4 | April | 1,455 | 87 | 238 | 167.2 |
| September | 548 | 10.5 | 209 | 140.3 | May | 90 | 125 | 222 | 174.6 |
| October | 914 | 46 | 220 | 150.4 | June | 615 | 97 | 253 | 175.8 |
| November | 685 | 48 | 231 | 164.1 | July | 281 | 150 | 265 | 197.9 |
| December | 464 | 85 | 233 | 168.8 | | | | | |

## CYNOSCION NOTHUS (Holbrook) BASTARD TROUT

The bastard trout ranges from Chesapeake Bay to the southwestern coast of Texas. Although it was described (from South Carolina) as early as 1860, its exact status as a species was not well understood until recently. For a time its validity was doubted by some writers (Coles, 1916, p. 30, and Welsh and Breder, 1923, p. 169), probably because plain colored *C. regalis* were thought to be *C. nothus*. However,

Hildebrand and Schroeder (1928, p. 299) obtained two specimens of true *C. nothus* from Chesapeake Bay, and thereby were enabled to show definitely that this is a valid species. Finally Ginsburg (1929, p. 71–85), who examined many specimens, shows the relationship of *C. nothus*, *C. regalis*, and *C. arenaris* (a Gulf coast species) in great detail. The fishermen and fish dealers of Beaufort and Morehead City recognize *C. nothus* as distinct from *C. regalis*, giving it the name "bastard trout" because it is supposed to be a cross of *C. regalis* and some other species. The diagnostic characters of the bastard trout are given in the key to the species.

It has been found during recent years that the bastard trout is rather common off Beaufort Inlet during the summer. However, no specimens were taken during the winter, probably because the fish migrate to warmer water. This trout certainly is not a regular inhabitant of the inside waters of the vicinity, as no adult specimen and only 4 young were taken there during 5 years of rather systematic and extensive collecting. The young, all taken in 1 tow-net haul, may have drifted in with the tide, as explained elsewhere.

The bastard trout appeared rather frequently during the summer, sometimes in considerable numbers, in a collecting trawl hauled in a few to several fathoms of water off Shackleford and Bogue Banks. At times, particularly during the early part of summer, catches of about 100 pounds a day were taken in a commercial pound net operated for a few years off Bogue Banks. It cannot be said, however, that this species is of much commercial importance on the coast of North Carolina. Further southward, and particularly on the Gulf coast, it seems to be more important.

The bastard trout apparently does not grow large. The largest individual seen at Beaufort was only 228 millimeters (9¼ inches) long.

This species is closely related to *C. regalis*, and the separation of the young prior to the development of the anal fin, that is, specimens under about 6 millimeters in length, may be difficult. It is thought, however, that the position of the color markings, which differ somewhat in specimens 9.5 millimeters long (the smallest *C. nothus* recognized), as pointed out on page 113, would aid in separating the smaller young. The position of the color markings in all the specimens at hand of this group under 9.5 millimeters in length agree with *C. regalis*. It is concluded, therefore, that specimens of *C. nothus* under 9.5 millimeters in length are missing.

The descriptions of the young that follow are based on specimens collected at Beaufort, exclusive of the account of fish 75 millimeters and upward in length, which is based in part on specimens from Beaufort and in part on specimens from the Gulf coast.

### SPAWNING

No ripe fish, so far as known, have been observed, and if the eggs have been taken in the tow they were not recognized, therefore, the only clue to the time and place of spawning is furnished by the collection of young fish. The smallest young taken were secured on August 8, 1930, and the smallest specimen in that collection is 9.5 millimeters long. The largest specimen taken the same month, which certainly belongs to the 0-class, is 88 millimeters long. No specimen of this year class less than 39 millimeters and none exceeding a length of 95 millimeters were taken during September. However, in October 30 specimens 17 to 25 millimeters in length were secured, and the largest one of this year class is only 80 millimeters long, showing that the larger young are missing in the collection. In November, when numerous specimens of the 0-class were taken, the range in length extends from 19 to

147 millimeters. It seems reasonable to conclude from the range in size of specimens taken during four summer and fall months, when the rate of growth no doubt is rapid, that spawning very probably begins in May or June (for specimens 80 to 88 millimeters long, such as were taken on Aug. 14, 1930, quite probably are 2 to 3 months old), and that it extends at least through August (as 30 specimens 17 to 25 millimeters long, were taken on Oct. 30, 1929).

It probably may be assumed that spawning takes place at sea at Beaufort in the general vicinity inhabited by the adults. At least, that is where all the young in the collection, exclusive of one small collection consisting of 4 specimens 9.5 to 12 millimeters long, were taken. It is thought that the 4 specimens of young, too, were hatched at sea, but that they had drifted in part with the tides and probably in part had swum to the place of capture, namely, near the mouth of Core Creek in Newport River. The presence of these four fish in the inside waters is interesting, not only because no other young were taken there, but because no adults were caught in the inside waters.

### DESCRIPTIONS OF THE YOUNG

*Specimens 9.5 to 11.0 millimeters long.*—The body is rather deep and compressed, the depth being contained 3.0 to 3.25 in the standard length. The head

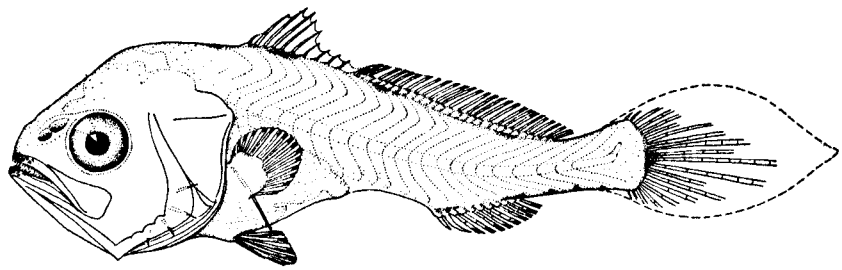

FIGURE 42.—*Cynoscion nothus*. From a specimen 10.5 millimeters long.

particularly is short and deep, being contained 2.85 to 3.0 times in the length. The snout, too, is rather short and blunt, and is about as long as the eye, 3.7 to 4.4 times in the head. The mouth is large, quite strongly oblique; the gape anteriorly is scarcely above the lower margin of the eye; the lower jaw projects only slightly; and the maxillary reaches nearly opposite the posterior margin of the eye, 1.65 to 1.85 in the head. The fins are all developed and a definite enumeration of the rays is obtainable. The anal consistently has 9 articulated rays in the 4 specimens of this size at hand (although in larger specimens only 8 rays sometimes are present), and the dorsal fin has 28 or 29 rays. The caudal fin is frayed in the specimens at hand, and its exact shape cannot be determined. However, it evidently is quite long and pointed. The ventral fins are small, scarcely as long as the eye. Preserved specimens are very plain in color. A few dusky markings are evident along the ventral outline of the caudal peduncle, and an elongate dusky spot is present at the base of the anterior rays of the anal and similar spots at the end of that fin. A dusky spot is situated just in advance of the spinous dorsal, another one is under the base of the spinous dorsal, a third one is situated under the anterior rays of the soft dorsal, and a fourth one is near the end of the base of this fin. The jaws anteriorly are slightly dusky (fig. 42).

This species is closely related to *C. regalis* from which it is distinguished, at the size described, chiefly by the shorter anal fin, which has 9 (sometimes 8) rays, where-

as *C. regalis* has 11 to 13. According to the preserved specimens at hand, *C. nothus* is somewhat plainer in color and some of the markings present are a little differently placed. *C. regalis* at a length of 9 to 11 millimeters has numerous dusky dots on the side, which *C. nothus* does not possess. *C. regalis* generally has more numerous spots on the back also. On the other hand, *C. nothus* has two elongate dusky spots at the base of the anal, one being below the anterior rays and the other one at the base of the last rays, whereas only one spot placed near the middle of the anal base is present in *C. regalis*.

The specimens described are the smallest ones of the species recognized. It is possible that this species and *C. regalis* are so similar in the younger stages that they were not recognized as distinct. Identification apparently would be somewhat uncertain until the anal fin is developed sufficiently to permit the enumeration of the rays. However, it is thought that the markings on the ventral surface of the tail might be useful in separating the species, since the spots appear to be a little differently placed in the two species, as already stated. In the younger specimens the markings are quite uniformly placed, and the large spot near midcaudal length (being the one that is situated below the base of the anal when that member becomes developed) is steadfastly present and is thought to be diagnostic for *C. regalis*.

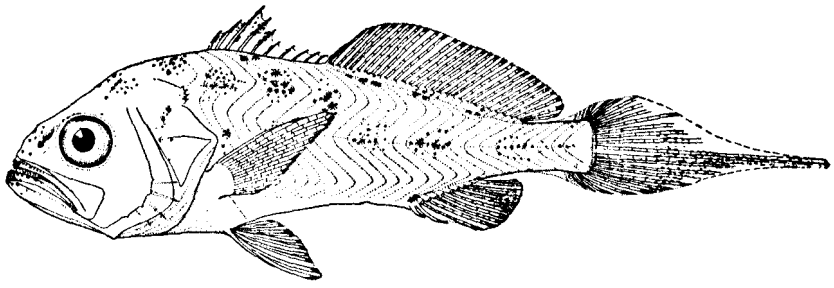

FIGURE 43.—*Cynoscion nothus*. From a specimen 26 millimeters long.

*Specimens 24 to 26 millimeters long.*—The fish has become more shapely since a length of 9 to 11 millimeters was attained (no specimens of intermediate sizes are at hand), that is, the head and trunk are not as disproportionately deep in comparison with the tail as in the smaller fish. The greatest depth is contained 3.2 to 3.6 times in the standard length, and the head now is considerably longer than deep, its length being contained 2.5 to 2.7 times in the standard length. The snout is a little sharper than in smaller fish; its length remains about equal to the diameter of the eye, and is contained 3.7 to 4.3 times in the head. The mouth is moderately oblique; the lower jaw projects little; and the maxillary reaches to or a little beyond the posterior margin of the pupil, 2.0 to 2.2 in the head. Gill rakers are developed, 11 were counted on the lower limb of the first arch in each of two specimens. Scales are evident on the side, though the sides are not completely covered. The caudal fin is sharply pointed and the middle rays are much longer than the head. The ventral fins have increased greatly in length and are about twice as long as the eye. Dark color markings have become much more numerous; the markings (chromatophores) mostly remaining small and rather scattered, and are present on the sides, on the head, on the back, and along the ventral outline. In some specimens congregations of dark marks are present along the lateral line, forming indefinite quadrate spots. In some specimens a concentration of dark markings, also, has occurred on the back

where they form saddle-like blotches. A dark cross line is present on the base of the caudal fin and a few dark dots have appeared on the spinous dorsal (fig. 43).

This species is very close to *C. regalis*, differing (in addition to having fewer anal rays) chiefly in color. In general, the individual markings (chromatophores) are smaller and form less definite blotches. Furthermore, blotches on the back and in the lateral line, if present, are separate, whereas in *C. regalis*, blotches somewhat similarly placed, are connected and form more or less definite crossbands, at least on the anterior part of the body. The indications are that *C. nothus* has the middle rays of the caudal more strongly produced, though this cannot be determined definitely because this fin is more or less damaged in all the specimens at hand.

*Specimens 40 to 46 millimeters long.*—The body has become deeper posterior to the ventral fins, and the head is rather more pointed. The proportions, measured as in the smaller specimens, have not changed greatly. The head is contained 2.5 to 2.75 in the standard length, and the depth 3.2 to 3.6 times. The eye and snout are of about equal length and are contained 3.7 to 4.3 in the head. The mouth remains quite oblique, the gape anteriorly being somewhat above the lower margin of the eye, and the maxillary reaches about opposite the posterior margin of the pupil, it being contained 1.9 to 2.2 in the head. The body is fully covered with scales and small scales also are evident on the base of the soft dorsal and on the anal. The caudal fin remains long and pointed, the middle rays being much produced and nearly an eye's diameter longer than the head. The body has become more definitely blotched, the blotches consisting chiefly of a series along the lateral line and another on the back. In the majority of specimens examined the blotches are separate, but in some examples the ones on the anterior part of the back tend to unite with those on the side to form cross bars. Dark dots are present on both dorsals, the caudal, and occasionally on the anal.

This species continues to differ from *C. regalis* in color, the body generally being blotched, or if suggestions of crossbars occur they are present anteriorly only, and are less distinct than in *C. regalis*. The caudal fin is notably longer and more sharply pointed in *C. nothus*, the longest rays being nearly an eye's diameter longer than the head, whereas in *C. regalis* none of the rays exceed the length of the head. In the proportional measurements given in the foregoing description the two species are almost identical at a range in length of 40 to 46 millimeters.

*Specimens 75 millimeters and upward in length.*—The depth is contained 3.4 to 4.0 times in the standard length in specimens 75 to 90 millimeters long, and these proportions prevail in adult fish, also. However, the body remains notably more compressed, its greatest width being somewhat less than the length of the maxillary. The fish apparently increase in robustness very gradually as long as growth continues. At a length of 150 millimeters the width of the body is about equal to the length of the maxillary, and in larger fish the width exceeds the length of the maxillary. The head is contained 2.9 to 3.0 times in the length in fish 75 to 90 millimeters long, as compared with 3.2 to 3.4 in specimens ranging from 150 to 200 millimeters in length. Therefore, the head remains proportionately longer, as usual, in the smaller fish. The mouth virtually has attained the position and nearly the proportions of the adult in specimens only about 40 millimeters long, described in the foregoing section, and the two large recurved canines in the upper jaw, characteristic of this genus, slightly evident at a length of 45 millimeters, are prominent in specimens 75 millimeters long. Small scales are present on the basal portion of the fins, exclusive of the spinous dorsal, at a length of 75 millimeters (and earlier in some

specimens), and they are extended almost all over the fins by the time the fish reach a length of about 125 millimeters, apparently increasing in density with age.

The caudal fin remains pointed in specimens 75 millimeters long and the longest rays (although proportionately shorter than in smaller fish) are about equal to the length of the head. This fin is still moderately pointed in fish 150 millimeters long, but the longest rays then are notably shorter than the head. The caudal does not acquire the shape it has in adults, that is, with the upper lobe slightly concave and the lower one rather sharply rounded, until the fish reach a length of about 200 millimeters.[17]

The blotches present in the smaller fish described in the preceding section become less distinct at a length of about 60 millimeters. In the preserved specimens examined only traces are left in fish 75 millimeters long, and soon afterward they disappear and the fish are plain grayish above and silvery below. Only large specimens (of the preserved material examined) 200 millimeters and upward in length have traces of oblique lines running along the rows of scales above the lateral line. The dark

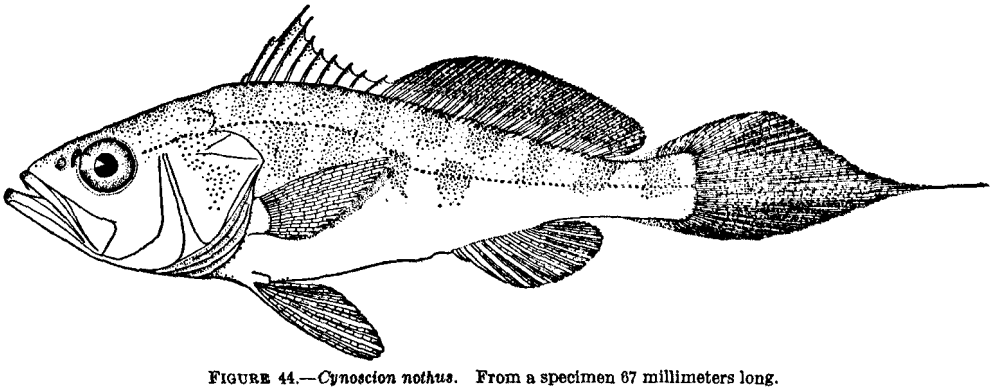

FIGURE 44.—*Cynoscion nothus*. From a specimen 67 millimeters long.

cross line on the base of the caudal, present in small fish, has disappeared in specimens about 60 millimeters long. Dark dots on the dorsal and caudal fins increase rapidly in number as growth proceeds. In specimens about 100 millimeters long the caudal fin is quite dusky and distally almost black. The dorsal fins, too, are densely dotted and soon become dusky in color, and the spinous dorsal has a black margin (fig. 44).

This species and *C. regalis* resemble each other closely. Beside the difference in the number of anal rays, the slight difference in the number of gill rakers, and vertebrae, pointed out elsewhere, it is evident that almost throughout life (that is, after the caudal fin becomes developed) *C. nothus* has a longer and more sharply pointed caudal fin, which never becomes truncate as in *C. regalis*. Although the fins, exclusive of the spinous dorsal, become covered with small scales in both species, those of *C. nothus* appear to be more densely scaled in adult specimens.

## DISTRIBUTION OF THE YOUNG

It has been pointed out elsewhere (p. 111) that no young under 9.5 millimeters in length were taken. Therefore, the early stages remain unknown. It has been stated, also (p. 112), that all the young collected, exclusive of four specimens, were caught in the

[17] The shape of the caudal, because the fin was frayed in the specimen drawn, is incorrectly shown as round for the adult in Hildebrand and Schroeder (1928, p. 299, fig. 175). It is correctly indicated in Ginsburg's figure (1929, p. 81, fig. 5), which shows the upper lobe to be slightly concave and the lower one rather sharply rounded.

general vicinity (off Beaufort Inlet) inhabited by the adults during the summer. It is quite certain, therefore, that at least the larger young occupy the same grounds with the adults.

Both young and adults were taken only with an especially adapted otter trawl, which, of course, was hauled on the bottom. If the larvae of this species behave like those of the gray and the spotted trout, as would be expected, they may occur at the surface when very small, but soon descend to the bottom.

### GROWTH

An insufficient number of young fish was caught to determine accurately from length measurements the rate of growth of the 0-class. Specimens that definitely belong to this year class were taken only during August, September, October, and November. In August 54 young, ranging in length from 9 to 88 millimeters, with an average length of 61.1 millimeters, were measured. In September only 15 specimens, 31 to 95 millimeters in length, averaging 57.2 millimeters, were measured. The smaller young obviously are missing in the collection for September, as the fish caught during October consisting of 179 specimens, contain fish ranging in length from 17 to 80 millimeters, averaging only 46.5 millimeters in length. The larger young of the 0-class obviously are missing in the collections made in October. In November, only, a sufficient number of specimens was taken and measured to give reliable information. The 486 specimens of the 0-class measured, range in length from 19 to 147 millimeters, and have an average length of 75.8 millimeters.

Since this fish quite certainly is a smaller species than the other local species of this genus (as pointed out on p. 111) a slower rate of growth would be expected, and that is what the limited number of measurements appears to indicate. Instead of attaining a length of about 170 millimeters (6¾ inches) during the first 7 or 8 months of life, as in *C. regalis*, and probably in *C. nebulosus*, this species appears to reach a length of only about 75 millimeters (3 inches). The size at which sexual maturity is reached remains unknown.

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