Numerous specimens ranging from 26 to 125 millimeters (1 to 5 inches) in length were preserved. Most of the specimens were taken in fresh water, but some of them were found where the water was slightly brackish. The young are very similar in color to the young of *Notropis bifrenatus*, both species having the black lateral band, but in the present species, in specimens of 2 inches and upward in length, the lateral band is not nearly as black, having become more plumbeous. This fish is said to differ from the typical *hudsonius* in having a longer and more obtuse head and in the faint or absent caudal spot. (The latter is a character that applies only to adult fish.) This minnow may be distinguished from other species of this genus of the Chesapeake by the rather small scales in advance of the dorsal, 14 to 16 rows crossing the median line of back, the slightly inferior mouth, and by the anterior rays of the dorsal and anal, which are long, projecting beyond the posterior rays when the fin is deflexed.

The peritoneum is silvery, but sometimes with few and at other times with numerous dark punctulations. The air bladder is large and it has a constriction a little in advance of the middle of its length, from which arises a small tube that extends forward to the throat. The alimentary canal is a little longer than the total length of the body.

The food in 13 stomachs examined consisted mainly of insects, a few small mollusks, and various forms of plants.

Spawning evidently occurs very early in the spring, as specimens taken in November have the ovaries somewhat distended with eggs, which are plainly visible to the unaided eye. This shiner, although locally abundant, is of little commercial value because of its small size. It is considered good bait for black bass, however, and the food it furnishes for larger fish is probably of considerable importance. The largest individual in the Chesapeake collection measures 5 inches in length, which is probably the maximum length attained, as it is an inch longer than the greatest length given in current works. All specimens at hand except one were taken in rather quiet, shallow water, and usually on grassy bottom. One, however, was taken off the mouth of the Sassafras River, one-half mile from shore, with a beam trawl hauled at depths of 36 to 54 feet. It is not known whether this fish was caught on the bottom or at the surface as the trawl was being hauled up, but the capture is unusual because this species is typically an inhabitant of brooks and rivers and rarely strays from the immediate vicinity of the shore.

Habitat.—"Delaware and Potomac Rivers." (Jordan and Evermann, 1896–1900.)

Chesapeake records.—(*a*) Previous records: "Chesapeake Bay" (Girard); Patapsco River; Potomac River; East River and Octoraro Creek, Md. (*b*) Specimens in collection: From the vicinity of Havre de Grace, Md. (Susquehanna River to Spesutie Island), 30-foot seine, August 26 to September 1 and November 9 to 12, 1921; Howell Point, mouth of Sassafras River, beam trawl, depth 36 to 54 feet, May 11, 1922; Baltimore, Hawkins Point and Bear Creek, 30-foot seine, May 4, 1922; highest salinity 6.54 per mille.

51. Notropis bifrenatus (Cope). Bridled minnow; "Minnie."

Hybopsis bifrenatus Cope, Trans., Amer. Philo. Soc., XIII, 1869, p. 384; Schuylkill River, Conshohocken, Pa.
Notropis bifrenatus Jordan and Evermann, 1896-1900, p. 258; Fowler, 1912, p. 52.

Head 3.7 to 4.25; depth 4 to 4.9; D. 9 or 10; A. 8; scales 33 to 36. Body rather slender, compressed; caudal peduncle long and slender in young, less so in larger individuals, its depth varying from 2.2 to 3.7 in head; head of moderate size; snout blunt, its length 3.35 to 4.6 in head; eye 2.8 to 3.25; interorbital space 2.5 to 3.3; mouth very oblique, upper anterior margin of gape slightly below median line of eye; maxillary reaching about to anterior margin of eye; pharyngeal teeth 0, 2—2, 0 to 1, 4—4, 1, the larger teeth prominently curved at the tips; scales rather large, 12 or 13 rows crossing the median line of back in advance of dorsal; lateral line incomplete, curved somewhat downward, extending nearly to or somewhat beyond vertical from origin of dorsal; origin of dorsal a little nearer tip of snout than base of caudal; caudal fin forked, the lower lobe slightly the longer; anal fin with slightly concave outer margin, its origin slightly behind vertical from end of base of dorsal, about equidistant from insertion of pectorals and base of caudal; ventral fins inserted under or a little in advance of the dorsal, reaching beyond origin of anal; pectoral fins inserted on ventral edge, 1.35 to 1.6 in head.

Color greenish brown above, pale silvery below; the scales in upper part of body with brownish punctulations, densest on the margins, making brownish edges; sides with a prominent black band,

extending around the tip of snout but not involving the lower lip, through the median part of the eye, to base of caudal, where it ends in a dark spot; a somewhat darkened vertebral stripe, at least in advance of the dorsal; fins pale, the dorsal and caudal a little darker, the first rays of the dorsal and pectorals and the outer rays of the caudal more or less dusky.

Numerous specimens of this species ranging from 25 to 60 millimeters (1 to 2⅜ inches) in length are at hand, all taken in slightly brackish water. This species is very close to *Notropis procne* (Cope), from which it differs, however, according to Fowler (1906, p. 140), in having a shorter caudal peduncle and tail, larger dark edges on the dorsal scales, and a more plumbeous lateral band. According to the same author, there is much variation in *N. bifrenatus* in the development of the lateral line, which, he says, barely extends to the origin of the dorsal in some specimens and is nearly complete in others. In 48 specimens examined by us in regard to the development of the lateral line, we find comparatively little variation, as only one specimen has a few scattered pores posterior to the end of the base of the dorsal fin, and in only a few specimens the lateral line fails to reach opposite the origin of the dorsal.

This fish is known only from coastwise streams, but we find no previous mention made of its occurrence in brackish water. The alimentary canal is short, not as long as the body. The food in six stomachs examined consisted wholly of vegetable matter, ranging from the lowest forms of algæ to the higher plants. Except that it furnishes food for larger fish, the species is of no commercial importance.

Nothing appears to be known concerning the spawning habits of this fish. According to Fowler (1906, p. 140), this minnow prefers the smaller creeks with deep water having a gentle current. The specimens at hand were taken in tidal currents, on a grassy bottom, and in shallow water.

Habitat.—In coastwise streams from Massachusetts to Maryland.

Chesapeake localities.—(*a*) Previous record: "Tributaries of the Big Bohemia Creek," Md. (Fowler). (*b*) Specimens in collection: Havre de Grace, Md., May 10, 1922; Baltimore, Hawkins Point, and Bear Creek, May 4, 1922, and August 24, 1921; Annapolis, lower Severn River, May 2 and 3, 1922, and August 19, 1921; Love Point, May 12, 1922; highest salinity 11.80 per mille.

Order NEMATOGNATHII

Family XXVII.—ARIIDÆ. The sea catfishes

Body naked; gill membranes united, forming a fold across the isthmus; mouth terminal; nostrils usually close together, without barbel; maxillary and one or two pairs of mandibular barbels present; dorsal fin anterior, with a spine; adipose fin present; anal short or of moderate length; ventral fins with six rays.

40. Genus FELICHTHYS Swainson. Gaff-topsail catfishes

Body elongate, little if at all compressed; head depressed; snout very broad, projecting; mouth large; teeth all villiform, in more or less distinct bands on jaws, vomer, and palatines; a large fontanel; barbels 4, maxillary barbel long, broad, bandlike; pectoral spines and usually the dorsal spine with a long bandlike filament; caudal fin deeply forked; anal fin more or less emarginate.

A single species is known from the Atlantic coast of the United States.

52. Felichthys felis (Linnæus). Gaff-topsail catfish; Sea catfish.

Silurus felis Linnæus, Syst. Nat., ed. XII, 1766, p. 503; Charleston, S. C.
Ælurichthys marinus Uhler and Lugger, 1876, ed. I, p. 177; ed. II, p. 150.
Felichthys marinus Jordan and Evermann, 1896–1900, p. 118, Pl. XXIII, fig. 52.

Head 3.66 to 4.2; depth 4.35 to 5.4; D. I. 7; A. 22 to 24. Body robust, depressed anteriorly, compressed posteriorly; head low and broad; snout very broad, 2.4 to 3.5 in head; eye 5.35 to 7.2; interorbital space 1.42 to 1.64; mouth very broad, the cleft extending nearly or quite to eye; maxillary 2.32 to 2.38 in head; teeth small, in villiform bands on the jaws, vomer, and palatines; two pairs of barbels present, the maxillary barbel flattened, ribbon-shaped, reaching from vertical below middle of base of dorsal nearly to base of ventrals; mandibular barbels small, reaching nearly or quite to

the gill covers; dorsal spine bearing a filament, varying in length, frequently reaching to or past adipose fin; adipose fin rather small, inserted over or a little behind the middle of the base of the anal, its base 6.1 to 7.75 in head; caudal fin deeply forked, the upper lobe slightly the longer; anal fin moderate, its outer margin rather deeply concave, its base 1.43 to 1.6 in head; ventral fin inserted about equidistant from the tip of the snout and the base of caudal; pectoral spine bearing a compressed filament, reaching nearly or quite opposite the origin of the anal, the spine 1.15 to 1.48 in head.

Color, top of head and back uniform steel blue, blending into bronze; sides silvery; underneath white; dorsal fin white or bluish, adipose blue, caudal dusky or gray, anal white or pale blue, ventrals plain white or slightly dusky, pectorals more or less dusky.

The Chesapeake Bay collection contains five female specimens, ranging in length from 325 to 565 millimeters (12¾ to 22¼ inches). The gaff-topsail catfish is characterized by the reduced number of barbels or whiskers, only two pairs—the maxiliary and mandibular barbels—being present. Other characters that readily distinguish this fish from all others of the Atlantic coast of America are the long, flat, ribbon-shaped filaments borne by the dorsal and pectoral spines. The filament on the dorsal often projects far above the surface of the water as the fish swims, and it is from this character and habit that the fish has received the name "gaff-topsail catfish."

The stomachs of the specimens at hand were not examined for food content, as the fish were taken from a pound net where the usual foods may not have been available and where other foods probably were taken. According to Gudger (1918, p. 39), the principal food of the gaff-topsail

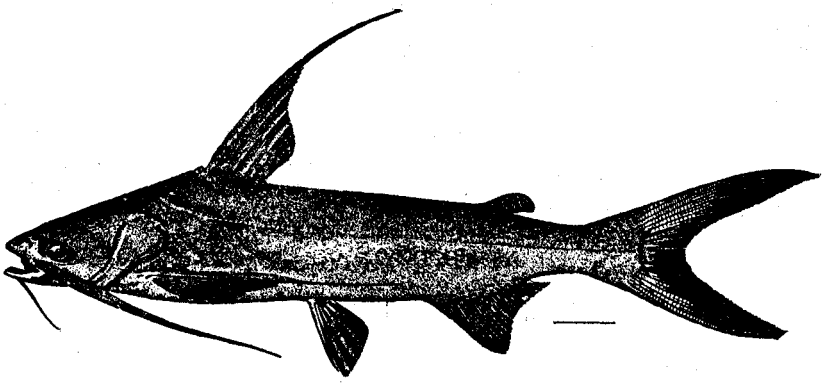

FIG. 69.—*Felichthys felis*

catfish at Beaufort, N. C., consists of crabs, supplemented by an occasional shrimp or fish or both. According to the same author, while carrying eggs and young in the mouth the male fish does not feed at all.

The sexual organs of our specimens taken on May 17, 1921, at Lynnhaven Roads, Va., are completely collapsed, as if the fish had spawned shortly before being captured. The ovaries of two fish caught in the same locality on May 25, 1922, contained eggs in various stages of development, as follows: A fish 557 millimeters in total length contained 5 eggs about 20 millimeters in diameter, 51 eggs 10 to 12 millimeters, 16 eggs 8 to 9.5 millimeters, 30 eggs 5.5 to 7.5 millimeters, and 50 eggs 3 to 5 millimeters, all opaque. In addition many undeveloped, translucent eggs, from less than 3 to 6 millimeters in diameter also were present. A fish 537 millimeters long contained 25 eggs 10 to 12 millimeters in diameter, 9 eggs 7.5 to 9 millimeters, 17 eggs 5 to 7 millimeters, and 21 eggs 3 to 4 millimeters, all of which were opaque. In addition about 22 translucent eggs, 2 to 4 millimeters in diameter, were present. A fish 476 millimeters in total length, taken on June 25, 1924, in the lower Potomac, contained numerous immature translucent eggs 2 to 4 millimeters in diameter.

The breeding season at Beaufort, N. C., according to Gudger (1918, p. 30–32), occurs during the last half of May and to a lesser extent in June. The eggs of the catfish are very large; Gudger (1918, p. 35) gives the size as varying from 15 to 25 millimeters (three-fifths to 1 inch) in diameter. After they are laid and fertilized the eggs are transferred in some mysterious manner to the mouth of the male, where they are held until hatched and where the young are retained for some time after hatching. The largest number of eggs found in the mouth of one fish by Gudger (1918, p. 36) was

55, which were taken from a male 22 inches long. The size of the young soon after hatching is probably about 1¾ inches, and according to Gudger (1918, p. 37) they are 4 inches in length before they are released from the shelter of the paternal mouth.

This catfish usually is not used as food in the United States, but on September 23, 1921, about 10 individuals were observed in a lot of "mixed" fish in the Baltimore wholesale fish market, which were said to have been taken in Chesapeake Bay. In Panama marine catfishes are seen in the markets daily and form an important food. In southern Florida this fish, together with a related species, *Galeichthys milberti*, is very abundant, causing considerable damage to the nets of mullet fishermen.

This catfish is known to reach a length of at least 22½ inches. It is not abundant in Chesapeake Bay, but a few individuals are taken from time to time during the spring and summer from the lower Potomac River to the mouth of the bay. "It is said to have become less common than formerly." (Uhler and Lugger, 1876, p. 177.)

Habitat.—Cape Cod to the Isthmus of Panama.

Chesapeake localities.—(*a*) Previous records: "Chesapeake Bay" (Uhler and Lugger, 1876); "vicinity of Norfolk, Va." (Moseley). (*b*) Specimens in collection: Lynnhaven Roads, Va., pound net, May 17, 1921, and May 25, 1922; Rock Point, Md. (Potomac River), June 25, 1924.

Family XXVIII.—AMEIURIDÆ. The horned pouts

Body naked; gill membranes separate or notched, free or at least forming a free fold across the isthmus; nostrils far apart, the posterior with a barbel; dorsal fin anterior, with a spine; adipose fin present; anal fin short or of moderate length; ventral fins with 8 or 9 rays.

41. Genus AMEIURUS Rafinesque. Horned pouts

Body moderately elongate, robust anteriorly; caudal peduncle compressed; head large, wide, supra-occipital extending backward, terminating in a more or less acute point, entirely separate from the second interspinal buckler, making the bony bridge from snout to dorsal incomplete; mouth large; teeth in broad bands on the jaws; those of the upper jaw without backward extensions at angle of mouth; adipose fin short, inserted over the posterior half of the anal; anal fin varying in length, with 15 to 35 rays.

53. Ameiurus catus (Linnæus). White cat; "Channel cat."

Silurus catus Linnæus, Syst. Nat., X, 1758, p. 305; "northern part of America."

Pimelodus lynx Girard, 1859 (1860), p. 160.

Amiurus catus Uhler and Lugger, 1876, ed. I, p. 179; ed. II, p. 152; Bean, 1883, p. 367; Jordan and Evermann, 1896–1900, p. 138; Smith and Bean, 1899, p. 181; Fowler, 1912, p. 53.

Amiurus lynx Uhler and Lugger, 1876, ed. I, p. 180; ed. II, p. 152.

Ameiurus albidus Bean, 1883, p. 367.

Head 3.38 to 3.9; depth 3.75 to 4.5; D. I, 6; A. 22 or 23. Body rather robust, somewhat compressed; head depressed and broad; snout very broad, 2.06 to 2.57 in head; eye 6.9 to 7.84 (young 4.25 to 4.8); interorbital space 1.46 to 1.67 (young 1.89 to 1.92); mouth very broad, the cleft short, not extending to eye; maxillary 2.19 to 2.66 in head (young 2.87 to 3); teeth small, in villiform bands on jaws; four pairs of barbels present, two on chin, the longest about equal to or shorter than snout, one at angle of mouth, slightly greater than interorbital space, and one at posterior nostril equal to about twice diameter of eye; the barbels of young fish are generally longer; margin of dorsal rounded, longest ray 1.67 to 1.82 in head (young 1.2 to 1.36); adipose moderate, inserted about over middle of base of anal; caudal fin moderately forked; the lobes about equal, rounded; anal fin moderate, its outer margin gently rounded, its base 1.35 to 1.5 in head (young 1.05 to 1.1); ventrals inserted a little nearer base of caudal than tip of snout in adult, in the young this proportion is reversed; pectoral spine stout, not as long as longest soft rays, 2.22 to 2.41 in head (young 1.53 to 1.8); humeral process very rough.

Color of fresh specimen, grayish on back and sides, head olive gray; underneath white; dorsal, adipose, and caudal grayish; anal whitish, edged with gray; ventrals and pectorals plain, with trace of gray.

The above description is based on eight specimens taken in Chesapeake Bay, ranging in length from 35 to 330 millimeters (1⅜ to 13 inches).

This catfish is seldom taken in the Chesapeake proper, except at the head of the bay, where the water is usually fresh. It is a common species in the deeper rivers, particularly the Potomac, where it occasionally strays into brackish water. The species is included in the present report upon receipt of an adult specimen taken from a pound net at Rock Point, Md., on June 25, 1924. The water in this part of the Potomac is decidedly brackish, and salt-water species such as weakfish, croakers, etc., are commonly caught there throughout the summer. The channel catfish, as its name implies, is frequently found in river channels and deep holes. The channel cat of the Mississippi is a different species (*Ictalurus punctatus*).

This catfish spawns in the summer. The parent fish are said to build a nest of gravel and to guard the eggs and the young until some time after hatching.

The channel catfish is considered a good food fish, being superior to several other species of cats. At Washington and Baltimore it is an important market species. It is known to reach a length of about 2 feet and a weight of 5 pounds.

This catfish is caught chiefly with hook and line and in pound nets and fyke nets. Large numbers are caught in the Potomac, in Back River near Baltimore, and in the Havre de Grace region of the bay.

Habitat.—Coastwise streams from New York to Texas.

Chesapeake localities.—(*a*) Previous records: Havre de Grace, Baltimore, Patapsco, and Potomac Rivers. (*b*) Specimens in collection: Rock Point, Md., pound net, June 25, 1924; Spesutie Island, Md., August 26, 1921; Elk River, Md., May 8, 1922; Northeast River, Md., August 29, 1921, collecting seines. Definite density readings are not available; however, it is known certainly to enter brackish water.

Order INIOMI

Family XXIX.—SYNODONTIDÆ. The lizard fishes

Body elongate, more or less cylindrical; mouth large; premaxillaries very long, forming entire margin of the upper jaw; maxillaries long and slender, closely adhering to the premaxillaries; teeth sharp, present on jaws, palatines, and tongue; gill membranes separate and free from the isthmus; branchiostegals usually numerous; pseudobranchiæ present; gill rakers small or obsolete; lateral line present; scales cycloid, rarely absent; adipose fin present; dorsal fin single, consisting of soft rays only; caudal fin forked; anal fin moderate or long; pectoral and ventral fins present; air bladder small or wanting; intestinal canal short. A single genus of this family is represented in the fauna of Chesapeake Bay.

42. Genus SYNODUS (Gronow) Scopoli. Lizard fishes

Body elongate; cylindrical; head depressed; snout pointed; mouth very large; premaxillaries long, not protractile; teeth rather large, present on jaws, palatines, and tongue; teeth in the jaws compressed, very sharp; branchiostegals 12 to 16; gill rakers small, spinous; scales cycloid, present on body, cheeks, and opercles; upper surface of head naked; dorsal fin short, placed well forward; adipose fin small, situated over the anal; caudal fin forked; ventral fins moderately large, the inner rays longest; pectorals rather small. A single species is known from Chesapeake Bay.

54. Synodus fœtens (Linnæus). Lizard fish; "Providence whiting"; "Scarpen fish."

Salmo fœtens Linnæus, Syst. Nat., ed. XII, 1766, p. 513; South Carolina.

Synodus fœtens Uhler and Lugger, 1876, ed. I, p. 152, ed. II, p. 129; Lugger, 1877, p. 85; Bean, 1891, p. 93; Jordan and Evermann, 1896–1900, p. 538, Pl. LXXXVIII, fig. 236; Evermann and Hildebrand, 1910, p. 159.

Head 3.8 to 4.4; depth 5.8 to 7.3; D. 10 to 12; A. 12; scales 6–60 to 65–7. Body elongate, more or less cylindrical, about as broad as deep; head depressed, broader than deep; snout pointed, projecting beyond tip of mandible, 3.4 to 3.7 in head; eye 8.5 to 9.6; interorbital broad, concave, 5.3 to 5.9; mouth very large, the gape extending far beyond eyes; maxillary long and narrow, 1.6 to 1.7 in head; teeth present on jaws, palatines, and tongue, those in the upper jaw sharp and compressed, in two series, the inner and larger series depressible, the teeth in the lower somewhat smaller and in a narrower band, the teeth on the tongue and palatines rather prominent in bands;

scales moderate, rather thin, cycloid, seven rows on cheeks; dorsal fin rather high, the anterior rays not reaching tips of the posterior ones when deflexed, origin of fin a little behind base of ventrals and about equidistant from the adipose fin and middle of eye; adipose fin small, its base about as long as pupil of eye, situated over anterior half of anal base; caudal fin forked, the lobes of about equal length; anal fin rather long and low, the median rays shortest, its origin about equidistant from end of base of dorsal and base of caudal; ventral fins long, the inner rays about 1.5 times as long as the longest rays of the pectoral, inserted about equidistant from tip of snout and vent; pectoral fins rather small, 2 to 2.1 in head.

Color of two specimens 9¼ and 13 inches in length, brownish or olivaceous above, lower sides and below silvery white; operculum yellowish above; chin white; dorsal plain or pale yellow; adipose pale with dusky spot posteriorly; caudal dusky or yellowish, lower lobe darkest; anal white; ventrals white, pale yellow at base; pectorals plain, yellowish or light green. The young usually have more or less distinct dark crossbars on the back.

Six large specimens of this species, ranging from 234 to 330 millimeters (9¼ to 13 inches) in length, form the basis for the foregoing description. The young of this fish was not seen during the investigation. This species is the only one of the genus known from Chesapeake Bay and therefore is easily distinguished by its elongate form, depressed head, low, pointed snout, very large mouth, and the presence of an adipose fin.

In regard to the food of this fish, Smith (1907, p. 139) says:

"The lizard fish has a formidable mouth and it is a voracious feeder; small fish constitute its principal food, but crabs, shrimp, worms, and other animals are also eaten."

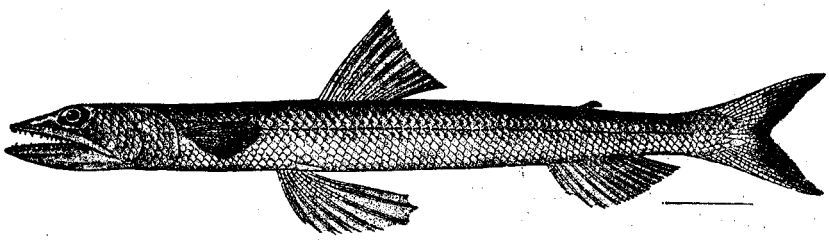

FIG. 70.—*Synodus fœtens* (lizard fish)

The contents of five stomachs of specimens taken in Chesapeake Bay consisted exclusively of small fish, as many as three being contained in one stomach. Three of these small fish, taken from three different stomachs, could be recognized as young weakfish (*Cynoscion regalis*). The others were too fragmentary to be identified.

The lizard fish is found on sandy shores and it is a bottom species. In some localities, because of this habit of living on the sand, together with the general shape of the body, this fish is known as the "sand pike."

Its spawning habits appear to be unknown.

This species is not common in Chesapeake Bay. During an entire season (April to November, 1921) of shore collecting not a single specimen was taken. From September 23 to October 27, 1922, at Ocean View, Va., 18 fish were caught in 11 of a total of 32 hauls of 1,800-foot seines on 10 different dates, the highest catch in one haul being 5. Nearly all these fish had gilled themselves far out on the wings of the seine and very few were taken in the bunt. These specimens were 11 to 13¼ inches in length. The only other lizard fish taken during the present investigation (a fish 9¼ inches long) was caught with hook and line on September 1, 1922, far up the bay at Chesapeake Beach, Md. Fish of the following lengths and weights were secured: Eleven inches, 5½ ounces; 12 inches, 7½ ounces; 12½ inches, 8½ ounces; 13 inches, 10 ounces. The lizard fish is reported to reach a length of 2 feet. As a food fish it has no value.

Habitat.—Massachusetts to Brazil.

Chesapeake localities.—(*a*) Previous records: Tide waters of the Potomac and along the shore of the southern end of the eastern peninsula, St. Charles Island, St. Jeromes, and Cape Charles City, Va. (*b*) Specimens in collection: Chesapeake Beach, Md., September 1, 1922, hook and line; Ocean View, Va., September and October, 1922, 1,800-foot seine.

Order HAPLOMI

Family XXX.—ESOCIDÆ. The pikes, pickerel, and muskallunges

Body very elongate, not elevated, and not much compressed; head long; snout long and broad, depressed; mouth very large; mandible projecting; margins of upper jaws formed by maxillaries, provided with a supplemental bone; teeth present on jaws, vomer, palatines, and tongue; gill slits wide; gill membranes not united and free from the isthmus; gill rakers small, tuberclelike or toothed; branchiostegals numerous; lateral line weak, obsolete in young; scales small, wanting on upper surface of head and snout, cheeks and opercles partly or completely scaled; dorsal placed far back, similar to and opposite the anal; caudal fin forked; no adipose fin; air bladder simple. This family consists of a single genus.

43. Genus ESOX Linnæus. Pikes; Pickerels; Muskallunges

The characters of the genus are included in the family description.

KEY TO THE SPECIES

a. Dorsal rays 13 or 14 (counting branched rays only); anal 12 or 13; branchiostegals 14 to 16; scales 122 to 126; adults with numerous lines, forming reticulations on the sides ..... *reticulatus*, p. 132

aa. Dorsal rays 11 or 12; anal 11 or 12; branchiostegals 11 to 13; scales about 105; sides usually with black vertical bars; no reticulations ..... *americanus*, p. 134

55. Esox reticulatus LeSueur. Eastern pickerel; "Chain pickerel"; "Pike."

Esox reticulatus LeSueur, Journ., Ac. Nat. Sci., Phila., I, 1818, p. 414; Connecticut River, Adams, Mass.; Philadelphia. Uhler and Lugger, 1876, ed. I, p. 145; ed. II, p. 124; Bean, 1883, p. 366; Evermann and Hildebrand, 1910, p. 159; Fowler, 1912, p. 54.
Lucius reticulatus Jordan and Evermann, 1896–1900, p. 627; Smith and Bean, 1899, p. 184.

Head 2.7 to 3.3; depth 5.3 to 6.6; D. 13 or 14 (counting divided rays only; 18 or 19 including rudiments); A. 12 or 13 (counting divided rays only; 16 or 17 including rudiments); scales 122 to 126. Body rather slender, somewhat compressed, deepest near the middle; head large, depressed above, the profile a little concave over snout; snout long and broad, equal to or a little longer than postorbital part of head, 2.1 to 2.8 in head; eye 5 to 10; interorbital 5.5 to 12; mouth large, nearly horizontal; the lower jaw projecting; maxillary scarcely reaching eye in very young, to or slightly past anterior margin of pupil in large specimens, 2 to 2.8 in head; teeth present on jaws, vomer, palatines, and tongue; the lateral teeth on lower jaw and those on vomer enlarged; branchiostegals 14 to 16; scales small, covering entire cheek and opercle; dorsal fin mostly opposite the anal, its origin about an eye's diameter in advance of origin of anal; caudal fin forked, the lower lobe the larger; anal fin similar to the dorsal; ventral fins rather small, inserted a little nearer the origin of the anal than base of pectorals; pectoral fins similar to the ventrals, 2.5 to 6.6 in head.

Color greenish above; pale underneath; scales above with golden luster; sides in adult reticulated with dark lines and streaks. These reticulations are most evident in the largest specimens and entirely wanting in the very young. A dark vertical bar under the eye and the young also with a dark longitudinal bar extending from the tip of the snout, through the eye, to margin of opercle. Fins plain, the dorsal and caudal darker than the others.

Many specimens of this pickerel, ranging from 28 to 490 millimeters (1⅛ to 19¼ inches) in length, were preserved, and these fish form the basis for the foregoing description. The chief diagnostic differences between this species and the banded pickerel are shown in the key to the species. The principal change that takes place with age is in color. The reticulations that are characteristic of the species, according to specimens at hand, are not well defined until the fish reaches a length of about 12 inches. The very young (1 to 2 inches long) are grayish in color in spirits, and the upper parts everywhere bear dusky punctulations. A black bar extends from the tip of the snout, through the eye, to the margin of the opercle. When the fish exceeds a length of 2½ inches dark areas appear on the sides, which for some time become more prominent with age. As the fish increases in length, narrow, pale, vertical bars appear along the upper parts of the sides. These pale bars

form the first suggestions of the reticulations that are to appear later. In specimens upwards of 10 inches in length the pale bars still persist, and along the lower part of the sides are numerous, elongate, pale blotches. It is these pale blotches that are destined soon to be inclosed by darker lines, forming the reticulations. In the adults, 12 inches or more in length, the reticulations usually are well formed; the pale vertical bars along the upper parts of the sides are very indefinite or entirely wanting. The dark bar, which in the young passes from the snout through the eye and over the opercle, has entirely disappeared, but instead a dark bar extending downward from the eye has developed. It will be seen from the description of the pronounced changes in color that take place with age that a general description of the color markings can not be relied upon in classifying specimens of this fish of varying sizes. The most reliable diagnostic characters are the number of rays in the dorsal and anal fins and the number of branchiostegals (the riblike rays under the lower edge of the gill cover), as shown in the description and in the key to the species.

The eastern pickerel, according to Kendall (1917, p. 27), feeds principally upon other fish, although it includes many other animals in its diet, such as frogs and other batrachians, and in fact any living thing moving in the water within reach and which it can capture and manage. Of 6 stomachs from specimens taken in the tide waters of Chesapeake Bay, which we examined, 1 was empty, 4 contained fish only, and 1 contained fish and shrimp. The fishes (which could be recognized among the food) consisted of silversides, sticklebacks, and killifishes.

The usual haunts of the pickerel are weedy streams and bays or coves of lakes. It is characteristically found among weeds, with the head slightly projecting. It often remains very quiet in this position for a long time, and upon the approach of small fish or other small animals it "shoots" forth from its hiding place with great rapidity in an effort to capture its prey.

Spawning takes place early in the spring. Specimens taken in Severn River early in November already had the sexual organs somewhat developed. Welsh (field notes) took a ripe female at Havre de Grace, Md., on April 11, 1914. Kendall (1917, p. 28) writes that the eggs are laid in glutinous strings of a yellowish-white color, which often form large masses and have been seen clinging to submerged bushes in great mats or long strings. Strings of eggs averaging from 2 to 9 feet in length have been reported. The eggs of the pickerel are said to hatch in about a week to 10 days. The larvæ are reported to be very small when hatched, but under favorable conditions and with a sufficient food supply growth proceeds fairly rapidly. Nearly all the young collected during the investigation were taken in a brackish, marshy pond near Solomons, Md., on April 28, 1922. These specimens, 90 in number, ranged from 28 to 90 millimeters (1⅛ to 3½ inches) in length.

As a food fish it is variously esteemed, being regarded by some as an excellent fish and by others as decidedly inferior. (Kendall, 1917, p. 29.) In the Chesapeake drainage it is regarded with much favor.

This species is comparatively common in the tide waters of the Chesapeake, particularly at the head of the bay and in the lower Chester and Severn Rivers, where it is common in brackish water.

The pickerel is one of the important food fishes of the Chesapeake drainage, where, during 1920, 76,818 pounds, worth $16,591, were caught. The greater part of the catch was taken in fresh or slightly brackish water in the numerous tributaries of the Chesapeake. In Maryland, 62,208 pounds were caught, and in Virginia 14,610 pounds. The largest part of the catch was taken in seines and fyke nets, followed by pound nets, gill nets, and trammel nets.

The greater part of the catch is taken from October to April. During November it is one of the principal species found in the large fish markets of Baltimore and Norfolk. It commands a good price and sells well.

It is reported (Kendall, 1917, p. 29) that in Massachusetts this species has reached a weight of 4 or 5 pounds in three years when kept in a large, warm pond, covered with lily pads and well stocked with young alewives. The largest pickerel of which we have a record weighed 9 pounds and was caught during 1909 in a New York lake. Fish weighing more than 5 pounds are rare. In Chesapeake Bay and its tributaries the average size of the pickerel, as caught by anglers and fishermen, is from 1 to 2 pounds. The following weights were secured: 10½ inches, 3.7 ounces; 11 inches, 4.3 ounces; 11½ inches, 5.1 ounces; 12 inches, 5.8 ounces; 16½ inches, 12.6 ounces; 19¼ inches, 1 pound 8.4 ounces.

Habitat.—"It is believed originally to have been restricted to the fresh waters of the Atlantic seaboard, being commonly found anywhere east of the Allegheny Mountains, from southwestern Maine to Florida. Aided by man, its range has been extended throughout the southern half of Maine and even farther north, into the lower waters of the St. John River, into New Brunswick, and elsewhere." (Kendall, 1917, p. 24.)

Chesapeake localities.—(*a*) Previous records: Many places from the tide waters and streams tributary to Chesapeake Bay. (*b*) Specimens in collection or observed in the field: Havre de Grace, Md., April, 1912; May 8–19, 1922; Aug. 26–31, 1921; November 9–12, 1921; December 20, 1911. Baltimore, Md., fish market, November 4–8, 1921. Annapolis, Md., May 1–3, 1922; August 17–19, 1921; November 1–3, 1921. Solomons, Md., April 26–28, 1922. Love Point, Md., May 11, 1922. Norfolk, Va., fish market, November, 1921, and November, 1922. The greatest salinity in which the species was taken was 12.61 per mille.

56. Esox americanus Gmelin. Banded pickerel; "Pike."

Esox lucius americanus Gmelin, Syst. Nat., 1788, p. 1390; Long Island, N. Y.
Esox umbrosus Uhler and Lugger, 1876, ed. I, p. 144; ed. II, p. 123.
Esox niger Uhler and Lugger, 1876, ed. I, p. 146; ed. II, p. 124.
Lucius americanus Jordan and Evermann, 1896–1900, p. 626; Smith and Bean, 1899, p. 184.
Esox americanus Fowler, 1912, p. 54.

This species is much less common than *E. reticulatus* in the tide waters of Chesapeake Bay. A single small specimen occurs in the collection. This little species may be distinguished from the chain pickerel (the only other species of the genus known from Chesapeake waters) by the somewhat shorter dorsal and anal fins, fewer branchiostegals, and by the color. These differences are shown in the key to the species.

The food of this fish, according to Bean (1903, p. 294) and Smith (1907, p. 143), consists principally of minnows. Its breeding habits have not been specifically described, but Kendall (1917, p. 37) wrote that they probably were very similar to the eastern pickerel.

This pickerel is of small size; according to Smith (1907, p. 143) and other authors it rarely exceeds a foot in length and is of less importance than the eastern pickerel as a food fish.

This species is reported from brackish and salt water from New York and New Jersey (see Kendall, 1917, p. 36), but it appears to be rare in the brackish waters of Chesapeake Bay, and it is of no commercial value.

Habitat.—East of the Allegheny Mountains, from Vermont to Alabama.

Chesapeake localities.—(*a*) Previous records: Streams in the vicinity of Havre de Grace, Md.; Rappahannock River; Potomac River. (*b*) Specimen in collection: Havre de Grace, Md., September 1, 1921. This fish is known to enter brackish water, but it was not taken under these conditions in Chesapeake Bay during the present investigation.

Order CYPRINODONTES

Family XXXI.—CYPRINODONTIDÆ. The killifishes

Body elongate, compressed (at least posteriorly); mouth small, usually terminal; premaxillaries protractile; teeth pointed in Fundulinæ, incisorlike in Cyprinodontinæ; gill membranes united, free from the isthmus; gill rakers short and thick; scales large, cycloid; no lateral line; dorsal fin single, composed of soft rays only; caudal fin posteriorly square or rounded, not forked; anal fin somewhat similar to the dorsal, not modified in the male; ventral fins abdominal; species oviparous.

KEY TO THE GENERA

a. Body short and deep, compressed; head not notably depressed; teeth in a single series, incisorlike, tricuspid ..... Cyprinodon, p. 135
aa. Body elongate and less strongly compressed; head more or less depressed; teeth in a single series or in bands, pointed.
  b. Teeth in a single series, all pointed; head scarcely depressed ..... Lucania, p. 136
  bb. Teeth in bands, all pointed; head depressed, flattened above ..... Fundulus, p. 137

44. Genus CYPRINODON Lacépède. Short minnows

Body short and deep; back elevated; mouth small; teeth in a single series, incisorlike, tricuspid; opercle superiorly fused with the shoulder girdle; scales large; males larger than females; oviparous. A single species of the genus occurs in the brackish waters of Chesapeake Bay.

57. Cyprinodon variegatus Lecépède. Variegated minnow; Sheepshead minnow.

Cyprinodon variegatus Lacépède, Hist. Nat., Poiss., V, 1803, p. 486; South Carolina. Lugger, 1877, p. 84; Smith, 1892, p. 64 Pl. XVIII; Jordan and Evermann, 1896–1900, p. 671, Pls. CXI and CXII, figs. 296 and 296a; Evermann and Hildebrand, 1910, p. 159; Fowler, 1912, p. 54.

Head 2.65 to 3.3; depth 2 to 2.65; D. 11 or 12; A. 10 or 11; scales 24 to 27. Body compressed, short and deep, becoming deeper with age, especially in the male; back elevated; upper profile gently and evenly elevated in the young and in females, with a concavity at occiput in adult males; head short; snout blunt, its length 3.3 to 4.7 in head; eye 2.5 to 4; interorbital 2.8 to 3.8; mouth rather small, terminal; premaxillaries strongly protractile; teeth in the jaws in a single

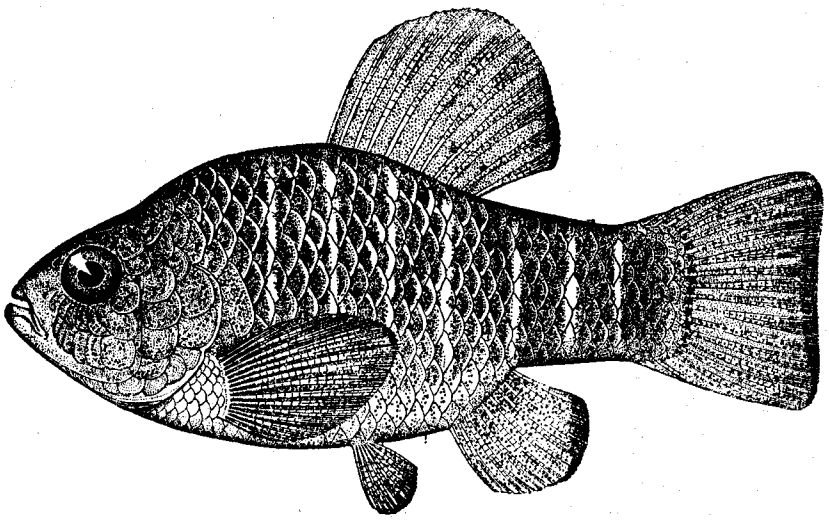

FIG. 71.—*Cyprionodon variegatus*, adult male

series, rather large, tricuspid, the median cusp the longest and broadest; scales large, the one placed just above the base of pectoral excessively enlarged, 4 or 5 oblique rows between the upper angle of gill opening and origin of dorsal; fins moderate, the dorsal particularly proportionately much larger in adult males than in females, inserted much in advance of the anal in both sexes; caudal fin with almost straight margin; anal fin smaller than the dorsal, particularly in adult males; ventral fins rather small, inserted equidistant from tip of snout and base of caudal or slightly nearer the latter; pectoral fins moderate, rounded, proportionately longer in adult males than in females, 1 to 1.5 in head.

Color of female brassy on the back and sides, with dusky blotches, usually forming bars on the lower part of the sides; yellowish or white below; dorsal olive or dusky, with a black blotch on the middle of the posterior rays; caudal greenish to dusky, with a dark bar at base; anal and ventrals pale yellowish with white margins; pectorals dusky to orange. Males darker, with bluish reflections on upper parts in advance of dorsal, sometimes brilliant blue along entire back; abdomen, at least during the breeding season, deep orange; dorsal bluish to dusky anteriorly, edged with pink or orange; caudal olive, with a very narrow dusky bar at base and a black margin; anal, ventrals, and pectorals orange, with bluish black margins.

Many specimens of this species were preserved. The above description is based on specimens ranging in length from 20 to 65 millimeters (4/5 to 2½ inches). The species is readily recognized by the short, deep body and the variegated color.

The food probably consists largely of vegetable matter. In 20 stomachs examined, only sand, mud, débris, and filamentous algæ were found. The intestine is convoluted and more than twice as long as the body, which is a further indication that the species is chiefly herbaceous. In the aquarium this fish readily feeds on fish and other meats. It is very ferocious in confinement, waging constant fights with other fishes. Whether they are of its own kind or of another species does not appear to make a particle of difference. It frequently kills fishes larger than itself by making repeated attacks and inflicting wounds here and there with its sharp tricuspid teeth until the victim succumbs from exhaustion or from the attack of disease. It then proceeds to devour its prey by tearing off piece after piece at any convenient place.

Spawning takes place throughout the spring and summer (Hildebrand, 1917, p. 13), one female laying eggs several times during one season. The eggs are spherical and about 1.2 to 1.4 millimeters in diameter (Kuntz, 1916, pp. 410–414). They are slightly heavier than sea water and adherent, being held together by minute adhesive threads. The period of incubation at ordinary summer temperatures in the laboratory extended over five to six days. The newly hatched larva is quite plump and about 4 millimeters in length. At a length of 9 millimeters the young fish already has many of the characters of the adult, and at a length of 12 millimeters virtually all of the diagnostic characters of the full-grown fish are developed.

The males of this species, contrary to the more usual rule among fishes, especially in related genera, are notably larger than the females, the average difference in length being about 12 millimeters. The sexual differentiation in color takes place when the fish are about 30 millimeters long. The young of 8 millimeters and less in length are almost entirely unmarked, but when the fish becomes a little larger, spots and bars appear and all the young (males and females) assume the color of the female.

This minnow is very common in all brackish waters of Chesapeake Bay, from Cape Henry to Love Point and Annapolis, but none at all were found from Baltimore to Havre de Grace, and none were taken in strictly fresh water. It is especially abundant in coves, bays, ponds, and creeks, and less common along the open beaches. In one instance, while collecting near Buckroe Beach, one haul with a 30-foot bag seine yielded about 1 bushel of variegated minnows. This minnow generally travels in schools, and on a rising tide swims about near the shore's edge in water 1 or 2 inches deep. At high tide the fish work their way up among the grass on overflowed banks, returning to open water with the receding tide.

The largest specimen taken during the investigation was 76 millimeters (3 inches) long, and it represents the maximum size attained by this species. It is too small to be of commercial importance, but on account of its abundance and wide distribution no doubt it is an important food for larger fishes.

Habitat.—Coastwise in brackish water from Cape Cod, Mass., to Mexico.

Chesapeake localities.—(*a*) Previously recorded from "Chesapeake Bay," "Lower Potomac," St. George Island, Tolchester, and Chestertown. (*b*) Specimens in collection: From many parts of the bay, from Love Point, Md., to Lynnhaven Roads, Va.

45. Genus LUCANIA Girard. Rain-water fishes

Body rather short, compressed; head small; mouth small, nearly terminal; teeth in the jaws pointed, in a single irregular series; scales rather large; dorsal and anal fins rather small, the dorsal above or in advance of the anal; the anal fin not modified; oviparous. A single species occurs in the waters of the Chesapeake.

58. Lucania parva (Baird and Girard). Rain-water fish.

Cyprinodon parvus Baird and Girard, Ninth Smithsonian Report, 1854 (1855), p. 345; Greenport, L. I.

Lucania parva Smith, 1892, p. 68; Jordan and Evermann, 1896–1900, p. 665, Pl. CIX, fig. 292; Evermann and Hildebrand, 1910, p. 159.

Head 3.4 to 3.7; depth 3 to 3.8; D. 11 or 12; A. 10 or 11; scales 25 or 26. Body rather short, compressed; caudal peduncle rather strongly compressed, its depth 1.6 to 2.4 in head; head small, about as deep as broad at eyes; snout blunt, its length 3.5 to 6 in head; eye 3 to 4; interorbital 1.3 to 1.8; mouth nearly terminal, the lower jaw projecting slightly; premaxillaries protractile; teeth small, pointed, in a single irregular series in each jaw; scales rather large, 6 or 7 oblique series between

the upper angle of gill opening and origin of dorsal; dorsal fin moderate, higher in adult males than in females, inserted nearly an eye's diameter in advance of origin of anal; caudal fin straight or slightly rounded posteriorly; anal fin similar to dorsal, the rays proportionately longer in adult males than in females; ventral fins rather small, inserted about an eye's diameter nearer the tip of snout than base of caudal; pectoral fins moderate, 1.3 to 1.8 in head.

Color of female dark olive above, pale underneath; scales on sides with dusky punctulations and dark edged, those on anterior part of sides with bluish and silvery reflections; a dark vertebral streak present in advance of dorsal; dorsal, caudal, and pectorals more or less greenish or olivaceous; other fins colorless. General color of male similar to female but somewhat brighter, at least during the breeding season; the anterior rays of the dorsal black or sometimes with only a black spot at base, the black occasionally extending on the outer margin of the fin; anal fin also sometimes with a dark margin; anal and ventrals with more or less red during the breeding season. The color of the young is similar to that of the adult female, the markings differentiating the sexes appearing when the fish has reached a length of about 25 millimeters.

Many specimens of this species were taken, ranging in length from 24 to 58 millimeters (1 to $2\frac{3}{16}$ inches). This fish is recognized by its small size and plain greenish coloration, no bars or stripes being present.

The only food present in 28 stomachs examined consisted of small crustaceans. However, the species no doubt also feeds on other small animal life. In the aquarium it readily takes finely chopped fish and beef.

Ripe or nearly ripe fish were taken from early in April until near the end of July. It seems probable that the fish spawn more than once suring a season, as the gravid females taken during the early part of the saeason, in addition to the ripe eggs, contained another size of eggs easily visible with the unaided eye. This may also account for the long spawning season. The eggs, when mature, are about 1 millimeter in diameter, and the largest number found in one fish was 104. Sexual maturity appears to be attained very soon after the color differentiation between the sexes takes place, or when the fish are about 25 millimeters in length. The largest inidividual taken during the present investigation was 58 millimeters ($2\frac{3}{16}$ inches) long, and it appears to represent the maximum size attained by the species. The females reach a somewhat larger size than the males, the average difference in the length being about one-fourth inch.

This fish is very abundant in all brackish waters of Chesapeake Bay, but was not taken in strictly fresh water. It is especially plentiful in coves, bays, ponds, creeks, and open flats, where vegetation is present. Its abundance is indicated by the following catches made with a 30-foot collecting seine: Love Point, Md., May 12, 1922, brackish creek, bottom mud and vegetation, 7 hauls, 18,300 *Lucania parva;* Annapolis, Md., May 2, 1922, brackish pond, bottom mud, dense vegetation, 20 hauls, 14,600 *Lucania parva.* The fish travel in schools and are often found in association with Gambusia and Fundulus.

Several investigators have mentioned this species as being of value for mosquito control, but this appears to have been based upon the nature of its habitat rather than upon direct investigations, and no definite information is available.

This fish is too small to be of commercial importance, but, because of its abundance and wide distribution, it no doubt is an important food for larger fishes.

Habitat.—As given by Smith (1907, p. 151) and others, Cape Cod to Key West.

Chesapeake localities.—(*a*) Previous records: "Lower Potomac," St. George Island, and Cape Charles City. (*b*) Specimens in collection: From shore waters of all parts of the bay from Love Point, Md., to Lynnhaven Roads, Va.

46. Genus FUNDULUS Lecépède. Killifishes; Mummichogs

Body elongate, posteriorly compressed, back little or not elevated; head rather broad, usually depressed; mouth terminal or the lower jaw slightly projecting; teeth usually villiform and in narrow bands; dorsal and anal fins usually higher in males than in females; caudal fin with straight or rounded margin; the anal fin not modified; oviparous, the sexes differing in color and size, the females being the larger. Several species of this genus frequent salt and brackish water and others, not considered in this report, are confined to strictly fresh water.

KEY TO THE SPECIES

a. Dorsal fin inserted over or in advance of origin of anal, with 10 to 15 rays; its base equal to or longer than that of the anal.

b. Scales rather large, 33 to 38 in a lateral series.

c. Body robust, average depth in length about 3.2; 11 to 13 oblique series of scales between upper angle of gill opening and origin of dorsal; ventral fins usually inserted equidistant from tip of snout and base of caudal; size rather large, maximum length about 125 millimeters ..... *heteroclitus*, p. 138

cc. Body less robust, average depth in length about 4; 18 or 19 oblique series of scales between upper angle of gill opening and origin of dorsal; ventral fins usually inserted about an eye's diameter nearer base of caudal than tip of snout.

e. Snout rather long, 2.6 to 3.5 in head; dorsal fin with 13 to 15 rays; young of both sexes with vertical black bars along sides; adult males with vertical side bars and a black ocellus on posterior rays of the dorsal; adult females with longitudinal black stripes and with variable oblique and vertical bars; size large, maximum length about 200 millimeters ..... *majalis*, p. 140

ee. Snout shorter, 3.7 to 5.5 in head; dorsal fin with 10 or 11 rays; both sexes usually with a black ocellus on the posterior rays of the dorsal; size rather small, maximum length about 65 millimeters ..... *ocellaris*, p. 141

bb. Scales rather small, 41 to 46 in a lateral series, 14 to 18 oblique rows between upper angle of gill opening and origin of dorsal; ventral fins inserted about an eye's diameter nearer tip of snout than base of caudal; size medium, maximum length about 111 millimeters ..... *diaphanus* p. 143

aa. Dorsal fin inserted over or a little behind origin of anal, about equidistant from the tip of the tail and anterior half of eye, very small, with only 8 rays its base shorter than that of the anal; snout short, 4 to 4.8 in head; size small, maximum length about 50 millimeters ..... *luciæ*, p. 144

59. Fundulus heteroclitus (Linnæus). Mummichog; Mud minnow; Killifish; Common killifish; "Pike minnow"; "Mud dabbler"; "Gudgeon."

Cobitis heteroclita Linnæus, Syst. Nat., ed. XII, 1766, p. 500; South Carolina.

Fundulus viridescens Uhler and Lugger, 1876, ed. I, p. 147; ed. II, p. 126.

Fundulus heteroclitus Uhler and Lugger, 1876, ed. I, p. 149, ed. II, p. 127; Bean, 1891, p. 92; Smith, 1892, p. 66, Pl. XIX; Jordan and Evermann, 1896–1900, p. 640, Pl. CII, fig. 273; Smith and Bean, 1899, p. 184; Evermann and Hildebrand, 1910, p. 159.

Fundulus pisculentus Uhler and Lugger, 1876, ed. I, p. 149; ed. II, p. 127.

Fundulus heteroclitus macrolepidotus Fowler, 1912, p. 54.

Head 3.2 to 3.7; depth 2.8 to 3.7; D. 11 or 12; A. 10 to 12; scales 35 to 38. Body rather robust, compressed; caudal peduncle strongly compressed, its depth 1.65 to 2.1 in head; head depressed; snout short, broad, its length, 2.7 to 4.7 in head; eye 4 to 5.8; interorbital 2.1 to 2.3; mouth terminal, mostly transverse; premaxillaries protractile; teeth all pointed, in villiform bands, the outer ones somewhat enlarged; scales moderate, 11 to 13 oblique series between upper angle of opercle and origin of the dorsal; dorsal fin rather long, higher in adult males than in females, its origin slightly in advance of origin of anal, inserted nearer end of caudal than tip of snout in adult females, about equidistant from tip of snout and end of caudal in adult males; caudal fin broadly rounded; anal fin with a slightly shorter base than the dorsal but with longer rays, the oviduct attached to the first ray; ventral fins rather small, inserted about equidistant from tip of snout and base of caudal; pectoral fins rather broad, 1.3 to 1.6 in head.

Color of large female in life plain brownish green above, paler underneath. Small females usually with 13 to 15 dark cross bars, narrower than the interspaces. No dark vertebral line; a small dark area at origin of dorsal; fins all unmarked, the vertical ones often with a greenish tinge. Color of a 3-inch breeding male dark green or olive above, blending into silvery on lower part of sides; yellow underneath; sides with about 15 narrow silvery vertical bars and numerous irregular white or yellowish spots, pale spots extending on lower half of vertical fins; head brownish between the eyes; silvery-blue punctulations below eyes; operculum dusky above, golden below, with punctulations; chin olive; caudal peduncle the color of back; dorsal and caudal dusky with yellow margins, a dark spot on posterior 4 or 5 rays of dorsal (this spot may not always be present); anal and ven-

trals golden; pectorals dusky yellow. When not in breeding condition the colors of the male fade somewhat. The young are mostly grayish and bear dark cross bars, which vary greatly in number. The color markings differentiating the sexes usually become evident when the fish have attained a length of 1½ to 1¾ inches. A large variation in the intensity of color exists among specimens, depending upon the environment in which they are taken, color adaptation being developed to a considerable degree.

Numerous specimens of this species taken in many localities, ranging in length from 20 to 123 millimeters (⅘ to 4⅞ inches), were preserved. This species is recognized by its chubby form, short and broad snout, and by the coloration. The smaller, brightly colored males are sometimes difficult to separate from the adult males of *F. luciæ*. When the color can not be relied upon for identification, the length and position of the dorsal fin must be taken into consideration. The dorsal fin in the present species consists of 11 or 12 rays and is inserted over or a little in advance of the origin of the anal. In *F. luciæ* the dorsal fin has eight rays and is inserted a little posterior to the origin of the anal.

This fish feeds on a large variety of foods. Among the contents of 48 stomachs examined, the following foods were found: Small crustaceans, small mollusks, annelid worms, insects, small fish, and vegetable matter, such as blades of grass, bits of roots, algæ, and seeds. A considerable amount of sand also was present in some of the specimens examined, but this may have been taken incidently in the capture of foods.

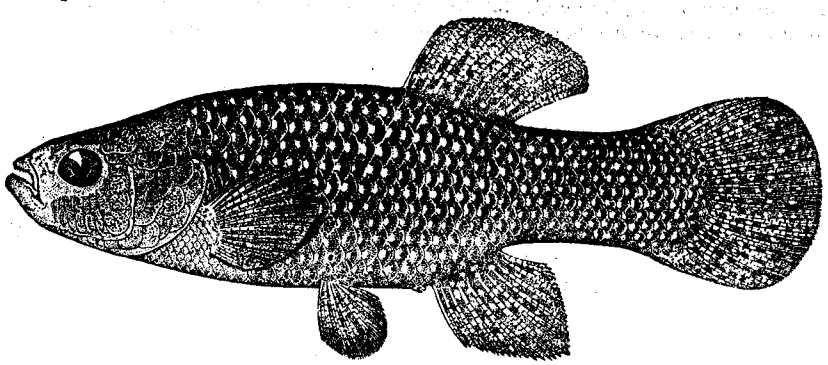

FIG. 72.—*Fundulus heteroclitus*, adult female

Spawning takes place from April to August, and it seems probable that one female may produce several broods of eggs during one summer. The ovary is single and the number of eggs produced varies greatly among specimens. The largest number of ova of one size found among several dozen specimens examined was taken from a female 98 millimeters in length, which contained 460. The eggs of one brood are of uniform size, rather large, and spherical when mature, measuring about 2 millimeters in diameter. Sexual maturity is attained by the female when it has reached a length of approximately 1½ inches, and the male may be sexually mature when 1¼ inches long. The largest fish taken during the present investigation was a female 4⅞ inches long, which represents the maximum size attained by the species, and the largest male was 4 inches long. The females reach a somewhat larger size than the males, the difference in the average length between the sexes among the adult fish being about one-half inch.

This fish is very common in the shallow, brackish-water coves and inlets of Chesapeake Bay, ascending streams to fresh water. It was rarely taken in strictly salt water, the species being more fresh than brackish water in its habits than *F. majalis*, athough the habitats of the two overlap. *F. heteroclitus* is found on many kinds of bottom, but it prefers mud, one of its common names being "mud dabbler," in allusion to its mud-frequenting habit. Chidester (1920, pp. 551–557), who made a special study of the habits of *F. heteroclitus* on the Bonhamptown Marshes, N. J., and at Woods Hole, Mass., states that a spring migration from the mouth of the Raritan River to the brackish and fresh waters takes place, and that when cold weather comes they again retire to the deeper waters. Those caught in pools burrowed in the mud upon the approach of cold weather. During the winter fish were found burrowed in the mud at a depth of 6 to 8 inches.

This killifish has been found to be of considerable value as an eradicator of mosquito larvæ on the brackish-water marshes of New Jersey and elsewhere. In addition to its value as a mosquito destroyer, it is of importance, no doubt, as food for larger predacious fishes. In some localities, notably New York and New Jersey, large quantities are sold as bait.

Habitat.—Coastwise, in brackish and fresh water, from Anticosti Island, Labrador, to Tampico, Mexico.

Chesapeake localities.—(*a*) Previously recorded from many sections of the bay and from tributary streams from Baltimore to Cape Charles. (*b*) Specimens in the collection: From all parts of the bay; taken almost daily during shore collecting, from April to November, in coves, inlets, and streams from Havre de Grace, Md., to Lynnhaven Roads, Va.

60. Fundulus majalis (Walbaum). Killifish; Striped killifish; "Gudgeon"; "Bull minnow."

Cobitis majalis Walbaum, Artedi Genera Piscium, III, 1792, p. 12; Long Island.
Hydrargyra majalis Uhler and Lugger, 1876, ed. I, p. 150; ed. II, p. 128.
Fundulus fasciatus Uhler and Lugger, 1876, ed. I, p. 148; ed. II, p. 126.
Fundulus majalis, Bean, 1891, p. 92; Smith, 1892, p. 64; Jordan and Evermann, 1896–1900, p. 639, Pl. CI, figs. 271, 271a, 271b; Evermann and Hildebrand, 1910, p. 159; Fowler, 1912, p. 54.

Head 3 to 3.6; depth 3.3 to 4.7; D. 13 to 15; A. 11 or 12; scales 33 to 36. Body rather slender, compressed posteriorly; caudal peduncle moderate, its depth 2 to 2.8 in head; head rather long, depressed; snout long, blunt, its length 2.6 to 3.5 in head; eye 6 to 8.6 in adults, 4 to 5.6 in young; interorbital 2.7 to 3.1; mouth horizontal, terminal, small; premaxillaries protractile; lower jaw

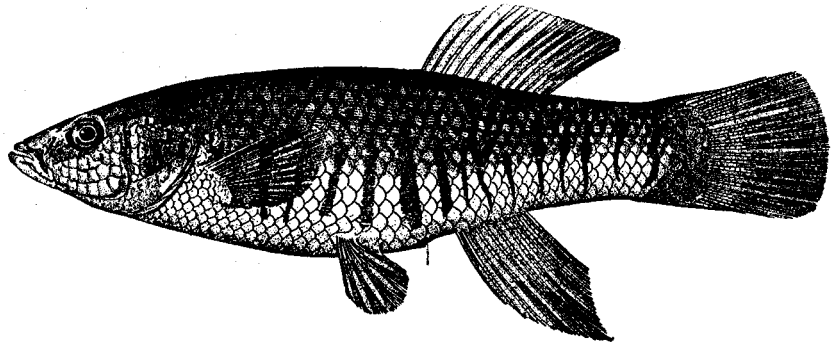

FIG. 73.—*Fundulus majalis*, adult male

slightly in advance of the upper; teeth all pointed, in villiform bands; scales moderate, 18 or 19 rows in advance of dorsal; dorsal fin rather long, notably higher in adult males than in the females. The rays of about equal length, its origin a little nearer upper anterior angle of gill opening than the base of caudal in the male, about equidistant from these two points in the female; caudal truncate or slightly rounded; anal rather short, much higher in adult males than in the females, the fourth or fifth rays longest, the origin of fin below anterior third of dorsal; ventrals inserted about equidistant from anterior margin of eye and base of caudal, usually reaching origin of anal in adult, shorter in young; pectoral rounded, the upper rays longest, 1.4 to 1.9 in head.

Color of adult male, back olive, sides salmon yellow, with 15 to 20 vertical black stripes; belly salmon yellow; cheeks and opercles diffused with black; dorsal dusky, a black ocellated spot on last rays; caudal somewhat dusky; anal, ventrals, and pectorals lemon. Female olivaceous above, white below, black markings on side, with considerable variation in adults of same size. The most common markings are two or three longitudinal stripes with several vertical crossbars near base of tail. Some fish marked with mixture of longitudinal, oblique, vertical, and complete or broken lines. The young of both sexes are marked with about 7 to 12 vertical bands along the sides. The markings differentiating the sexes usually occur when the fish are 1½ or 2 inches in length.

Many specimens of this species were preserved, ranging from 20 to 170 millimeters (⅘ to 6¾ inches) in length. This species is readily recognized by the large size that it attains, by the long head and snout, and by the distinct dark bars and stripes. The sexes, as shown by the color

description, are readily recognized by the difference in the markings, the males having dark cross-bars only and a prominent dark spot on the last rays of the dorsal fin, while the females have two or three longitudinal dark lines along the sides and no black spot on the dorsal fin.

The food of this fish consists of small mollusks, small crustaceans, small fish, and insects and insect larvæ. Many of the stomachs examined contained a considerable amount of sand and some vegetable débris. In the field it was noticed that this killifish fed greedily on pieces of meat, bread, and on shrimp eggs.

Spawning occurs from April to September, one female probably producing several broods of eggs during a single season. The eggs are rather large and spherical, measuring about 2 millimeters (12 to 14 to an inch) in diameter. Those of one brood are of uniform size. The ovary is single, and the largest number of eggs of uniform size contained therein in specimens examined was 540. In general the large fish produce more eggs at one time than the smaller ones. Sexual maturity is attained by the female when it has reached a length of approximately 3 inches, and the male may be sexually mature when 2½ inches long. The largest fish caught during the present investigation was a female 8 inches long, which represents the maximum size of the species. The females reach a somewhat larger size than the males, the difference in the average length between the sexes among the adult fish being about one-half inch.

This fish is very common in the vicinity of Chesapeake Bay and is found in bays, coves, creeks, tide pools, and along the outer shores. It is most abundant in small protected bodies of water, preferring especially to hover near the entrances to such places. It travels in schools of a few individuals to several hundred or more. On an ebbing tide it may be found on shallow flats, where the water it but a few inches in depth; but on a flood tide it adheres to the very shore's edge, where it often is cast on the beach by the waves, from which it easily returns to the water. If placed on the beach some distance from the water the fish has the ability to reach its habitat by a series of jumps. Experiments of this kind were made by the authors. Fish were placed at various distances (5 to 20 feet) from the water's edge. In almost every instance they jumped unerringly toward the water, progressing from several inches to several feet at a time. A special article on this apparent "homing instinct" in this species, written by Prof. S. O. Mast, appears in the Journal of Animal Behavior, vol. 5, No. 5, September–October, 1915, pp. 341 to 350.

This fish is of no commercial value, but because of its general distribution and great abundance in Chesapeake Bay it is of importance as food for other species.

Habitat.—Massachusetts to Florida in coastwise protected waters, brackish ponds, creeks, mouths of rivers, tide pools, etc.

Chesapeake localities.—(*a*) Previous records: Patapsco, Patuxent, and Potomac Rivers, Hampton Creek, Cape Charles, and other localities. (*b*) Specimens in collection: From all parts of Chesapeake Bay, along the shores from Baltimore, Md., to Lynnhaven Roads, Va., taken almost daily during the entire period of shore collection from April until November, 1921.

61. Fundulus ocellaris (Jordan and Gilbert). Killifish; Ocellated killifish.

Fundulus ocellaris Jordan and Gilbert, Proc., U. S. Nat. Mus., 1882, p. 255; Pensacola, Fla. Jordan and Evermann, 1896-1900, p. 642, Pl. CII, fig. 274.

Head 3.1 to 3.6; depth 3.7 to 4.3; D. 10 or 11; A. 9 or 10; scales 34 to 36. Body rather slender, compressed; caudal peduncle strongly compressed, its depth 1.8 to 2.3 in head; head depressed; snout moderate, 3.7 to 5.5 in head; eye 3.6 to 4.6; interorbital 2.2 to 2.7; mouth slightly superior, largely transverse; premaxillaries protractile; teeth all small, in a villiform band in each jaw; scales moderate, 18 or 19 oblique rows between upper angle of gill opening and origin of dorsal; dorsal fin moderate, much higher in the male than in the female, inserted over or slightly in advance of the anal, about equidistant from tip of tail and anterior margin of eye; caudal fin convex, somewhat more so than in *F. heteroclitus;* anal fin of about the same size as the dorsal, notably higher in the male than in the female; the oviduct ending at base of first anal ray; ventral fins rather small, inserted about equidistant from anterior margin of eye and base of caudal; pectoral fins moderate, 1.65 to 2 in head.

Color of female in life, brownish olive above, pale or slightly greenish below; lower part of sides from eye to anal yellowish; head, back, and sides of body irregularly sprinkled with black dots; sides with about 13 blackish cross bars; dorsal and caudal dusky golden, the base of these fins with

small black dots similar to those on the body; a large black ocellus on posterior rays of the dorsal (elongate on some specimens and not completely surrounded by white); anal fins wine color; ventral fins plain translucent; pectoral fins dusky golden. Color of male in life dark green above, pale below, sides with pearly spots, these most numerous on posterior half of body, frequently forming indistinct vertical bars; dorsal mostly dusky, with pearly spots at base, a black ocellus near base of last ray usually present; caudal and anal fins slightly dusky, each with pearly spots on base; the margin of the anal pale or slightly pinkish; other fins plain translucent. In young individuals of 30 millimeters and less in length the color is uniformly that of the adult female. The color of the

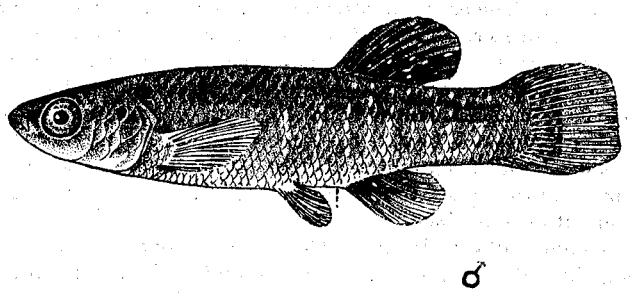

FIG. 74.—*Fundulus ocellaris*, adult male

species appears to be rather variable. As no notes were taken on the life colors of the males taken in Chesapeake Bay, the color description of that sex offered herewith is based on specimens from Beaufort, N. C.

This species is represented by 25 specimens in the present collection, ranging from 30 to 60 millimeters (1¼ to 2⅜ inches) in length.

The females of this species may be recognized by the brownish olive color, the upper parts being sprinkled with black dots and the sides having short, black, vertical bars. The males may be recognized by the same general greenish color of the female, but instead of being sprinkled with black dots this sex is sprinkled with pearly dots, which sometimes form indistinct vertical bars on

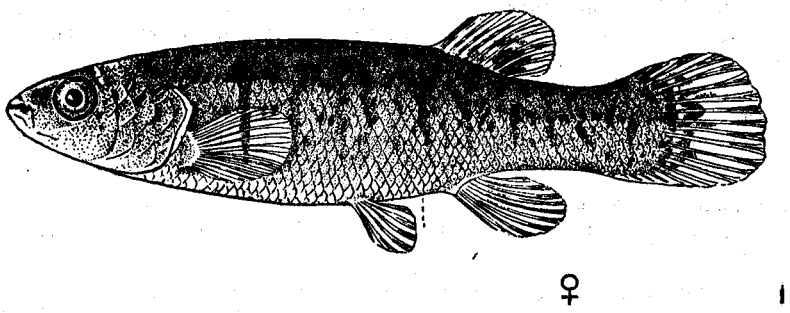

FIG. 75.—*Fundulus ocellaris*, adult female

the sides. Both sexes usually have a large ocellus on the posterior rays of the dorsal fin in allusion to which the species received its specific name, *ocellaris*.

The food of this fish, as shown by the contents of 15 stomachs, consists of insects, insect larvæ, small crustaceans, and small mollusks. A small amount of vegetable matter, too, was removed from three of the stomachs examined.

Gravid specimens were taken only during April and May. At Beaufort, N. C., however, where the senior author made special observations of this and related species, spawning fish were found from April to October. Sexual maturity appears to be attained when the fish are about 40 millimeters long. The largest female taken during the present investigation measured 60 millimeters (2⅜ inches) in length. The largest specimen taken at Beaufort during extensive collecting was 65 millimeters (2⅝ inches) long. The size of the male averages somewhat smaller.

This fish was taken only on the muddy marshes of Lynnhaven Bay. Our imperfect knowledge of the life history of this fish would indicate that the species is limited in its habitat to shallow, muddy, brackish-water swamps, where it is taken in company with *F. heteroclitus*.

This fish is said to be rather common on the Gulf coast. On the Atlantic coast it has been recorded only from Beaufort, N. C. (Hildebrand, 1916, p. 306). The range is now extended northward to Lynnhaven Bay, Va.

Habitat.—Coastwise from Chesapeake Bay to Louisiana.

Chesapeake localities.—(*a*) Previous records: None. (*b*) Specimens in collection: Lynnhaven Marshes, May 9 to 16, June 10 to 17, September 26, 1921, and April 6, 1922.

62. Fundulus diaphanus (LeSueur). Killifish; Fresh-water killy.

Hydrargyra diaphanus LeSueur, Journ., Ac. Nat. Sci., Phila., 1817, p. 130; Saratoga Lake.

Fundulus multifasciatus Uhler and Lugger, 1876, ed. I, p. 150; ed. II, p. 127.

Fundulus diaphanus Bean, 1883, p. 366; Smith, 1892, p. 65, Pl. XIX; Jordan and Evermann, 1896-1900, p. 645, Pl. CIII, figs. 275 and 275a; Smith and Bean, 1899, p. 184; Evermann and Hildebrand, 1910, p. 159; Fowler, 1912, p. 54.

Head 3.3 to 4; depth 4.1 to 5.7; D. 13 or 14; A. 10 to 12; scales 41 to 46. Body rather elongate, compressed; depth of caudal peduncle 2.2 to 3.3 in head; head depressed; snout broad and rather long, 2.8 to 4 in head; eye 2.8 to 4; interorbital 2.4 to 3.4; mouth mostly transverse, slightly superior; teeth in villiform bands, rather fewer and stronger than in related species; scales rather small, 14 to 18 oblique rows between upper angle of gill opening and origin of dorsal; dorsal fin rather long, scarcely higher in males than in females; inserted nearly an eye's diameter in advance of origin of anal in both sexes; inserted about equidistant from tip of snout and tip of caudal in females; fully an eye's diameter farther forward in adult males; caudal fin straight or slightly concave; anal fin shorter than the dorsal; the oviduct extending slightly above the base of the first anal ray; ventral fins of moderate size, inserted about an eye's diameter nearer tip of snout than base of caudal; pectoral fins rounded, 1.3 to 1.7 in head.

Color in life, female, olive above, silvery white on lower part of side, abdomen white; sides with about 16 to 20 narrow greenish bars, becoming dark in spirits; dorsal, caudal, and pectorals yellow; anal and ventrals plain translucent. Male, greenish olivaceous above, abdomen white; caudal peduncle bluish white underneath; sides with about 20 to 22 silvery iridescent vertical bars; dorsal more or less dusky, sometimes with small dark dots on the base; caudal dusky; anal and pectorals more or less yellowish; ventrals mostly bluish white, tinged with yellow. The young, as usual in this group of fishes, are similar in color to the adult female, the differentiation in color between the sexes taking place when the fish reach a length of approximately 50 millimeters.

Numerous specimens, ranging from 32 to 111 millimeters (1¼ to 4⅜ inches) in length, were preserved. This fish is distinguished from related species by the elongate body, long depressed snout, small scales, and by the many narrow vertical bars on the sides, the latter being darker than the ground color in the female and silvery in the male.

The food of this species, as indicated by the contents of 15 stomachs examined, consists of small crustaceans, insects, mollusks, annelid worms, and of miscellaneous unidentified vegetable matter.

Gravid fish were taken from April until September. The eggs, when fully developed, are spherical and about 2 millimeters in diameter. The ovary is single, and it usually contains eggs of more than one size. The largest number of eggs of one size found in one ovary in a limited number of specimens examined was 252. The males in this fish, as well as in the other species of the genus, are somewhat smaller than the female, the average difference in size being about one-half inch. Sexual maturity appears to be attained when the fish is about 2¼ inches in length. The largest individual of this species taken during the present investigation was a female 111 millimeters (4⅜ inches) in length, which appears to represent the maximum size attained by the species.

This minnow is more fresh-water in its habits than are the other members of the genus discussed in the present report. It is common in bays, rivers, and coves where the water is only slightly brackish, and it runs up the streams tributary to Chesapeake Bay into fresh water.

This killifish no doubt is of some value as an eradicator of mosquito larvæ. It is said to be an excellent bait for the larger predatory fishes, and it also is valuable as a natural food for these larger fishes.

Habitat.—From Quebec to North Carolina, represented by the variety *menona* in the region of the Great Lakes and in the northern part of the Mississippi Valley.

Chesapeake localities.—(*a*) Previously recorded from many sections of the fresher arms of the bay and from the streams tributary to the bay. (*b*) Specimens in the collection from the lower Rappahannock River, Va., to Havre de Grace, Md., on the western shore of the bay and as far south as Cape Charles City, Va., on the eastern shore. Not taken in the lower York River, Buckroe Beach, and Lynnhaven Bay.

63. Fundulus luciæ (Baird). Killifish; Baird's killifish.

Hydrargyra luciæ Baird, Ninth Smithsonian Report, 1854 (1855), p. 334; Beasley's Point, N. J.
Zygonectes luciæ Smith, 1892, p. 68, Pl. XVIII, fig. 3.
Fundulus luciæ Jordan and Evermann, 1896–1900, p. 654, Pl. CVII, fig. 286; Crawford, 1920, p. 75.

Head 3.1 to 3.6; depth 3 to 4.4; D. 8; A. 10; scales 34 to 36. Body rather elongate, compressed; caudal peduncle strongly compressed, its depth 2 to 2.4 in head; head depressed, snout short, 4 to 4.8 in head; eye 4 to 4.8; interorbital 2.1 to 2.6; mouth slightly superior, largely transverse; premaxillaries protractile; teeth pointed, in villiform bands in each jaw, with the outer teeth in each jaw considerably enlarged; scales moderate, 15 or 16 oblique rows between upper anterior angle of gill opening and origin of dorsal; dorsal fin short, its origin in both sexes over or slightly behind origin of anal and inserted about equidistant from the tip of the tail and the anterior half of the eye; caudal fin convex; anal fin with a somewhat longer base than the dorsal; ventral fins very small, inserted a little nearer base of caudal than tip of snout; pectoral fins moderate, 1.4 to 1.7 in head.

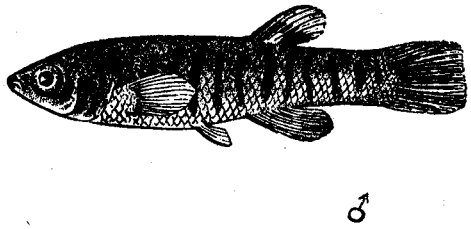

FIG. 76.—*Fundulus luciæ*, adult male

Color of female plain grayish green, pale below; eye dark, with narrow golden band; opercle with brownish peppery spots, forming a blotch; a dark vertebral line present; the fins all plain yellowish brown. Male olive-green above, lower sides golden, orange-white underneath; sides with 11 to 14 crossbars slightly darker in color than the back; the fins orange, pinkish, or light brown, the dorsal and anal usually bright orange to reddish; the dorsal with a black ocellus on the posterior rays. The young of about 26 millimeters and less in length all bear the modest color of the female, and the sexes are not distinguishable.

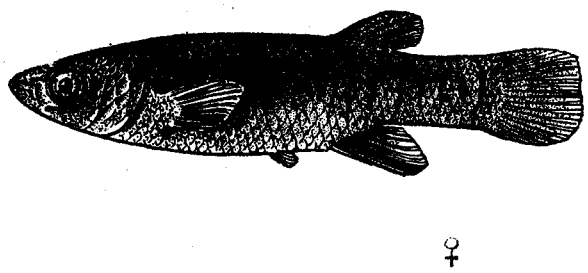

FIG. 77.—*Fundulus luciæ*, adult female

This species is represented by about 75 specimens in the present collection, ranging in length from 22 to 40 millimeters (7/8 to 1 9/16 inches). The females are readily recognized by the plain grayish green color, but the males resemble very closely the smaller brightly colored males of *F. heteroclitus*. For example, at Love Point, Md., both species were taken and placed in the same jar. Later it was found impossible in some instances to separate the males by the color. Usually the species may be distinguished by the slightly more posteriorly placed dorsal fin in *F. luciæ*, but the most reliable character, for purposes of identification, is the length of the dorsal fin, which in the present species constantly has two or three fewer rays, the usual number being eight.

The food of this species, as shown by the contents of nine stomachs, appears to be similar to that of *F. heteroclitus*, consisting largely of small crustaceans, small mollusks, and annelid worms.

Gravid specimens were taken only during April and May, but at Beaufort, N. C., the senior author found that in that vicinity, at least, the species spawns throughout the spring and summer, or from April until October. The eggs are rather large and spherical, measuring about 2 millimeters in diameter when mature. Since the fish reaches a much smaller size than *F. heteroclitus*, sexual

maturity is attained when the fish is much smaller. The exact size at which the sexual organs begin to develop has not been determined, but fish 1¼ inches long are plainly adult fish.

This minnow is not generally common. It was taken at only five localities in Chesapeake Bay, and it was only fairly common in one of these places, namely, Love Point, Md. It frequents very shallow, brackish water, and is taken in company with *F. heteroclitus*. This species has rarely appeared in collections. It was first taken and described by Baird (1855, p. 334) from Beasely Point, N. J. Then it appears not to have been taken again until Smith (1892, p. 68) secured two specimens from the lower Potomac. Fowler records the species from Pecks Bay, N. J. (1912, p. 36), and from Cedar and Parramores Islands, Lotusville Branch, and Virginia Beach, Va. (1912, p. 57). The senior author found the species common in restricted areas near Beaufort, N. C. (1916, p. 306), and Crawford took some specimens at Lewisetta, Va. (1920, p. 75). The color of the female appears not to have been described previously.

The species reaches a small size. The largest specimen taken in Chesapeake Bay during the present investigation was a female measuring 40 millimeters ($1\frac{9}{16}$ inches) in length. This fish, because of its small size and general scarcity, is of little or no commercial importance, either directly or indirectly.

Habitat.—Coastwise in brackish water from New Jersey to North Carolina.

Chesapeake localities.—(*a*) Previously recorded: Only from the lower Potomac. (*b*) Specimens in collection: Love Point, Md., May 11 and 12, 1922; Annapolis, Md., September 9, 1921, and May 1 to 3, 1922; Solomons, Md., April 27, 1922; Crisfield, Md., November 21, 1921; brackish swamp opposite Lynnhaven Roads, Va., June 10 to 17, 1921.

Family XXXII.—PŒCILIIDÆ. The top minnows

Body elongate; compressed posteriorly; head depressed; mouth terminal, or nearly so; teeth pointed; no lateral line; dorsal fin small, composed of soft rays only; caudal fin usually round, never forked; anal fin in the male modified, some of the rays produced, others short and more or less coalesced, the fin forming an intromittent organ. Species viviparous.

47. Genus GAMBUSIA Poey. Top minnows

Body moderately robust; head rather short, depressed; mouth moderate, the lower jaw projecting; teeth all fixed, pointed, in bands in each jaw; scales rather large; fins small, the anal fin in the male modified, the third, fourth, and fifth rays much produced, forming an intromittent organ; color plain; intestinal canal short; species viviparous.

64. Gambusia holbrooki Girard. Top minnow.

Gambusia holbrooki Girard, Proc., Ac. Nat. Sci., Phila. 1859, p. 61; Palatka, Fla.

Gambusia affinis Smith, 1892, p. 69, Pl. XX (female); Jordan and Evermann, 1896–1900, p. 680, Pl. CXIII, figs. 299 and 299a; Evermann and Hildebrand, 1910, p. 160.

Head 3.5 to 4.4; depth 3.5 to 4.7; D. 7 or 8; A. 9 to 11; scales 26 to 30. Body rather robust moderately compressed, usually deeper in the female than in the male; caudal peduncle strongly compressed, its depth 1.75 to 2.3 in head; head depressed; snout short and broad, it length 2.85 to 4.65 in head; eye 2.5 to 3.5; interorbital 1.8 to 2.5; mouth slightly superior, the lower jaw projecting; premaxillaries protractile; teeth small, pointed, in a band in each jaw; scales moderate, 12 to 14 oblique series between the upper angle of gill opening and origin of dorsal; dorsal fin small, placed behind origin of anal; caudal fin rounded; anal fin similar to dorsal in female, modified into an intromittent organ in the male, the third, fourth, and fifth rays being much produced, placed proportionately farther forward in adult males than in females; ventral fins small, inserted much nearer tip of snout than base of caudal; pectoral fins moderate, 1.1 to 1.4 in head.

Color of male and female similar but with considerable variation according to the environment because of the development of color adaptation; usually olivaceous above, grayish on sides, and pale underneath; scales on upper parts with dusky punctulations, these often concentrated on the margins of certain scales, forming irregular dark dots; a dark vertebral streak present in front of dorsal; a dusky area usually present under the eye and at occiput; dorsal and caudal usually slightly greenish and with dark dots (in light colored specimens the dots are frequently wanting); other

fins plain translucent. The female with a black blotch on each side of abdomen just above and in front of vent when gravid, increasing in size with the development of embryos and becoming very prominent before parturition takes place.

Many specimens were collected from various restricted areas, ranging in length from 19 to 42 millimeters (¾ to 1⅝ inches), and these form the basis for the above description. The species is recognized by its small size (although not unlike *Lucania parva* in size), the plain greenish or grayish coloration, and the depressed head. The males are readily distinguished by the peculiar prong-shaped development of the anal fin, which occurs in no other minnow in the vicinity of the Chesapeake. Geiser recently (1923, pp. 175 to 188) has shown that Gambusia of the eastern part of the United States differ from those of the Mississippi drainage in the detailed structure of the modified anal fin (intromittent organ; also called gonopod by Geiser). The eastern form has a larger number (11 to 14) of antrorse teeth on the distal ossicles of the third ray; and the larger ossicles, situated toward the base of the fin from the distal ones, are posteriorly denticulate, whereas in the Mississippi fish these segments are entire. The posterior branch of the fourth ray usually has seven ossicles, with teeth on the posterior margin in the eastern fish, while the Mississippi Valley fish has only about five ossicles with teeth. These differences, together with other minute differences, appear to be constant and therefore of specific value. Consequently the eastern Gambusia must be regarded as distinct from the central western one; and, as pointed out by Geiser, the Atlantic slope one, in accordance with rules of nomenclature, becomes *G. holbrooki* Girard and the Mississippi Valley fish should stand as *G. affinis* (Baird and Girard).

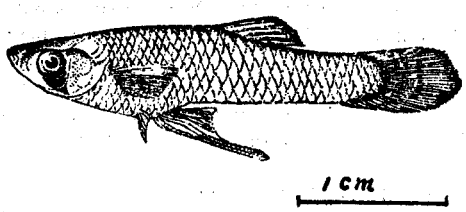

FIG. 78.—*Gambusia holbrooki*, adult male

This fish feeds on a large variety of foods, which, however, are taken principally at the surface, the habit of surface swimming and feeding being more strongly developed in Gambusia than in any of the other so-called "top minnows" inhabiting the waters of the United States. In 15 stomachs examined from specimens in the present collection the principal food consisted of insects and insect larvæ, although a few small crustaceans and a few egg masses, too, were present.

The young of this species are born alive and well developed, being 8 to 10 millimeters long. The first young appear in May, and spawning continues until about September. One female may deliver several broods of young during a single season. The number of young produced at one time may vary from a few to a hundred or more. The largest brood on record (Hildebrand, 1921, p. 12) consisted of 211 young. As a rule a small female has fewer young than a large one, although there are many exceptions to this rule. The average number of young in a brood probably does not exceed 25. A female kept in the aquarium (Hildebrand, 1917, p. 6) once produced six broods of young during one summer. The young grow rapidly, and usually when about 20 millimeters long the sexual differentiation in the anal fin takes place, and the fish are sexually mature very soon thereafter. Young born in May and reared in the aquarium have been known to produce young by September of the same year.

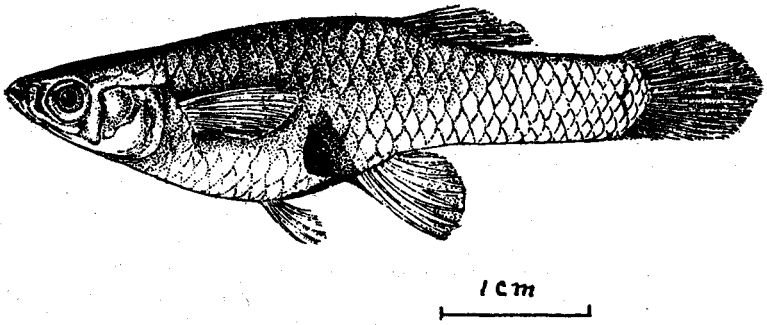

FIG. 79.—*Gambusia holbrooki*, gravid female

The largest specimen taken during the present investigation was only 1⅝ inches in length. This would indicate that the fish run rather small in the vicinity of the Chesapeake, for the maximum size attained by the species is about 2⅜ inches. The males, however, are much smaller, rarely reaching a length of 1½ inches.

This fish is common only in restricted areas in the brackish and fresh-water arms and disconnected pools and marshes of Chesapeake Bay, where, as a rule, the water is quiet and more or less stagnant. Although a few specimens of this fish have been reported as far north as New Jersey, the species may be said to reach the northern limits of its distribution in the Chesapeake region, where it is much more particular in the selection of its habitat than in more southern localities. However, it is usually quite common within the restricted places where it is found.

This top minnow and closely related varieties or species are now widely employed in the South for the destruction of the aquatic stages of the mosquito. Gambusia are so effective for this purpose that it is doubtful if a more valuable fish swims in American waters. For accounts of the importance of this fish for the control of mosquito breeding see Hildebrand (1919, 1921, and 1925) and Howard (1920).

Habitat.—As here understood, the range of *G. holbrooki* extends from New Jersey to Florida. The top minnows of this genus that occur in the United States have been considered identical and as belonging to a single species by some writers while by others they are considered three distinct species. Geiser, from studies based upon the microscopic anatomy of the anal fin of the male, as already stated, has recently determined (1923, pp. 175 to 188) that the structure of the distal part of this fin ("gonopod") is different in the eastern Gambusia from those of the South Central States, and he also found slight differences in this structure between specimens from the Central and Southwestern States; but he regards this last difference as of varietal importance only, while the more pronounced difference between the eastern and central specimens he regards as of specific value. He also found the Mexican species, *G. senilis*, extending into Texas. According to Geiser, the species of Gambusia should now stand as follows: Eastern form, *G. holbrooki;* central form, *G. affinis;* southwestern form, *G. affinis* var. (unnamed, presumably *patruelis* Baird and Girard); and the Mexican form, *G. senilis*, from southern Texas. On the basis of these new divisions, the exact limits of distribution of the species and varieties remain to be established. (A further revision of the species of Gambusia and their distribution has appeared since the foregoing was written, in "Studies of the Fishes of the Order Cyprinodontes, VI," by Carl L. Hubbs, in Miscellaneous Publications No. 16, Museum of Zoology, University of Michigan, 1926, pp. 26–40, to which the reader is referred.)

Chesapeake localities.—(*a*) Previous records: "Lower Potomac" and St. Georges Island. (*b*) Specimens in collection: Annapolis, Love Point, Solomons, Oxford, and Crisfield, Md.; also from the marshes of Lynnhaven Bay, Va.

Order SYNENTOGNATHI

Family XXXIII.—BELONIDÆ. The needlefishes

Body very elongate, slender, compressed or not; both jaws produced, forming a beak, the lower one a little the longer; maxillary united with the premaxillaries; each jaw with a band of short, pointed teeth and a series of enlarged ones; lateral line low, running along the edge of belly; scales small; dorsal fin opposite the anal; no finlets; air bladder present.

KEY TO THE GENERA

a. Body only moderately or not compressed, the depth not greatly exceeding the width ---------- Tylosurus, p. 147

aa. Body rather strongly compressed, the width less than half the depth----- Ablennes, p. 150

48. Genus TYLOSURUS Cocco. The needlefishes; the garfishes

Body very elongate, little or not compressed; gill rakers obsolete; lateral line on sides of abdomen, becoming median on the caudal peduncle; dorsal and anal elevated anteriorly, falcate.

KEY TO THE SPECIES

a. Origin of dorsal behind origin of anal, about equidistant from base of ventral and base of caudal, with 13 to 17 rays; caudal fin scarcely forked, the margin merely concave; a dark lateral band present on sides and a median band on back..... *marinus*, p. 148

aa. Origin of dorsal over the origin of the anal, much nearer the base of the ventral than base of caudal, with 23 rays; caudal fin well forked; no dark bands on sides or back... *acus*, p. 149

65. Tylosurus marinus (Walbaum). Garfish; Houndfish; Billfish; Needlefish.

Esox marinus Walbaum, Artedi Piscium, III, 1792, p. 88; Long Island.

Belone longirostris Uhler and Lugger, 1876, ed. I, p. 142; ed. II, p. 121.

Tylosurus marinus Bean, 1883, p. 366; Bean, 1891, p. 92; Smith, 1892, p. 69; Jordan and Evermann, 1896-1900, p. 714; Smith and Bean, 1899, p. 185; Evermann and Hildebrand, 1910, p. 160; Fowler, 1912, p. 54.

Head 2.45 to 3.25; depth 14.3 to 24; D. 13 to 17; A. 17 to 21; scales about 325. Body slender, not compressed, very slender in young; caudal peduncle depressed, broader than deep, with a slight keel on the sides, its depth 15 to 20 in head; head long, flat above and with a broad groove; cheeks and opercles straight and nearly vertical; snout produced into a long slender beak, its length 1.47 to 1.87 in head; eye 9.5 to 13; interorbital 9.5 to 13; mouth large, horizontal; lower jaw the longer; upper jaw scarcely arched; teeth in bands in each jaw, very sharply pointed, the inner ones enlarged, caninelike; lateral line complete, on lower edge of sides, curved upward on posterior part of caudal peduncle; scales small, cycloid, present on the preopercle but not on the opercle; dorsal fin inserted behind origin of anal, about equidistant from base of ventrals and base of caudal, the anterior 6 or 7 rays much longer than the posterior ones; caudal fin with concave margin; anal fin similar to the dorsal but with a somewhat longer base; ventral fins rather small, inserted about an eye's diameter nearer margin of opercle than base of caudal; pectoral fins moderate, the upper ravs the longest, 3.4 to 4.7 in head.

Color greenish above, silvery on sides, white below; a dark greenish stripe on median line of back and a narrower bluish silvery stripe along sides, becoming broader and less distinct posteriorly and frequently disappearing on caudal peduncle in large specimens; snout dark green; cheeks and opercles silvery; a blackish blotch, deeper than long, on upper part of preopercle; dorsal plain translucent or somewhat dusky, the longest rays yellowish at tips; caudal bluish at base, the lobes yellowish; anal plain, the longest rays dusky in some specimens, yellowish in others; ventrals and pectorals plain.

Many specimens of this common species were preserved. The above description is based upon specimens ranging from 47 to 619 millimeters (1⅞ to 24⅜ inches) in length. This fish is distinguished from related species by the short dorsal and anal fins, which, however, show considerable variation among individuals in the number of rays present. In 130 specimens, 3 had 13 rays in the dorsal, 11 had 14, 35 had 15, 66 had 16, and 15 had 17. In the same number of fish, 7 had 17 rays in the anal fin, 40 had 18, 65 had 19, 17 had 20, and 1 had 21. The body is cylindrical at all ages, but it is much more slender in the young than in larger fish, which accounts for the great variation in the depth of the body shown in the description.

The food of this gar, according to the literature consulted, consists almost wholly of fish. We are able to substantiate this statement by the fact that of 18 stomachs examined, the contents, with a single exception, consisted of small fish, including the silver mullet (*Mugil curema*), the killifish (*Fundulus diaphanus*), and one or more species of silverside. One specimen had fed on shrimp. It is said to take small fish crosswise in its jaws, afterwards turning its prey around for the purpose of swallowing it.

Little is known of the spawning habits of this fish, but it is said that the eggs are deposited during the summer in bays and estuaries (Smith, 1907, p. 157). The ovary is single and a very large number of eggs are produced at one time. A specimen taken on May 21, 1921, has the ovary greatly distended with eggs that slightly exceed 1 millimeter in diameter.

The habit of surface swimming, which is correlated with surface feeding, makes this gar one of the most conspicuous fishes, and it is therefore well known to those living on the sea shores within the range of the species. Its movements are very swift and it is extremely difficult to catch with a dip net. It readily becomes entangled in the meshes of a seine or drag net, however, because of

its large mouth and long teeth, sometimes doing a considerable amount of damage to the nets. At times it is a nuisance to anglers on account of its bait-stealing habits.

This garfish is said to attain a length of 4 feet (Smith, 1907, p. 157), but the largest fish observed in Chesapeake Bay did not exceed 2½ feet. Little is known concerning the rate of growth. Young fish taken during the late spring and summer were of the following sizes: June 10, 1921, Lynnhaven Roads, 47 to 50 millimeters (1⅞ to 2 inches); June 25–30, Buckroe Beach, 50 to 106 millimeters (2 to 4⅙ inches); July 10, lower York River, 54 to 70 millimeters (2⅛ to 2⅘ inches); July 25–30, lower Rappahannock River, 62 to 129 millimeters (2⅖ to 5$\frac{1}{12}$ inches). Larger fish are difficult to group. Thus, while using a small haul seine at Ocean View, Va., on October 3, 15 fish were taken, measuring from 11 to 16 inches, the intervening sizes being well represented.

Several specimens were weighed in the field, giving the following results: Length 13.3 inches, weight 1.4 ounces; length 13.4 inches, weight 1.6 ounces; length 21.1 inches, weight 9.4 ounces; length 23 inches, weight 9.6 ounces; length 23.2 inches, weight 10 ounces.

This species is comparatively common in the Chesapeake region and is found in all parts of the bay from Havre de Grace, Md., to Cape Henry, Va. It ascends the various tributaries and has been recorded from fresh water (Smith and Bean, 1899, p. 185). Bean (1901, p. 405) states that "it ascends rivers far above the limits of the tide, feeding upon minnows and other small fishes." It is generally found in small schools of from a few to several dozen fish, and occasionally an individual is taken alone.

Although the flesh of the gar is palatable, the fish has no commercial importance in Chesapeake Bay. It was never observed in any of the fish markets, and it was noted that fishermen always culled this species from the other food fishes.

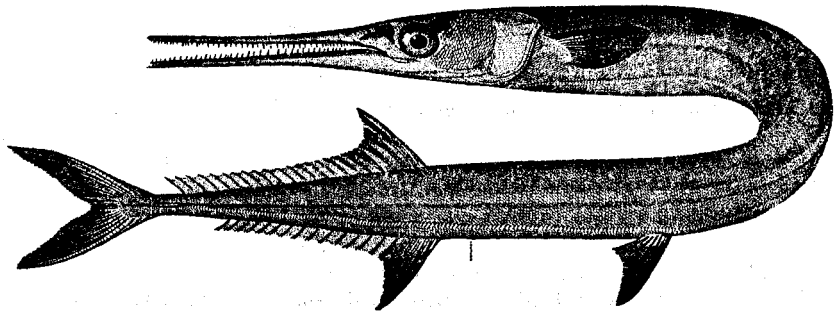

FIG. 80.—*Tylosurus acus*. From a specimen 43 inches long

Habitat.—Massachusetts to Texas, sometimes straying northward to Maine.

Chesapeake localities.—(*a*) Previous records: Nearly all brackish waters of Chesapeake Bay and its vicinity; Bryans Point and Aqueduct Bridge, Potomac River. (*b*) Specimens in collection: All parts of the bay from Havre de Grace, Md., to Lynnhaven Roads, Va.

66. Tylosurus acus (Lacépède). Houndfish; Garfish; Needlefish.

Sphyræna acus Lacépède, Hist., Nat. Poiss., V, 1803, p. 6, Pl. I, fig. 2; Martinique.
Tylosurus acus Jordan and Evermann, 1896–1900, p. 716, Pl. CXVI, fig. 309.

Head 2.6; depth 18.5; D. 23; A. 22; scales about 400. Body very elongate, not quite as broad as deep; caudal peduncle depressed, broader than deep, with a keel on the sides, its depth 24 in head; head long, flat above, and with a broad, shallow groove; cheeks and opercles straight and nearly vertical; snout very long and slender, its length 1.85 in head; eye 13.5; interorbital 11; mouth large, horizontal; the lower jaw slightly projecting; the upper jaw weakly arched, the mouth not quite capable of being closed; teeth in bands in each jaw, the inner ones enlarged, long and pointed, not compressed; lateral line complete, curved upward on caudal peduncle; scales quite small, cycloid, present on the preopercle but not on the opercle; dorsal fin inserted over the origin of the anal, much nearer the base of the ventral than base of caudal, the anterior rays elevated, much longer than the posterior ones; caudal fin forked, the lower lobe much the larger; anal fin similar to the dorsal, but with a shorter base; ventral fins moderate, inserted about equidistant

from posterior margin of eye and base of caudal; pectoral fins moderate, the upper rays longest, 5.25 in head.

Color of preserved specimen brownish above; sides silvery; pale underneath; ventral surface of head white; no bands on back or sides; dorsal largely black, the anterior part yellowish at base; caudal, anal, and ventrals mostly plain translucent, with more or less dusky, at least on the outer or anterior rays; pectoral fins largely black, only the base and the lower rays yellowish. The general color of the back is greenish in life.

A single specimen, 830 millimeters (32¾ inches) in length, occurs in the collection. In addition, a fish 32 inches in length, in a poor state of preservation, and which was thrown away by fishermen, was found on the shores at Buckroe Beach. This fish was colored blue along the back. The species of this genus are not all well known and the identification is more or less tentative. This disposition of the species is based mainly upon the long snout, the round, sharply pointed teeth, the small scales, the length of the dorsal fin, and the position of the ventral fins. This species is readily separated from the common garfish of Chesapeake Bay by the longer dorsal fin, the more deeply forked tail, and the absence of dark lateral and vertebral bands.

This gar appears to be a West Indian species that occasionally strays northward. In Chesapeake Bay it occurs only as a straggler and has no commercial importance. It reaches a length of 4½ feet.

Habitat.—Massachusetts to the West Indies; also said to occur in the Mediterranean.

Chesapeake localities.—(*a*) Previous records: None. (*b*) Specimens in collection or observed in the field: Lynnhaven Roads, June 8, 1916, pound net; Buckroe Beach, Va., June 21, 1921, found on beach.

49. Genus ABLENNES Jordan and Fordice. The garfishes

This genus differs from Tylosurus chiefly in the compressed body.

67. Ablennes hians (Cuvier and Valenciennes). Garfish; Needlefish; "Silver gar"; "Silver fish."

Belone hians Cuvier and Valenciennes, Hist. Nat. Poiss., XVIII, 1846, p. 432; Havana, Bahia.
Athlennes hians Jordan and Evermann, 1896–1900, p. 718.

Head 3.1 to 3.8; depth 15.9 to 16.5; D. 24; A. 25 or 26. Body very elongate, strongly compressed, head compressed, more or less quadrate, flat above, and with a broad groove, much narrower underneath, the sides nearly straight; snout very long and slender, 1.4 to 1.5 in head; eye 9.65 to 11.6; interorbital 9.7 to 11.3; mouth large; teeth in narrow bands, sharply pointed, the inner ones enlarged; lateral line following the lower edge of the body throughout; scales minute, too small to enumerate accurately; dorsal fin inserted behind origin of anal, about an eye's diameter nearer the base of ventral than base of caudal, the anterior rays elevated; caudal fin broadly forked; anal fin similar to the dorsal; ventral fins rather small, inserted considerably nearer eye than base of caudal; pectoral fins moderate, the upper rays the longest, 3.5 to 3.9 in head.

Color greenish with bright bluish-green reflections above; lower part of sides and abdomen bright silvery; snout bright red at tip; dorsal fin mostly greenish, the tip of the produced rays as well as the posterior rays black; caudal greenish, with more or less dusky and a pale margin; other fins mostly pale green, the pectorals with dusky tips.

Only two specimens of this gar, 400 and 445 millimeters (15¾ and 17½ inches) in length, were secured. The species is readily recognized by the compressed body and the straight and nearly vertical sides.

A considerable variation in color exists among specimens, as shown by a series of fresh specimens examined at Beaufort, N. C. Some specimens have dark blotches on the sides, others have distinct black crossbars, and in still others, as in the Chesapeake Bay specimens at hand, the sides are plain silvery. Much variation with age in the depth of the body, too, was noticed in the Beaufort specimens. In nine specimens, ranging in length from 4⅝ to 26 inches, the depth in the length to base of caudal varied from 11 in the larger fish to 24 in the smaller ones.

This fish is carnivorous. The alimentary canal is a straight tube, without a definite differentiation between the stomach and intestine. The air bladder is very long and narrow and it has very thin walls. The peritoneum is silvery and it bears dusky punctulations. The bones are greenish.