Comparative statistics of the shad product of Maryland and Virginia for various years from 1880 to 1921

Years	Pounds	Value	Years	Pounds	Value
1880	6,946,379	$275,422	1901	10,083,393	$486,805
1887	7,855,946	319,223	1904	10,332,148	599,397
1888	11,924,908	498,289	1908	11,251,000	733,000
1890	14,393,693	471,806	1909	9,282,888	761,205
1891	12,723,115	418,969	1915	6,168,669	849,527
1896	16,712,018	473,606	1920	9,161,001	1,500,323
1897	17,329,037	463,813	1921	8,716,250	1,546,990

NOTE.—The catch of shad in these States, outside of the Chesapeake Bay, is included for some years but is practically negligible.

27. Genus OPISTHONEMA Gill. Thread herring

Body elongate, compressed; the abdomen strongly compressed, armed with about 33 prominent scutes; lower jaw projecting; upper jaw somewhat emarginate; dorsal inserted in advance of ventrals the last ray greatly produced, filamentous; vertebræ about 42. A single species of this genus is known from the Atlantic coast of America.

37. Opisthonema oglinum (LeSueur). "Hairy-back"; Thread herring; "Shad herring."

Megalops oglina LeSueur, Journ., Ac. Nat. Sci., Phila., I, 1817, p. 359; Newport, R. I.
Opisthonema thrissa Uhler and Lugger, 1876, ed. I, p. 158; ed. II, p. 134.
Opisthonema oglinum Bean, 1891, p. 93; Jordan and Evermann, 1896–1900, p. 432.

Head 3 to 4.3; depth 2.6 to 2.9; D. 18 or 19; A. 22 to 24; scales 70 to 77. Body moderately deep, compressed; abdomen compressed, with sharp scutes on ventral edge; head rather small; snout moderate, 3.7 to 4.2 in head; eye with adipose eyelid, 3.6 to 4.2; interorbital 3.8 to 4.2; mouth nearly terminal; the lower jaw projecting a little; maxillary reaching anterior margin of pupil, 2.4 to 2.6 in head; teeth wanting in the jaws, small ones present on median line of tongue; gill rakers long and slender, numerous, 70 to 77 on the lower limb of the first arch; scales rather large, cycloid, loosely adherent; ventral scutes 17 or 18+15 or 16; lateral line wanting; dorsal fin rather small, somewhat elevated anteriorly, the last ray greatly produced in the adult, reaching nearly or quite to base of caudal, origin of dorsal in advance of ventrals and much nearer tip of snout than base of caudal; caudal fin forked, the lower lobe slightly the longer; anal fin long and very low, its origin nearer base of caudal than base of ventrals; ventral fin small, inserted under middle of base of dorsal; pectoral fins moderate, inserted a little in advance of margin of opercle, 1.2 to 1.3 in head.

Color in alcohol, bluish gray with a metallic luster above; lower part of sides silvery; tip of snout black; a more or less distinct dark shoulder spot; indefinite dark lines along the rows of scales on the back; fins chiefly plain translucent, the dorsal and caudal with black tips.

No small individuals were taken. Eight specimens of adult fish, ranging from 198 to 230 millimeters (7¾ to 9 inches) in length, were preserved. This species is readily recognized (except the very young) by the greatly produced posterior ray of the dorsal fin, which reaches nearly or quite to the base of the caudal fin. It is from this long, threadlike ray that the fish has received the name "hairy-back" and "thread herring."

The food of this fish appears to consist largely, if not wholly, of small organisms, which it strains from the water by means of its long gill rakers. Doctor Linton examined the contents of three stomachs and found copepods exclusively.

The hairy-back is essentially a tropical fish and as a rule it is not abundant in Chesapeake Bay. Its spawning habits are almost wholly unknown. This herring reaches a size of about 12 inches, but its flesh is bony and of little value as food. Its commercial importance among the fishes of Chesapeake Bay is slight, as it is rarely used for food. However, it is utilized along with the menhaden in the manufacture of fertilizer and oil when taken in sufficient quantities. The fish usually makes its appearance about the middle of May, and it leaves the bay during October. It is taken in comparatively small quantities in pound nets throughout the summer in the southern parts of the bay, the catch rarely exceeding 100 pounds a day for one set of nets. The hairy-back appears

to visit mainly that section of the bay that lies southward from the mouth of the Rappahannock River. The fish taken in the spring, among the specimens at hand, are very thin and poor, but those collected during the fall are fat and have broad, round backs.

Habitat.—Middle Atlantic States, southward to Brazil, and occasionally straying northward to Massachusetts.

Chesapeake localities.—(*a*) Previous records: Tributaries of Chesapeake Bay in the salt water (Uhler and Lugger, 1876); Cape Charles City (Bean). (*b*) Specimens seen or taken during the present investigation: York River, Va., July 8, 1921; Buckroe Beach, June 22, 1921; Lynnhaven Roads, May 25, 1922, and September 26, 1921.

28. Genus BREVOORTIA Gill. Menhadens

Body elongate, compressed, tapering posteriorly; head large; cheeks notably deeper than long; abdomen compressed and provided with bony scutes; mouth large; lower jaw included; teeth wanting; gill rakers long, thin, and numerous; scales deeper than long, closely imbricated, strongly pectinate; alimentary canal long; peritoneum black; vertebræ 46 to 49; fins small. A single species is known from Chesapeake Bay.

38. Brevoortia tyrannus (Latrobe). Menhaden; Skipjack; Bunker; Moss bunker; Alewife; Fatback; Bugfish.

Clupea tyrannus Latrobe, Trans., Amer. Phil. Soc., Phila., V, 1802, p. 77, Pl. I, Chesapeake Bay.

Brevoortia menhaden Uhler and Lugger, 1876, ed. I, p. 156; ed. II, p. 133.

Brevoortia tyrannus Bean, 1883, p. 366; Bean, 1891, p. 93; Smith, 1892, p. 64; Jordan and Evermann, 1896–1900, p. 433. Pl. LXXIII, fig. 195; Smith and Bean, 1899, p. 184; Evermann and Hildebrand, 1910, p. 158; Fowler, 1912, p. 52.

Head 2.9 to 3.4; depth 2.4 to 3.8; D. 18 to 20; A. 20 to 22; scales in oblique series along median line of side 48 to 56. Body elongate, compressed, the ventral outline much more strongly curved than the dorsal; abdomen compressed, with sharp scutes on the ventral edge; head large,

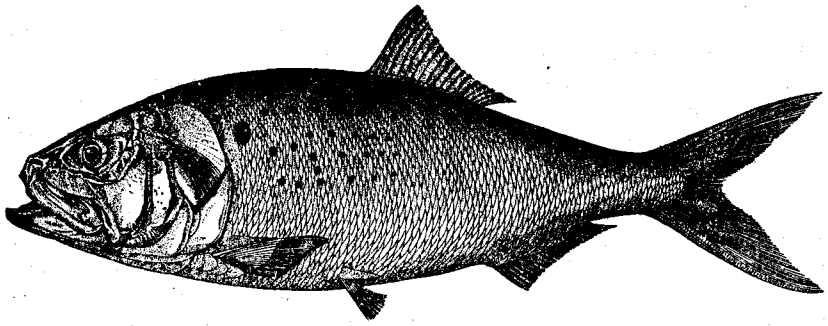

FIG. 55.—*Brevoortia tyrannus.* From a specimen 12 inches long

compressed; snout rather blunt, 3.8 to 5.5 in head; eye 4 to 5.9; interorbital 3.9 to 5.8; cheeks and opercles very deep, the upper part of opercle in adult with strong radiations, less prominent ones on the lower part of the preopercle; mouth moderate, terminal, the lower jaw largely included in the upper, the latter with a deep notch anteriorly; maxillary broad, rounded posteriorly, reaching past eye, in the adult, to middle of eye in young about 50 millimeters long; teeth in the jaws in the very young weak, disappearing entirely early in life; gill rakers extremely long, slender, close-set and exceedingly numerous; scales very closely imbricate, strongly pectinate, irregularly placed on upper part of sides, but in more definite series below median line of sides, the posterior margins nearly vertical instead of rounded, as in the herrings; lateral line wanting; dorsal fin rather small, somewhat elevated anteriorly, with a sheath of scales at base, except in the very young, origin of fin about equidistant from tip of snout and base of caudal; caudal fin rather deeply forked, the lower lobe somewhat the longer; anal fin rather long and low, slightly elevated anteriorly, its origin under tips of last rays of dorsal; ventral fins small, inserted slightly behind vertical from origin of dorsal; pectoral fin moderate, inserted slightly in advance of posterior margin of opercle, 1.7 to 2.1 in head.

Color of back dark green to bluish; sides brassy; a round, black, humeral spot present (except in the young of less than about 70 millimeters in length) and with or without a variable number of smaller dark spots on sides behind it; fins mostly pale yellow, some of them often more or less punctulate with dusky.

Many specimens of this species, ranging from larvæ 20 millimeters to adults 370 millimeters in length, were examined, and a large series was measured for the purpose of determining the range of variation within the species. The menhaden is so well known to those who live on the seashore within the range of the species that it is recognized at sight by old and young. The chief recognition marks of the species are the rather deep body, the compressed abdomen, deep cheeks, broad opercles, deeply emarginate upper jaw, strongly pectinate scales with posterior margins nearly vertical, and the greenish and brassy coloration. A pronounced variation in the depth of the body takes place within the species, which appears to be correlated, to a large degree, with the state of nourishment of the individual fish, the well-nourished fish being deeper than the poorer specimens. Similarly, a great variation in the width of the back also exists. When the fish is in a well-nourished state the back is very broad and layers of fat lie underneath the skin. The common name "fatback" is very appropriately applied to fish in this condition. A large crustacean parasite (*Cymothoa prægustator*) is commonly found inside the mouth of menhaden, giving rise to the name "bugfish."

The sexes are not distinguishable externally, so far as known to the writers, and the size attained appears to be nearly equal.

The menhaden feeds on small organisms, which it strains from the water by means of its long, slender, and very numerous gill rakers. The feeding and movements of schools of fish, as observed in the Patuxent River from aboard the *Fish Hawk* by the junior author, are described as follows in his field notes:

> The fish swam swiftly in circles, like the dust driven by a whirlwind; then suddenly formed in a straight line, continually rising and falling at various depths. Each time they rose their mouths were wide open, but it was not possible to see whether or not their mouths were open when they swam downward. The fish near the shore seldom "broke water," but those observed in the open swam in compact schools, causing ripples at the surface; at times hundreds of them swiftly darted a few inches out of the water, causing a noise that could be heard easily at a distance of 300 feet. One large school was seen to divide into two parts. Some schools swam against the tide and then suddenly turned back with the tide. No general direction seemed to be maintained.

Doctor Linton examined the contents of the alimentary canal of 44 specimens taken in Chesapeake Bay and found that in most cases they consisted of sandy mud, vegetable débris (mostly algæ), and some diatoms, and in a few cases they consisted principally of copepods. He gives (from his notes as follows) the contents of the alimentary canal of a specimen taken in the lower part of the Patapsco River, November 7, 1921, as typical of the lot examined:

> Gizzard full of yellowish mud, which, under high magnification, is resolved, as in previous cases, into vegetable silt with a little very fine sand. The vegetable material is reduced to a pulp, but vegetable cells can be distinguished, evidently of algal origin, material which makes up the vast majority of the food. Diatoms were present in considerable numbers, but do not constitute a large percentage of the food; very small, in fact, much less than 1 per cent. * * * Intestine filled with the same material.

Peck (1894, p. 113) gives the food of the menhaden as unicellular organisms, both vegetal and animal, together with the smaller Crustacea and other free-swimming forms.

Concerning the spawning habits of the menhaden, Kuntz and Radcliffe (1918, p. 119) state:

> Observations on the movements of the schools and examination of the reproductive organs lead to the belief that in New England spawning takes place in late spring or early summer and that from Chesapeake Bay southward the season is late fall or early winter. Some reasons have been advanced for believing that in the Chesapeake region, at least, there are two spawning seasons.

The present writers have secured no information that suggests two spawning periods in Chesapeake Bay during one year. The evidence at hand, however, indicates that spawning takes place during the fall, as fish with well-developed (although not ripe) roe were taken only during that season of the year. The size and development of the young taken during the winter and spring furthermore suggest that they were hatched during the fall. Fourteen larvæ caught during January had attained an average length of 27.7 millimeters; 6 taken during February averaged 33.5 millimeters; 5 taken during March averaged 27.3 millimeters; 4 taken during April averaged 33 millimeters; and 137 taken during May averaged 46 millimeters. The number of larvæ caught from January to April, of course, is too small to show the rate of growth during the winter months, but at any rate the indications are that it is very slow. These fish all bear large chromatophores, the majority of them still possess indications of fin folds, and none of them have developed scales, all of which shows that the fish are very young. No larval menhaden were taken during any other

season of the year. Further evidence that the breeding season may vary in different latitudes is produced by Bigelow and Welsh (1925, p. 122), for these authors state that in the vicinity of Woods Hole, Mass., spawning takes place chiefly in June, and that it continues well into October, and they add that the menhaden is equally a summer spawner in the Gulf of Maine, where spent fish and others approaching maturity have been reported during July and August.

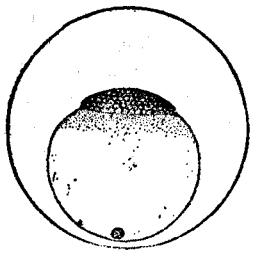

FIG. 56.—Egg in advanced stage of cell division

The eggs of the menhaden (Kuntz and Radcliffe, 1918, p. 119) are highly transparent, spherical in form, and they have a diameter of 1.4 to 1.6 millimeters. The period of incubation is given as "not over 48 hours," and the newly hatched larvæ have a length of approximately 4.5 millimeters. When the young fish reaches a length of about 33 millimeters all of the fins are well formed and scales are beginning to appear, but the body remains very slender. Large, black chromatophores are present on the head and nape, along the base of the anal, on the base of the caudal, and on the caudal peduncle posterior to the dorsal fin. Young fish 45 millimeters in length are fully scaled, and they have assumed the adult characters to such a degree that anyone familiar with the adult fish would recognize the young of this size. At one year of age the menhaden has reached a length of about 130 millimeters (5⅛ inches), and at two years of age it is 215 millimeters (8½ inches) long. Sexual maturity probably is reached during the third or fourth year.

The menhaden, as already indicated, is present in Chesapeake Bay throughout the year, although much less common during the winter than during the summer. The specimens caught during the winter were taken with a beam trawl in the deeper waters of the bay. During March, however, the fish again is common in the shallow waters and is taken in pound nets and haul seines. Very large schools of the migrating fish do not appear, as a rule, to enter Chesapeake Bay, and the abundance of menhaden does not seem to be affected by spring, summer, and fall "runs," as is the case along the outer shores of the middle Atlantic States.

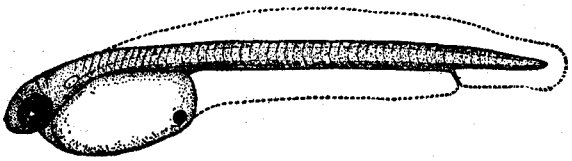

FIG. 57.—Newly hatched larva, 4.5 millimeters long

The menhaden industry[7] in the Chesapeake is of considerable importance. The amount of fish utilized in 1920 was 366,379,425 pounds, valued at $2,158,518. It is not known how much of this amount was taken within the bay, but a large percentage was caught outside the capes by purse-seine boats and brought in to the various factories in Virginia. Pound nets are credited with 6,233,920 pounds, worth $22,114, almost the entire catch being confined to Virginia.

The menhaden is utilized almost entirely for fertilizer (fish scrap) and fish oil. In 1920, 18 factories were in operation, employing about 900 persons. These factories were supplied by 42

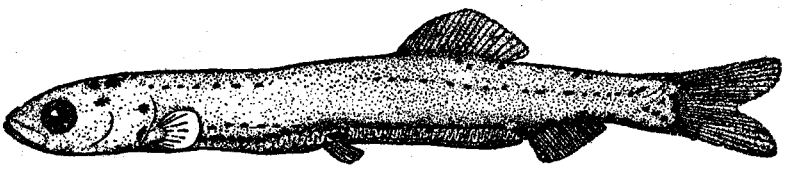

FIG. 58.—Larva 23 millimeters long

steam vessels, on which over 1,500 persons found employment. The industry is confined to Virginia, the chief centers being Northumberland and Lancaster Counties.

In many parts of the bay this fish is not utilized by the pound-net fishermen, but is separated from the catch of more valuable species and thrown away. In some localities it is sold to farmers at a small price and is used to enrich the soil. Within the vicinity of the factories, the pound-net fishermen sometimes dispose of a catch (when sufficiently large) by bringing the menhaden directly

[7] For a detailed account of the menhaden industry see "The Menhaden Industry of the Atlantic Coast" by Rob Leon Greer. Report, U. S. Commissioner of Fisheries, 1914 (1915), Appendix III, 27 pp., Pls. I-VII. Bureau of Fisheries, Document No. 811. Washington, 1915.

to the factory. During much of the fishing season the daily catch for a pound net is about 1 bushel of menhaden, an amount too small to market. Fishermen generally do not record the catch of menhaden, and for this reason the amount taken by pound nets probably is larger than that given in the statistics.

This species is taken during the major part of the fishing season—from March until late November. It ranges from the capes to the head of the bay and is very common as far north as Baltimore.

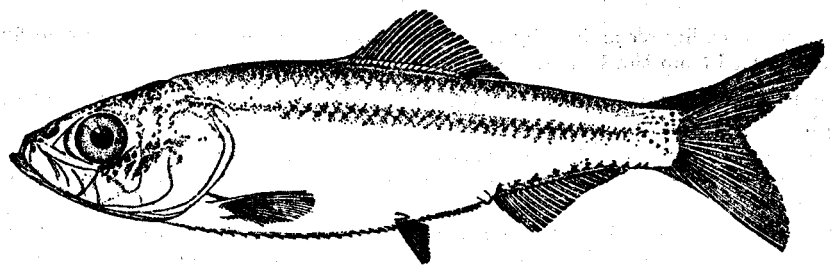

FIG. 59.—Young fish 33 millimeters long

Habitat.—"Nova Scotia to Brazil." (Jordan and Evermann, 1896–1900.)

Chesapeake localities.—(*a*) Previous records: Many parts of the bay, in salt and brackish waters. (*b*) Specimens in collection: From nearly all sections of the bay. Taken in shallow water during the summer and in deep water during the winter.

Comparison of weights and measurements of menhaden

Number of fish weighed and measured	Length	Average weight	Number of fish weighed and measured	Length	Average weight
	Inches	*Ounces*		*Inches*	*Ounces*
1	4	0.35	11	8.5	4.10
35	4.5	.58	9	9	4.65
17	5	.74	4	9.5	6.05
23	5.5	1.05	8	10	7.15
30	6	1.34	3	10.5	8.00
20	6.5	1.60	1	11.5	8.50
16	7	2.13	1	13	16.60
4	7.5	2.52	2	14	17.10
12	8	3.59			

For convenience the fish were divided into groups varying one-half inch in length. For example, the 4.5-inch group is composed of fish ranging in length from 4.25 to 4.74 inches, and the 5-inch group is composed of individuals ranging from 4.75 to 5.24 inches in length, etc. The weights given constitute the average weight for all fish weighed and measured falling within a group.

The weight of menhaden, with respect to size, varies according to season, the fat fish being heavier in the fall than corresponding sizes of spring-caught fish. Apparently weights of fish taken in the same season may vary from year to year, depending upon the amount and kind of food available. The following table illustrates the difference in weight of menhaden from lower Chesapeake Bay caught during October, 1921 and 1922. These fish were weighed by the same metric scale.

Number of fish weighed and measured	Length	Weight	Number of fish weighed and measured	Length	Weight
1921			1922		
	Inches	*Ounces*		*Inches*	*Ounces*
7	5.1	0.78	2	5.1	1.07
5	5.5	1.01	4	5.5	1.15
2	5.9	1.19	8	5.9	1.36
4	6.3	1.44	7	6.3	1.55
1	6.7	1.57	7	6.7	1.93
2	7.1	1.95	8	7.1	2.21
6	7.9	3.59	3	7.9	3.27
3	8.3	3.52	7	8.3	4.26
2	8.7	3.77	9	8.7	4.64
1	9.1	4.22	2	9.1	5.17

Family XXI.—DOROSOMIDÆ. The gizzard shads

Body rather short and deep, strongly compressed; head small, short; mouth small, inferior; gill rakers numerous, slender; no lateral line; scales thin, cycloid, deciduous; anal fin long and low; the stomach rounded and very muscular, developed into a "gizzard." Mud-eating fishes.

29. Genus DOROSOMA Rafinesque

This genus is readily recognized by the prolongation of the last ray of the dorsal fin. A single species is recognized from the United States.

39. Dorosoma cepedianum (LeSueur). Gizzard shad; "Toothed herring"; "Oldwife"; "Mud shad."

Megalops cepedina LeSueur, Journ., Ac. Nat. Sci., Phila., vol. 1, 1818, p. 361; Delaware and Chesapeake Bays.

Dorosoma cepedianum Uhler and Lugger, 1876, ed. I, p. 160; ed. II, p. 136; Bean, 1883, p. 367; Jordan and Evermann, 1896–1900, p. 416, Pl. LXIX, fig. 183.

Head 3.3 to 4.6; depth 2.25 to 2.8; dorsal 14 or 15; anal 30 to 34; scales 56 to 64; ventral scutes 29 to 31. Body rather deep (with depth quite variable), compressed, the abdomen compressed,

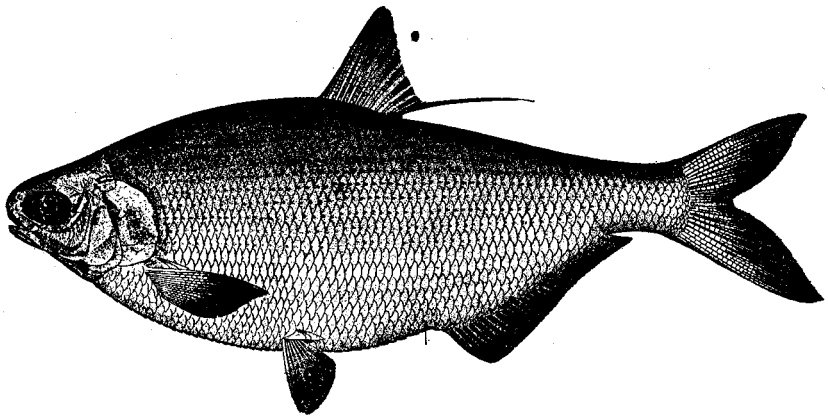

FIG. 60.—*Dorosoma cepedianum.* From a specimen 12⅝ inches long

with sharp scutes on ventral edge; head rather small (variable); snout blunt, projecting beyond mouth, 4.5 to 5.1 in head; eye with adipose eyelids, 3.45 to 5.25; interorbital 3.3 to 4.3; mouth inferior, rather small; maxillary reaching about opposite anterior margin of pupil, 3.1 to 3.75 in head; teeth wanting in the adult; gill rakers long and slender, numerous, about 135 on lower limb of first arch; scales rather large, reduced scales extending on base of caudal fin; lateral line wanting; dorsal fin rather small, somewhat elevated anteriorly, the last ray produced, sometimes nearly as long as head, origin of the fin somewhat nearer tip of snout than base of caudal; caudal fin rather deeply forked; anal fin very long, longer than head, 2.35 to 3.6 in length of body, its origin well behind the end of base of dorsal; ventral fins small, inserted about equidistant from base of pectorals and origin of anal, 1.65 to 2.3 in head; pectoral fins larger than ventrals, 1.15 to 1.3 in head.

Color of adult plain metalic blue above, silvery on sides; fins all more or less dusky. The color of immature fish, 107 to 127 millimeters in length, sea-green above, silvery below, frequently with a small black spot at shoulder; fins plain, dorsal and anal sometimes slightly dusky.

The Chesapeake collection contains 31 specimens ranging from 3¾ to 13 inches in length. No very young individuals were seen in brackish water. "The young are extremely different from the adult, slender and minnowlike in shape, and with a row of fine teeth on upper jaw, although the mouth of the adult is entirely toothless and smooth. The internal structure of the young also differs remarkably from that of the full-grown fish, especially in the much greater simplicity of the digestive apparatus, the intestine in specimens not more than an inch long passing almost directly back from the stomach to the vent." (Forbes and Richardson, 1908, p. 47.) The young also differ from the adult in having a large dark spot on the shoulder.

This species is readily recognized by the inferior mouth, the produced posterior ray of the dorsal, and by the very long anal fin. The adults also are characterized by the numerous, slender, close-set gill rakers, by the greatly thickened walls of the stomach, from which it derives the name "gizzard shad," and by the long convoluted intestine and numerous cœca.

The size of the head and the depth of the body vary greatly among specimens, as shown in the description. The dark shoulder spot, always present in the young, appears to persist much longer in some specimens than in others, and occasionally it probably never is lost. These variations form the basis for the descriptions of several nominal species. Only one species, however, is now recognized, and variations occur even among individuals taken in the same school.

The food consists almost exclusively of small organisms derived from mud, upon which it feeds. For the purpose of extracting these organisms from the mud, the fish is provided with a very effective straining apparatus in its gillrakers, which have already been described. Linton examined 10 stomachs taken from Chesapeake Bay specimens and found about 20 per cent of the "gizzard" content to consist of sand and mud and about 80 per cent of vegetable débris. One copepod was recognized and two Foraminifera. The intestine in this lot contained the same material, but with a rather larger proportion of sand. One Foraminifera, one Diffulgia, and one diatom were recognized.

Spawning occurs during the early summer. The species is very prolific. The gizzard shad is more fresh-water in habit than are the true shad and herrings, as it is found in fresh water at all seasons; in some instances it has become landlocked, under which conditions it is thriving. It has, in fact, become so fresh-water in its habits that it frequents only fresh and brackish water and is rarely seen in strictly salt water. Nevertheless, it appears to make certain migrations, at least in Chesapeake Bay, as there is a fall "run" in September and October; but we have no evidence that there is a corresponding spring "run", as one would expect and as reported for North Carolina by Smith (1907, p. 119).

We know comparatively little of the rate of growth of the gizzard shad in Chesapeake Bay, but the following total catches, and therefore unselected fish, show that a length of about 4 to 5 inches is attained by October. These fish all were collected at Ocean View, Va., except one specimen, which was taken from the Patuxent River on November 8.

Date	Number of fish taken	Range in size		Average length
		Millimeters	*Inches*	*Inches*
Sept. 25, 1922	5	101–125	4–5	4.3
Oct. 20, 1922	1	109	4.3	4.3
Oct. 18, 1922	14	107–126	4.2–5	4.5
Oct. 25, 1922	20	109–160	4.3–6.3	5.3
Nov. 8, 1921	1	101	4	4

The gizzard shad is a bony fish of rather poor quality and it commands a low price in the market. In the Chesapeake region it sells fairly well to a class of trade that demands a cheap fish. The retail price in the Baltimore market in 1921 was about 5 cents a pound. This fish is not taken in large quantities in Chesapeake Bay and it does not command a separate fishery, but at times when "fishing is bad" catches are made that are very helpful to the fishermen. During 1920, among the various Chesapeake Bay fishes, it ranked fifteenth in quantity and twentieth in value, the catch being 72,852 pounds, worth $2,013.

The importance of this fish among the commercial species, however, must not be judged from the quantity that is marketed and the price received. The food that the gizzard shad furnished for other fish, without itself eating foods utilized by most species, is no doubt of great economic importance. This point is well stated by Forbes and Richardson (1908, p. 46) in speaking of its importance among the fishes of Illinois:

> This immensely abundant species, although little esteemed as a food fish, is one of the most useful in our waters because of the almost exhaustless food supply which it offers to all the game fishes of our larger streams and lowland lakes. Living itself mainly upon food derived from the muddy bottoms of our very muddy rivers and lakes, it serves as a means of converting this mere waste of nature into the flesh of our most highly valued fishes.

The maximum length attained by the gizzard shad is given as 15 inches by Jordan and Evermann (1896–1900, p. 416), and the *average weight* is given as 1½ to 2 pounds by Smith and Bean (1899, p. 183) and others. This weight is quite certainly the maximum instead of the average weight. The average length of the adult of Chesapeake Bay, at least, appears to be between 11 and 12 inches, and fish of this length, as shown by the accompanying table, weigh less than 1 pound.

The gizzard shad, as already indicated, appears to be common in Chesapeake Bay only during the fall months, when it is taken principally in brackish water near the mouths of fresh-water streams. In the rivers of the Chesapeake region it is common or even abundant throughout the year.

Habitat.—Fresh and brackish waters of the Atlantic coast, from Massachusetts to Mexico, and the Mississippi Valley and Great Lakes. Also landlocked in many ponds and lakes.

Chesapeake localities.—(*a*) Previous records: Chesapeake Bay (Le Sueur, 1817); Baltimore docks, Potomac, Patapsco, and other rivers (Uhler and Lugger, 1876); head of Chesapeake Bay (Bean, 1883); Potomac River (Smith and Bean, 1899). (*b*) Specimens seen or taken in brackish or salt water during the present investigation: Hawkins Point, Baltimore; mouth of Severn River; Chesapeake Beach; Blackistone Island, Md.; Lewisetta; Ocean View and Lynnhaven Roads, Va. Greatest salinity, 22.63 per mille.

The fish upon which the following weights are based with few exceptions were caught off Ocean View, Va., from September 25 to October 25, 1922.

Number of fish weighed	Length	Weight	Number of fish weighed	Length	Weight
	Inches	*Ounces*		*Inches*	*Ounces*
2	4.00	0.36	1	6.00	1.18
1	4.12	.40	1	6.25	1.42
7	4.25	.38	1	7.00	2.00
1	4.37	.43	1	[1] 8.00	4.50
3	4.50	.46	1	9.33	5.60
1	4.62	.54	1	[2] 9.63	4.57
4	4.75	.56	1	10.00	7.68
3	5.00	.59	1	[2] 11.75	7.42
1	5.25	.78	2	[1] 12.75	15.00
1	5.37	.82	1	[2] 13.00	12.00
1	5.75	.96			

[1] Caught off Chesapeake Beach, Md., in October, 1921.
[2] Caught October, 1921, on Blackistone Island, Potomac River, in a pond nearly landlocked. Note that the three fish from this locality are all below normal weight, due, perhaps, to the fact that they lived in a pond where the food supply was not abundant. All the remaining fish were taken in the open bay.

Family XXII.—ENGRAULIDÆ. The anchovies

Body elongate, more or less compressed; abdomen frequently compressed, forming a slight keel; snout pointed, usually projecting far beyond mandible; mouth large; maxillary usually reaching far past eye; premaxillaries not protractile; teeth usually small but sometimes uneven and caninelike; gill membranes separate or joined, free from the isthmus; gill rakers long and slender; pseudobranchiæ present; lateral line wanting; scales thin and cycloid, usually deciduous; dorsal usually about median in position; no adipose fin; caudal fin forked. A single genus of the family occurs in Chesapeake Bay.

30. Genus ANCHOVIELLA Fowler. Anchovies

Body elongate, compressed; abdomen usually compressed; snout conical, projecting prominently beyond the mandible; mouth large; the maxillary usually reaching far beyond eye; teeth very small, pointed; gill membranes separate and free from the narrow isthmus; gill rakers long and slender; scales rather large, thin, and usually deciduous.

KEY TO THE SPECIES

a. Anal fin with 24 to 27 rays, the origin of the fin under middle of dorsal base; silvery lateral band more or less diffuse; length about 3 inches ..... *mitchilli*, p. 109

aa. Anal fin with 20 or 21 rays, the origin of the fin under the last rays of the dorsal; silvery lateral band very bright and well defined; length about 4½ inches ..... *epsetus*, p. 110

40. Anchoviella mitchilli (Cuvier and Valenciennes). Anchovy.

Engraulis mitchilli Cuvier and Valenciennes, Hist. Nat. Poiss., XXI, 1848, p. 50, New York; Carolina and Lake Ponchartrain, La.

Engraulis vittatus Uhler and Lugger, 1876, ed. I, p. 161; ed. II, p. 137.

Stolephorus mitchilli Bean, 1891, p. 93; Jordan and Evermann, 1896–1900, p. 446; Smith and Bean, 1899, p. 184; Evermann and Hildebrand, 1910, p. 159.

Anchovia mitchilli Fowler, 1912, p. 52.

Anchoviella mitchilli Jordan and Seale, 1926, p. 405.

Head 3.9 to 4.45; depth 4.1 to 5.1; D. 13 to 15; A. 24 to 27; scales 37 to 40. Body strongly compressed; ventral outline much more strongly convex than the dorsal; the margin of abdomen compressed, forming a rather sharp edge; head moderate; snout conical, projecting notably in advance of lower jaw, 4.6 to 7 in head; eye 2.6 to 4.2; interorbital 4.1 to 5.9; mouth large, slightly oblique; maxillary long and sharply pointed posteriorly, reaching nearly or quite to margin of opercle, 1.1 to 1.38 in head; teeth pointed, present on both jaws; gill membranes largely separate

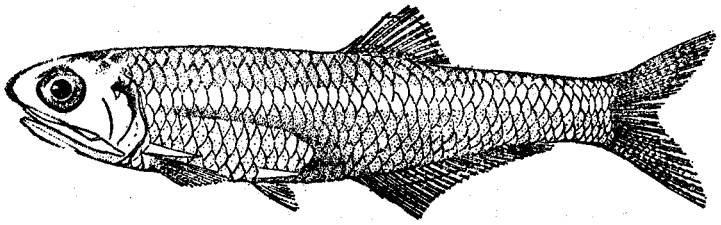

FIG. 61.—*Anchoviella mitchilli*, adult

and free from the isthmus; gill rakers rather long and slender, about 25 on the lower limb of first arch; scales thin, cycloid, deciduous, extending on the base of the fins; dorsal fin small, its origin notably nearer base of caudal than tip of snout, distance from tip of snout to dorsal 1.6 to 1.77 in body; caudal fin well forked; anal fin long and low, its origin near vertical from middle of base of dorsal; ventral fins small, inserted nearer origin of anal than base of pectorals; pectoral fins inserted low, 1.7 to 3.2 in head.

Color largely translucent, silvery; sides with a silvery lateral band, narrower than eye; back along base of anal and lower margin of caudal peduncle with dusky punctulations; cheeks and opercles silvery; fins pale or yellowish and usually with dark dots.

Many specimens of various sizes were preserved. The anchovies are readily recognized by their generally soft, delicate, more or less translucent appearance, large mouth, the prominently projecting, conical snout and the usually brilliant, silvery, lateral band. The present species differs from *A. epsetus* (the only other anchovy known from Chesapeake Bay) in the smaller size, narrower and less brilliant silvery lateral band, slightly longer anal, and in the relative position of the dorsal and anal fins. In *A. mitchilli* the origin of the anal is about under the middle of the base of the dorsal, whereas in *A. epsetus* the origin of the anal is only a little in advance of the base of the last ray of the dorsal.

A considerable variation in the depth of the body occurs among individuals of the same size, and a similar variation is especially great among individuals of various ages. In general the body becomes deeper with age. The larvæ are extremely slender, as the depth of specimens of about 16 millimeters in length is contained about 12 times in the body, 9 times in specimens 20 millimeters long, and 5.5 times in specimens 25 millimeters long. The range of variation in the depth of adult fish is shown in the foregoing description. The young, furthermore, differ from the adults in having a terminal mouth, a short rounded maxillary (which does not reach the margin of the opercle),

and in the absence of a definite silvery lateral band. The fish does not acquire all the characters of the adult until a length of about 60 millimeters is reached.

The food of this anchovy (according to an examination made of 44 stomachs taken from specimens collected during the months of January, February, April, May, July, August, October, and November) consisted almost wholly of Mysis and copepods. The former appeared to be the principal food of the adult and the latter the sole food of the young. Other foods consisted of two small anchovies (indicating cannibalism), three small gastropods, and one isopod. No changes in the foods taken at different seasons of the year are apparent.

The spawning season, as shown by field observations, egg collections, laboratory dissections, and by the widely separated dates upon which very young specimens were taken is a prolonged one, extending through the months of May, June, July, and August. The eggs, according to Kuntz (1914, p. 14), are slightly elongate, the major axis being 0.65 to 0.75 millimeter and the minor axis is from 0.1 to 0.3 millimeter shorter. The eggs are pelagic and almost perfectly transparent. The period of incubation at summer temperatures is about 24 hours. The larvæ, when hatched, are only 1.8 to 2 millimeters in length. The rate of growth of the young fish is extremely difficult to follow as it is impossible to separate collections into age groups by lengths. This almost perfect gradation of size among the young no doubt largely results from the protracted spawning season.

The maximum size attained by this anchovy, as shown by measurements made of Chesapeake collections, is a little less than 4 inches, for the largest fish obtained were 97 millimeters long (weight, one-third ounce). The average length of this fish for Chesapeake Bay is about 3 inches. This anchovy occurs in schools, and it is the most abundant species of fish, with the probable exception of the silverside (*Menidia menidia*), that inhabits the bay. It is present at all seasons of the year. During cold weather it appears to frequent chiefly deep water, but during the summer it is generally common along the shores and even in muddy coves, and it also ascends fresh-water streams. It is sometimes taken in the Potomac River in fresh water near Bryans Point, about 12 miles below Washington.

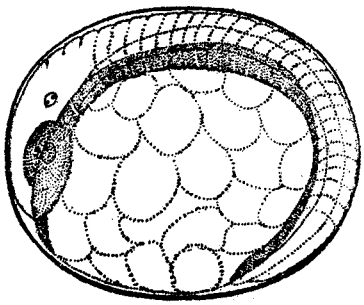

FIG. 62.—Egg with large embryo

In several Old World countries the anchovies are preserved like sardines and in various other ways. In America, however, they are much more important as food for other fish than as food for man. This species is not at all utilized by man in the Chesapeake region, yet it undoubtedly is of very great indirect commercial importance, as it appears to enter into the food of the larger predatory species more frequently than any other one species.

Habitat.—Atlantic and Gulf coasts, from Massachusetts to Texas; rarely northward to Maine.

Chesapeake localities.—(*a*) Previous records: Tolchester Beach, Riverside, Somerset Beach, lower Potomac, St. Jeromes, Md., and Cape Charles, Va. (*b*) Specimens seen or taken during the present investigation: From virtually all parts of the bay, from Havre de Grace, Md., to Lynnhaven Roads, Va.

41. Anchoviella epsetus (Bonnaterre). Anchovy.

Esox epsetus Bonnaterre, Ichthy., 1788, p. 175.
Stolephorus brownii Bean, 1891, p. 93; Jordan and Evermann, 1896–1900, p. 443.
Anchoviella epsetus Jordan and Seale, 1926, p. 396.

Head 3.6 to 4; depth 4.5 to 5.2; D. 14 to 16; A. 20 or 21; scales 38 to 40. Body moderately compressed; the ventral and dorsal outlines about evenly curved; the margin of abdomen little compressed; head moderate; snout conical, strongly projecting, 4.3 to 5.6 in head; eye 3.6 to 4.4; interorbital 3.8 to 5; mouth large, slightly oblique; maxillary long and sharply pointed, reaching nearly or quite to margin of opercle, 1.2 to 1.58 in head; teeth in the jaws small, sharply pointed; gill rakers rather long, about 20 on the lower limb of the first arch; scales thin, deciduous, extending on the base of the fins; dorsal fin small, its origin a little nearer base of caudal than tip of snout; caudal fin forked; anal fin of moderate length, its origin under the last rays of dorsal; ventral fins small, inserted equidistant from base of pectorals and the origin of the anal; pectoral fins moderate, 1.65 to 1.95 in head.

Color of fresh specimens pale gray and somewhat iridescent; the scales on back with dusky punctulations; sides with a broad, bright silvery band, a little narrower than eye; upper surface of head green and yellow; cheeks and opercles iridescent, silvery; fins mostly plain, the dorsal and caudal with more or less dusky.

Many specimens ranging in length from 46 to 150 millimeters were preserved and have been made use of in writing the foregoing description. The marks of distinction between this anchovy and *A. mitchilli*, the only other anchovy known from Chesapeake Bay, are indicated in the discussion following the description of the last-mentioned species.

The very young of this species, as in *A. mitchilli*, are much more slender than the adults. The great variation in the depth of the body among adults, noticed in *A. mitchilli*, however, is not apparent in the present species. The larvæ of both species are much alike, but those of *A. brownii* have the vent located correspondingly farther posteriorly, and as soon as the dorsal and anal fins have become differentiated the young of the present species may be recognized by the more posterior origin of the anal fin, which is under the base of the last rays of the dorsal, whereas in *A. mitchilli* it is under the middle of the dorsal base.

Nothing distinctive concerning the food of this anchovy can be said, as the examination of 16 stomachs shows that it is identical with that of *A. mitchilli*, consisting almost wholly of small crustaceans.

The spawning season of the present species appears to be identical with that of *A. mitchilli*. The eggs and embryology for *A. brownii* have not been described, and therefore such differences as may exist between the two species can not be given. The statements concerning the rate of

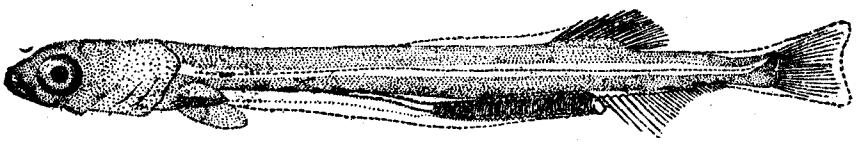

FIG. 63.—Larva 10 millimeters long

growth of the young fish, given in the discussion of *A. mitchilli*, appear to apply equally as well to *A. brownii*.

The maximum size attained by this anchovy, as shown by measurements made of Chesapeake collections, is 6 inches (weight, 1 ounce), and the average length is about 4½ inches (weight, one-half ounce). This anchovy, like *A. mitchilli*, occurs in schools. However, it is much less abundant in the bay as a whole than is *A. mitchilli*. *A. brownii* is common and at times very abundant in the southern parts of the bay. North of the mouth of the Rappahannock River it is comparatively rare. No specimens were taken during winter months, indicating that the species withdraws from the bay during cold weather.

The species has no direct commercial value in the region of the Chesapeake, but indirectly it must be of considerable importance because of the large numbers of these fish that are found in the food of the larger predaceous fishes.

Habitat.—Massachusetts to Uruguay.

Chesapeake localities.—(*a*) Previous record: Cape Charles, Va. (*b*) Specimens seen or taken during the present investigation: Annapolis, August 17, 1921, and Crisfield, Md., September 14, 1921; Lewisetta, August 4–8, 1921; lower Rappahannock River, July 25, 1921; Cape Charles, September 20–22, 1921; Buckroe Beach, October 5–10, 1921; Lynnhaven Roads, July 16, 1916, and September 27–30, 1921, and Ocean View, Va., September and October, 1922. All caught with collecting seines.

Order APODES. The eels

Family XXIII.—ANGUILLIDÆ. The common eels

Body very elongate, compressed posteriorly; head conical; opercles and branchial apparatus well developed; tongue distinct; teeth small, in cardiform bands on jaws and vomer; gill openings vertical; lateral line present; scales rudimentary, imbedded and placed at right angles to each other; dorsal and anal fins confluent around the tail; pectoral fins well developed.

31. Genus ANGUILLA Shaw. Common eels

Mouth large, the lower jaw projecting; nostrils well separated, the anterior one tubular; dorsal and anal fins long, the origin of the dorsal not near the head. A single species is known from American waters.

42. Anguilla rostrata (LeSueur). Common eel; Fresh-water eel.

Muræna rostrata LeSueur, Jour., Ac. Nat. Sci., Phila., V, 1817, p. 81; Lakes Cayuga and Geneva, N. Y.
Anguilla bostoniensis Uhler and Lugger, 1876, ed. I, p. 181; ed. II, p. 153.
Anguilla rostrata Bean, 1883, p. 367; Bean, 1891, p. 94.
Anguilla anguilla Smith, 1892, p. 69.
Anguilla chrysypa Jordan and Evermann, 1896–1900, p. 348, Pl. LV, fig. 143; Smith and Bean, 1899, p. 183; Fowler, 1912, p. 52.

Head 7.4 to 8.5 in total length; depth variable 1.65 to 2.65 in head. Body elongate, round anteriorly, compressed posteriorly; head of moderate length; snout rather pointed, 4 to 5.5 in head; eye 9.5 to 12; interorbital 6.5 to 8; mouth large, slightly oblique, reaching opposite middle of eyes; lower jaw projecting; anterior nostril situated on upper lip, provided with a tube; lateral line well developed, complete; scales small, imbedded, linear, arranged in groups, mostly at right angles to each other; origin of dorsal from 1.5 to nearly 2 times the length of head behind the gill slit; predorsal length of body 2.8 to 3.2 in total length; the dorsal and anal fins low, continuous with the caudal fin, which is round; pectoral fins moderate, proportionately longer in the adult than in the young; posterior margin round, the median rays longest, 2.65 (in adults) to 6 (in young) in head.

Color uniform greenish brown to yellowish brown above; white below.

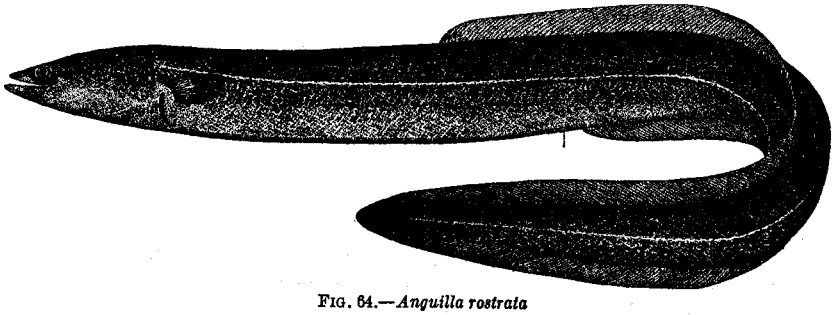

FIG. 64.—*Anguilla rostrata*

Numerous specimens, all of the adult form, ranging from the glass stage, 48 millimeters long to adults of 740 millimeters (1⅞ to 29⅛ inches), are represented in the Chesapeake collection. The young or larval form, known as the leptocephalus, has not yet been taken in Chesapeake Bay nor within the immediate vicinity of the shore anywhere along the American coast.

The eel is an omnivorous feeder. It is reported to be very destructive of other fish and even of one another and of the spawn of shad, herring, etc. Stomachs of 31 Chesapeake Bay specimens, ranging from 14¼ to 29¼ inches in length, examined by Linton, had fed on crustaceans, annelids, fish, echinoderms, mollusks, and eel grass, named in the order of the abundance in which they were found in the stomachs examined, beginning with the most common one. Thirteen stomachs of small examples, 2 to 8 inches in length, from various sections of the bay, examined by us, had fed mainly on amphipods and isopods. Three stomachs also contained fragments of a segmented worm bearing bristles; one contained the siphon of a mollusk, another a portion of a tunicate, and three specimens contained plant leaves or stems or both.

The life history of the eel is very complicated but extremely interesting. Although the female fresh-water eel spends most of its adult life in fresh water, it runs far out to sea to spawn.

Exactly where its spawning grounds are probably is not yet definitely known, although, with reference to the European and American eels, Dr. Johannes Schmidt is quoted[8] as saying:

[8] Fisheries Service Bulletin, Aug. 2, 1920, No. 63, p. 3 (United States Bureau of Fisheries). For an extensive account of the life history of fresh-water eels see Johs. Schmidt, IV.—The Breeding Places of the Eel. Philosophical Transactions, Royal Society of London, series B, vol. 211, 1922 (1923), pp. 179 to 208, pls. 17–18.

I think I am now able, after so many years' work, to chart out the spawning places of the European eel. The great center seems to be about 27° N. and 60° W. [southwest of Bermuda], a most surprising result, in my opinion. The American eel seems to have its spawning places in a zone west and south of the European, but overlapping. The larvæ of both species appear to pass their first youth together, but when they have reached a length of about 3 centimeters the one species turns to the right, the other to the left.

Neither is it definitely known, as far as the writers are aware, whether the eggs are pelagic or at what depth they are laid. The larvæ of such sizes as have been taken live at the surface, and it is now supposed that the eggs are pelagic.

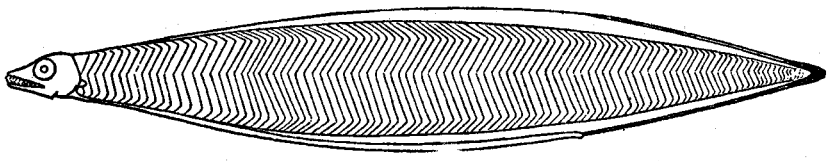

FIG. 65.—Leptocephalus stage, 49 millimeters long

The larva, or leptocephalus, is nearly as different in form from the adult as the caterpillar is from the butterfly. It was not until about 1895, or approximately 40 years after the leptocephalus was first described, that it was definitely determined that the leptocephalus was a young eel. The

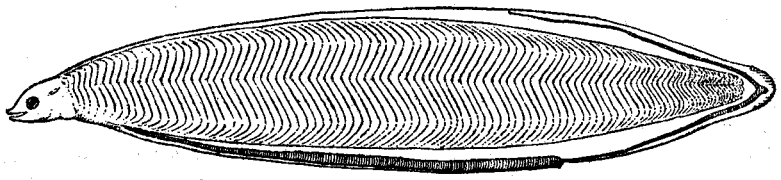

FIG. 66.—Leptocephalus stage, 55 millimeters long

larvæ are flat, ribbon shaped, tapering toward both ends. They are transparent, being entirely devoid of pigment, except in the eyes, and are readily overlooked in the collecting net. They have a well-developed mouth with very large teeth. In the process of metamorphosis the creature loses in length and depth but gains in width until the adult stage is attained.

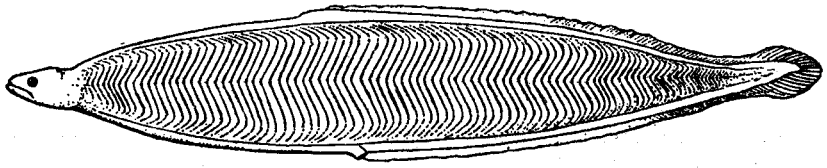

FIG. 67.—Leptocephalus stage, 58 millimeters long

The growth of the larvæ and metamorphosis take place while the young migrate from mid-ocean toward the shores. The smallest larvæ are taken nearest the spawning ground in mid-ocean and larger ones nearer the shores. By the time the eel reaches fresh water a complete metamorphosis has taken place. The length of fully developed larvæ, according to Schmidt (1912, p. 8),

FIG. 68.—Transition stage, 61 millimeters long

ranges from 60 to 85 millimeters, the length being reduced from 82 to 53 millimeters in the process of metamorphosis. The large larval teeth are lost, but they are replaced immediately by permanent ones. The dorsal and anal fins are produced farther forward; the pigment, however, is still largely wanting, as is indicated by the name "glass eel," and it forms very gradually. The following "glass eels" were collected at the surface in Chesapeake Bay by the *Fish Hawk* and the *Albatross*.

Date	Number	Size	Date	Number	Size
		Millimeters			*Millimeters*
Jan. 24, 1921	1	57	Jan. 17, 1916	14	50–60
Jan. 26, 1921	1	52	Jan. 18, 1916	2	48–50
Mar. 27, 1921	3	52–59	Feb. 19, 1922	2	54–57
Mar. 28, 1921	1	57			

Little is known of the rate of growth of the American eel or the approximate age at which it reaches sexual maturity and returns to salt water. Some attempts have been made by European investigators to determine the rate of growth and age of the European eel by an examination of the otoliths, the centra of the vertebræ, and the scales. Information derived from these studies indicate that the life of the eggs and larvæ may be two years (the American eel, however, is said to require only one year to pass through the metamorphosis), and that they probably have an average length of 7½ inches when 6 years old, and that at the age of 9 years the average length of the male is 14 inches and that of the female 15½ inches. Some evidence has also been obtained which indicates that maturity is reached at from 7½ to 9½ years of age. What becomes of the eel after it has spawned in mid-ocean also is not known, but it is generally supposed that it dies.

It is impossible to segregate eels into age groups based upon size, for all sizes are well represented in the catch of collecting seines. Commercial seines and nets have a mesh of such size that the smaller eels escape, so that data from this source are worthless as a means for determining rate of growth. However, our finest-meshed seines have caught enough very small eels so that some idea of the early growth may be had. It has already been pointed out that the "glass eel" that reaches our coast during the winter (January to March off the Chesapeake; as late as April in the Gulf of Maine) has a length of from 48 to 60 millimeters and is about 1 year old. The following catches of young eels that have passed the glass stage and possess the pigment of the adult have been made in Chesapeake Bay:

Date	Number measured	Inches	Date	Number measured	Inches
Apr. 26	2	2.4–3.1	Sept. 30	1	3
Aug. 8	3	2.3	Dec. 20	1	2.9
Sept. 1	1	2.5	Apr. 18	4	4.6–5.5
Sept. 19	3	2.7–3.9	Apr. 24	6	4.4–6.5
			July 23	3	6.9

Assuming that the fish have been grouped correctly in the foregoing table, the increase from one April to the next is from about 2½ to 5 inches, the greater length being attained when the eel is a little more than 2 years old.

The fresh-water eel is very common in the Chesapeake region, and in many places it is abundant in brackish water at the mouths of rivers and creeks.

The eel was considered so destructive of other fish that the legislature of Maryland, in 1888, passed an act and appropriated funds providing for the destruction of this fish. In 1892 and 1893 one-fourth of the funds appropriated for the use of the State fish commission was set aside for the destruction of the eel (Sudler and Browning, 1893, p. 27). The oak-split eel pot, baited with "fresh offal of any kind," was utilized in the capture of the eels. According to the report of the commissioners of fisheries of Maryland for 1892 and 1893 (p. 27), $3,413.25 were expended during these two years for destroying eels. A total of $80.77 was realized from the sale of the eels thus taken. No information concerning the number of eels destroyed or marketed is given. The work was discontinued in the following year. The effects upon the abundance of the eel and other fish, if any, which were brought about through the attempted destruction of eels, is not stated.

The following incident, which appears to be worthy of note on account of the difficulty with which an eel, because of its "slipperiness," is captured and retained after capture, was made by the junior author, whose field notes we quote:

WEEMS, RAPPAHANNOCK RIVER, VA., *July 25, 1921.*

An interesting incident was observed when a fish hawk caught an eel fully 20 inches long in several feet of water. The bird dropped the fish twice, recovering it each time, and several times it almost lost it. The hawk circled about several times with the eel before flying away. The fish could be seen plainly, squirming frantically to get away.

The eel reaches a large size in the Chesapeake region. Individuals 3 and 4 feet in length are seen occasionally in the markets. These large individuals are females, for the male probably does not exceed a length of 2 feet (Smith, 1907, p. 109). The flesh of the eel is firm and well flavored, but, owing to its resemblance to a snake, many people will not eat eels. In Europe this prejudice, if ever it existed, has been much more generally overcome, and the eel fisheries are of much greater importance than in America.

The eel is one of the important food fishes taken in the Chesapeake and its tributaries. During 1920 it ranked eleventh in quantity and tenth in value, the catch being 318,008 pounds, worth $33,704. Among the Maryland fishes it ranked seventh both in quantity and value, the catch being 197,293 pounds, worth $21,395. Of this amount, 77 per cent was taken in eel pots, 10 per cent in fyke nets, 7 per cent in pound nets, 4 per cent with spears, and 2 per cent with seines. In Virginia it ranked fourteenth in quantity and twelfth in value, the catch being 120,715 pounds, worth $12,309. Of this amount, 63 per cent was caught in eel pots, 21 per cent in fyke nets, and 16 per cent in pound nets.

This fish is taken principally in the vicinity of Rock Hall, Love Point, Oxford, and Crisfield, Md., and all western-shore rivers. A special fishery is conducted by means of eel pots in many of the tributaries of the bay. The majority of the pots are cylindrical in form with a conical entrance and are constructed of fine-meshed chicken wire. Sometimes many eel pots are attached to one cable, which may be from 500 to 2,000 feet long, similar to the gear used by lobster fishermen. The traps also are attached to the stakes of pound nets, for in such localities eels are attracted by the presence of dead fish.

Habitat.—Atlantic slope of North America from the Gulf of St. Lawrence to Panama, and in the West Indies, ascending fresh-water streams east of the Rocky Mountains.

Chesapeake localities.—(*a*) Previous records: Virtually all tributary streams. (*b*) Many specimens were taken during the present investigation from all parts of the bay and its tributaries.

Comparison of lengths and weights of Anguilla rostrata

[Actual lengths and weights of individual fish are given]

Inches	Ounces	Inches	Ounces	Inches	Ounces
2.7	0.03	20.8	11.1	23	12.4
3.1	.04	20.9	10.4	23	12.0
3.9	.07	21	11.3	23	14.1
7.9	.4	21.1	11.6	23	15.5
12.4	1.7	21.3	10.1	23.4	13.6
13	2.3	21.8	8.5	23.7	16.9
15.1	3.4	21.9	12.0	24.2	17.1
16.3	4.0	22	10.2	24.3	14.4
16.4	5.5	22.2	10.7	24.3	19.9
17.1	5.1	22.5	12.4	24.4	20.0
19	7.5	22.6	14.2	24.8	19.9
20.2	8.1	22.6	14.2	30	44.5
20.7	8.0	22.8	14.8	30.1	33.9

It will be noted that eels of the same length vary considerably in weight, due to the fatness of the individual. Thus, two fish, each 24.3 inches in length, differ in weight 5½ ounces, and two 30-inch fish differ by over 10 ounces. The 44½-ounce fish was abnormally fat. The sex of these eels was not determined, but it is not believed that a marked difference in weight due to sexual difference would occur between fish of the same length. As the male eel is said to reach a length of only 2 feet, the two largest fish of about the same length in the above table apparently were females and at the same time varied considerably in weight.

Family XXIV.—CONGRIDÆ. The conger eels

Body elongate; tongue largely free anteriorly; posterior nostril remote from the upper lip and placed near the eye; lateral line present; scales wanting; dorsal and anal fins confluent around the tail; pectoral fins well developed. A single genus of this family is represented in the fauna of Chesapeake Bay.

32. Genus CONGER Houttuyn. Conger eels

Mouth large, the upper jaw projecting; nostrils remote from each other, the anterior near tip of snout and tubular, the posterior near the eye; origin of the dorsal over or behind middle of the pectorals. A single species occurs in Chesapeake Bay.

43. Conger conger (Linnæus). Conger eel; Sea eel; Silver eel.

Murænа conger Linnæus, Syst. Nat., ed. X, 1758, 245; Mediterranean.
Conger oceanica Uhler and Lugger, 1876, ed. I, p. 180; ed. II, p. 153.
Leptocephalus conger Jordan and Evermann, 1896–1900, p. 354, Pl. LVII, fig. 148.

Head 6.35 to 7.3 in total length; depth 2.3 to 2.85 in head. Body elongate, anguilliform, round anteriorly, compressed posteriorly; head moderate; snout long, somewhat compressed, projecting beyond the mouth, 3.9 in head; eye 7.2 to 9; interorbital space 5.35 to 6.65; mouth inferior, slightly oblique; the gape reaching opposite posterior margin of pupil; anterior nostril situated on upper lip, provided with a short tube; lateral line complete, well developed; scales wanting; origin of dorsal over tips of pectorals, 0.4 to 0.7 length of head behind gill slit; predorsal length of body 4.6 to 5.15 in total length; dorsal and anal fins rather low, continuous with the caudal fin, which is narrowly rounded; pectoral fins moderate, round, 2.9 to 3.07 in head.

Color bluish gray, white beneath, dorsal fin with outer edge black, center light blue, dusky at base; anal pale with outer edge black; pectorals blue gray.

This eel is represented in the present collection by two specimens, 320 and 685 millimeters (12½ and 27 inches) in length. The conger eel is very similar in shape to the common fresh-water eel, from which it may be separated, however, by the projecting snout, the absence of scales, and by the very long dorsal fin, which has its origin about 0.4 to 0.7 the length of head behind the gill slit or over the tips of the pectoral fins, whereas in the fresh-water eel the origin of the dorsal is 1½ to 2 times the length of the head behind the gill slit and far behind the tips of the pectorals.

The conger eel feeds chiefly on fish, but it also takes other animal foods. (Smith, 1907, p. 112.) We have observed congers caught on the New Jersey coast on hooks baited with crab (Cancer) and clams (Macra, Mya). Cut fish is given as another bait.

The conger eel deposits its eggs at sea but evidently not as far from the shores as the fresh-water eel, for what were presumably conger eggs were collected by the *Grampus* 30 miles south of Nantucket Lightship, off the southern Massachusetts coast. These eggs were pelagic and about one-tenth inch (2.4 to 2.75 millimeters) in diameter when fertilized. (Eigenmann, 1902, p. 40.) "The number produced by a single eel is enormous, exceeding 7,000,000 in certain large European specimens. A conger in the Berlin aquarium, weighing 22.5 pounds, had ovaries weighing 8 pounds, which contained over 3,000,000 eggs (estimated)." (Smith, 1907, p. 111.)

The young, like the common eel, pass through a ribbonlike or leptocephalus stage. At this period the larvæ are recognized by the number of vertebræ and muscle segments, having 153 to 159 or more, whereas the American fresh-water eel has about 107 and the European fresh-water eel 114. The conger leptocephalus reaches a length of about 6 inches, while the American fresh-water eel reaches a length of only about 2½ inches and the European fresh-water eel only about 3 inches.

The conger eel seldom is caught in nets and nearly the entire catch is taken with hook and line. This eel is caught along our entire coast at least as far north as Woods Hole, where fish weighing up to 12 pounds are sometimes fairly common. The conger eel is a regular visitor along the Long Island and New Jersey coasts where from early summer to fall fish from 3 to 7 feet long and weighing up to 18 pounds are not uncommon. The usual length in the last-mentioned locality is 3½ to 6 feet, with a weight of 5 to 12 pounds. A Chesapeake specimen 27 inches in length weighed 1 pound 7½ ounces.

Uhler and Lugger (1876, p. 181) say of this fish for the Chesapeake region: "Common in the lower Potomac and in the parts of rivers within the reach of tide. Brought to our markets in large numbers and find a ready sale." At the present time, however, the conger is only a straggler in the bay, for many of the fishermen did not know the fish and we observed and collected only two specimens during 1921 and 1922. Because of its rarity, the conger obviously is of no commercial importance in the Chesapeake. Smith (1907, p. 112) remarks: "Although an excellent food fish, extensively sought and eaten in Europe and Asia, the conger supports no fishery in the United States and is sparingly utilized."

The conger eel attains a very large size in Europe, from whence a specimen of 128 pounds is recorded, and fish up to 60 pounds are not unusual. On our coast about 20 pounds appears to be the maximum. Only the female grows large and the male is thought to reach only 2½ feet in length and only several pounds in weight.

Habitat.—All warm seas except the eastern Pacific, inhabiting the Atlantic coast of America from Massachusetts to Uruguay.

Chesapeake localities.—(*a*) Previous records: Lower Potomac and within parts of rivers within the reach of tide (Uhler and Lugger, 1876). (*b*) Specimens in collection: Cape Henry, Va., February 19, 1922, beam trawl, depth 48 feet; Ocean View, October 11, 1922, 1,800-foot haul seine.

Order EVENTOGNATHI

Family XXV.—CATOSTOMIDÆ. The suckers

Body oblong or elongate, usually more or less compressed; head somewhat conical; nostril double; no barbels; mouth variable in size, usually protractile and with fleshy lips, jaws toothless; lower pharyngeal bones falciform, armed with a single row of numerous comblike teeth; branchiostegals 3; gill membranes somewhat connected with the isthmus, restricting the gill openings to the sides; gills 4, a slit behind the fourth; scales cycloid, wanting on the head; the fins without true spines; adipose fin wanting; ventral fins abdominal. The suckers comprise a large family of freshwater fishes. Only a few of the species venture into brackish water and none of them enter salt water.

KEY TO THE GENERA

a. Lateral line interrupted or wanting; scales large, 35 to 50 in a lateral series.
  b. Lateral line entirely wanting; species small ---------- Erimyzon, p. 117
  bb. Lateral line present, at least in adults, more or less interrupted; species larger ---------- Minytrema, p. 118
aa. Lateral line complete and continuous; scales small, 55 or more in a lateral series. ---------- Catostomus, p. 119

33. Genus ERIMYZON Jordan. Chub suckers

Body oblong, compressed; mouth subinferior; upper lip protractile; lower lip large, plicate, V-shaped; gill rakers long; pharyngeal bones weak, with small slender teeth; lateral line wanting; scales rather large, somewhat crowded anteriorly; dorsal fin short, with about 11 rays; the anal fin still shorter; caudal fin scarcely forked, but usually more or less concave. A single species of wide distribution in fresh and slightly brackish water is known.

44. Erimyzon sucetta (Lacépède). Chub sucker; "Mullet"; "Horned sucker."

Cyprinus sucetta Lacépède, Hist. Nat. Poiss., V, 1803, p. 606; South Carolina.
Moxostoma oblongum Uhler and Lugger, 1876, ed. I, p. 165; ed. II, p. 141.
Erimyzon sucetta Jordan and Everman, 1896–1900, p. 185, Pl. XXXVI, fig. 89; Smith and Bean, 1899, p. 181.
Erimyzon sucetta oblongus Fowler, 1912, p. 53.

Head 3.5 to 4.1; depth 3.1 to 3.9; D. 9 to 12; A. 7 or 8; scales 36 to 45. Body oblong, compressed, back elevated; head rather short; snout short, 2.5 to 3.2 in head; eye 3.8 to 5.8; interorbital space 2.2 to 2.6; scales large, closely overlapping, at least anteriorly, 13 to 15 in a transverse series; dorsal fin a little higher than long, situated over the ventrals; caudal fin with a more or

less concave posterior margin; anal fin very small, higher than long, its origin slightly nearer the base of caudal than the base of ventrals; ventral and pectoral fins moderate and of about equal size.

Color variable with age and environment; adults nearly uniform brownish olive above, intermixed with pinkish anteriorly, and everywhere with a coppery luster; pale underneath; fins all more or less dusky, sometimes reddish. The young with a black lateral band, later becoming broken into blotches, forming transverse bands and disappearing entirely with age.

This fish was not taken in brackish water during the present investigation, but it is reported from brackish water from the vicinity of Baltimore by Uhler and Lugger and for that reason the species is included in the present work. The chub sucker is readily recognized by the small dorsal and anal fins, the absence of the lateral line, and the thick lower lip, which contains many folds and the halves of which meet anteriorly in a V-shaped angle. The young, in general appearance, are very similar to some of the cyprinoid minnows. The males of this species, like many of the cyprinoid minnows, develop tubercles on the snout during the breeding season.

The chub sucker is a bottom feeder and largely herbivorous, yet it bites readily at a small hook baited with a piece of meat or earthworm. Spawning takes place in the spring. The species reaches a length of only about 10 inches; its flesh is bony and not of good flavor. It is common, although not abundant, in the fresh waters of the Chesapeake region. During cold weather, according to Smith and Bean (1899, p. 181), it ascends streams to the head waters, where it is taken and considered a good winter fish for the table.

Habitat.—Great Lakes, the Mississippi Valley, and seaboard streams from Maine to Texas.

Chesapeake localities.—(*a*) Previous records: Many fresh-water streams and in brackish water of the Patapsco River. (*b*) Specimens in the present collection: None. We have records of specimens taken near Havre de Grace, Md., in April, May, October, and December. The headwaters of Chesapeake Bay are slightly brackish from late fall until late winter.

34. Genus MINYTREMA Jordan. Spotted suckers

Body elongate, compressed; mouth inferior; upper lip freely protractile; lower lip plicate, the halves forming an acute angle anteriorly; air bladder in two parts; lateral line interrupted in adults, wanting in young; scales rather large, about 43 to 47 in a longitudinal series; dorsal fin high and short, with about 12 rays; caudal fin moderately forked.

45. Minytrema melanops (Rafinesque). Spotted sucker; Striped sucker.

Catostomus melanops Rafinesque, Ichthyologia Ohiensis, 1820, p. 57; Ohio River.

Minytrema melanops Jordan and Evermann, 1896–1900, p. 187, pl. XXXVI, fig. 90.

Head 4.4 to 4.9; depth 3.7; D. 15 or 16; A. 9 or 10; scales 43 to 46. Body elongate, compressed; upper anterior profile evenly and gently convex; head rather small; snout conical, 1.2 to 2.6 in head; eye 5.8; interorbital space 2.1 to 2.5; mouth inferior; the lips with strong folds, the lower lip much broader than the upper; scales large, cycloid, 12 longitudinal rows between the origin of dorsal and base of ventrals; lateral line present, complete; dorsal fin a little higher than long, its origin about equidistant from tip of snout and end of base of anal, its outer margin gently concave; caudal fin forked, the lobes pointed; anal fin much higher than long, its origin slightly nearer base of caudal than base of ventrals, the fourth or fifth ray the longest, the posterior rays decreasing rapidly in length; ventral fins moderate, inserted under the end of anterior third of base of dorsal; pectoral fins inserted less than an eye's diameter behind margin of opercle, 1.1 to 1.2 in head. Color of preserved specimens bluish-gray above, pale below; scales on sides with dark areas at base, which are deeper than long in large individuals, roundish in medium-sized individuals, and indistinct in young; dorsal and caudal slightly grayish, with darker margins; other fins plain, colorless.

A specimen 420 millimeters (16½ inches) long, weighing, when fresh, 1¾ pounds, taken in brackish water, and four small specimens, all of equal size, 85 millimeters (3⅜ inches) long, taken in fresh water, occur in the Chesapeake collection. We have compared these fish with specimens from Indiana and Texas. It was noticed that the body becomes much more compressed and deeper with age and size, the folds on the lips become more pronounced, and the dark spots on the scales on the sides of large specimens are much less distinct than they are in specimens 6 to 10 inches in

length. On the large example at hand the dark spots are much deeper than long; in the smaller specimens they are roundish. In specimens 5 inches and less in length these spots are indistinct or absent. The lateral line is not always complete and at times it is wanting. This character, however, does not appear to be correlated with age, as has been supposed. The spotted sucker usually is readily distinguished from all other suckers by the presence of dark spots on the scales, forming dark longitudinal lines. It also differs from related suckers in having the outer margin of the dorsal fin concave, and in the reduced number of longitudinal rows of scales on sides between the dorsal and ventral fins. This fish is known to reach a length of 18 inches.

The striped sucker evidently is rare in the Chesapeake Bay vicinity, as we are unable to find a record of its previous capture and the specimens in hand are the only ones seen in the field by the collectors. The species appears to be mainly a creek and small-river fish. However, the large specimen at hand was caught in brackish water in the narrows off Spesutie Island. "From the little that is known of its food we may surmise that it lives largely on mollusks and insect larvæ." (Forbes and Richardson, 1908, p. 83.) We are unable to find anything in the literature on the spawning and breeding habits of this sucker, and it is probable that nothing distinctive is known about it.

Habitat.—"Great Lakes region to North Carolina (Cape Fear River) and west to Texas; rather common westward." (Jordan and Evermann, 1896–1900.)

Chesapeake localities.—(*a*) Previous records: None. (*b*) Specimens in collection: From Spesutie Island near Havre de Grace, Md., 300-foot seine, Nov. 12, 1921, salinity, 1.53 per mille; Susquehanna River, Havre de Grace, Md., 30-foot seine, Aug. 27, 1921, water fresh.

35. Genus CATOSTOMUS LeSueur. Fine-scaled suckers

Head somewhat elongate; mouth inferior, the upper lip thick, protractile, papillose, lower lip greatly developed, incised behind, forming two lobes; scales small, 50 to 115 in a lateral series; lateral line well developed, air bladder with two chambers; dorsal fin with 14 to 19 rays.

46. Catostomus commersonii (Lacépède). Common sucker; White sucker; Mud sucker; Black mullet.

Cyprinus commersonii Lacépède, Hist. Nat. Poiss., V, 1803, p. 502; locality unknown.
Catostomus communis Uhler and Lugger, 1876, ed. I, p. 162; ed. II, p. 138.
Catostomus teres Bean, 1883, p. 367.
Catostomus commersonii Jordan and Evermann, 1896–1900, p. 178, Pl. XXXIV, fig. 83.

Head 4.08 to 4.35; depth 4.45 to 4.82; D. 14 or 15; A. 8; scales 63 to 67. Body elongate, little compressed; head quadrate, a little deeper than broad; snout conical, 1.9 to 2.15 in head; eye 4.4 to 6; interorbital 2.4 to 2.55; mouth inferior; lips papillose, the lower one broader than the upper; scales rather small, reduced in size anteriorly, about 20 longitudinal rows on sides between the dorsal and ventral fins; lateral line complete; dorsal fin about as long as high, the outer margin nearly straight, its origin a little nearer tip of snout than base of caudal; caudal fin moderately forked; anal fin much shorter, but higher than the dorsal, its origin about equidistant from base of ventrals and base of caudal; ventral fins short, inserted under middle of base of dorsal; pectoral low, 1.4 in head.

Color bluish-green above, pale below; dorsal and caudal fins more or less dusky, the other fins more or less orange. Spring males with a more or less distinct rosy lateral band. Young darker gray, mottled with black; the blotches sometimes more or less confluent and occasionally forming a lateral band.

The Chesapeake collection contains three specimens, respectively, 215, 222, and 235 millimeters (8½, 8¾, and 9¼ inches) in length, which were taken in slightly brackish water. These three and some smaller specimens from fresh water form the basis for the above description. This sucker is distinguished from all other suckers of the vicinity by the small scales, of which there are from 63 to 67 in a lateral series and about 20 longitudinal rows on the side between the dorsal and ventral fins. The scales are reduced in size anteriorly and appear crowded.

The alimentary canal is long and somewhat convoluted, without a sharp differentiation between the stomach and intestine. A specimen 8½ inches in length had an alimentary canal 17½ inches long. The food of this sucker, according to Smith (1907, p. 73), consists of insects, mollusks,

worms, and "other animals." Forbes and Richardson (1908, p. 85) point out that the thick pharyngeal jaws with a relatively small number of pharyngeal teeth, the lower ones of which are much thickened and expanded at the crowns, constitute a crushing and grinding apparatus strongly suggesting that a molluscan diet prevails. The specimens at hand had fed abundantly on plankton, consisting mainly of Cladocera, copepods, and Ostracoda. No insects or insect larvæ were noticed. The earthworm is the commonly used bait for hook and line fishing for this sucker.

Referring to the spawning habits of this sucker, Uhler and Lugger (1876, ed. I, p. 162, and ed. II, p. 138) say: "In early summer these fish build their nests of piles of sand and stones, and shortly afterwards their dead bodies may sometimes be found in dozens along the shores of streams such as Gwynns Falls, Md." The death of adult fish after spawning is not reported by other observers. Smith (1907, p. 73) states that in North Carolina spawning occurs in spring in the headwaters of small streams. According to Forbes and Richardson this sucker prefers riffles or swiftly flowing water for depositing the spawn. The writers have seen this sucker ascend small creeks in the spring in schools, when the splashing of water on the shallow riffles could be heard from a distance. It is then frequently possible to approach quietly with a torch, and when the light once is over the fish they become quiet and may be gigged easily.

This fish, although quite bony, is generally considered a fairly good food fish. Uhler and Lugger (1876, ed. I p. 162, and ed. II, p. 138), however, say: "The rank taste of the flesh renders it distasteful to many persons, but in the interior sections of the western shore (Maryland) it is generally eaten by the people."

The sucker is found in the fresh waters of the Chesapeake Bay region throughout the year, and according to Smith and Bean (1899, p. 181) it is taken in the Potomac and its tributaries, chiefly in winter, with seines and fyke nets. This species reaches a length of about 2 feet and a weight of about 5 pounds.

Habitat.—"Streams and ponds from Quebec and the Great Lakes to Montana, Colorado, and southward to Missouri and Georgia. * * * Excessively abundant from Massachusetts west to Kansas." (Jordan and Evermann, 1896–1900.)

Chesapeake localities.—(*a*) Previous records: Apparently all from strictly fresh water. (*b*) Specimens in collection: From Susquehanna River, Havre de Grace, Md., 300-foot seine, November 9, 1921, salinity 1.53 per mille.

Family XXVI.—CYPRINIDÆ. The minnows and carps

Body more or less elongate, compressed or rounded; margin of upper jaw formed only by the premaxillaries; lower pharyngeal bones supporting one to three series of teeth, the teeth few in number and sometimes differing in number on the two sides; snout sometimes with two to four small barbels; gill membranes joined to the isthmus; pseudobranchiæ present; branchiostegals 3; body scaly; head naked; dorsal fin short; ventral fins abdominal. During the breeding season the males often develop tubercles on the snout, and in some of the species they become brightly colored.

KEY TO THE GENERA

a. Mouth with four barbels; dorsal and anal each with three spines, the third in each fin enlarged and serrated behind ..... Cyprinus, p. 121

aa. Mouth without barbels; dorsal and anal fins without spines.

b. Body in adult much compressed; belly behind ventrals compressed to a keel; lateral line strongly decurved; anal fin long, with about 14 to 16 rays; origin of dorsal behind ventrals ..... Notemigonus, p. 123

bb. Body not greatly compressed; belly rounded; lateral line only slightly decurved; anal fin short, with about 8 to 10 rays.

c. Peritoneum black; alimentary canal long, more than three times the length of body ..... Hybognathus, p. 124

cc. Peritoneum pale; alimentary canal short, less than twice the length of body ..... Notropis, p. 125

36. Genus CYPRINUS Linnæus. Carps

Body robust, compressed; mouth moderate, inferior, with four barbels; snout blunt; scales large (wanting in the leather carp); lateral line complete; dorsal fin long, with three spines; anal fin short, also with three spines; the third spine of dorsal and of anal serrated behind.

47. Cyprinus carpio Linnæus. The carp.

Cyprinus carpio Linnæus, Syst. Nat., ed. X, 1758, p. 320; Jordan and Evermann, 1896, p. 201; Fowler, 1912, p. 53.

This fish has been domesticated and as a consequence it is subject to much variation; numerous varieties have resulted, which vary greatly in the depth of the body, the relative length of the head, the length of the fins, and especially in the number and arrangement of the scales. One variety has only a few scales on the back or is wholly naked and possesses a thick, soft skin. This variety is known as the "leather carp." Another variety has enlarged scales on the sides, often in only a few rows. Such fish are known as "mirror carp." A third variety is fully and normally scaled. This variety is the "scale carp" and probably is most like the original "wild" species.

Owing to these great and numerous variations, no attempt is made to offer a technical description. In general, the body is elongate and compressed, the back being elevated. The head is rather low and small. The dorsal fin is long, consisting of three spines and usually from 20 to 23 soft rays. The anal fin, too, has three spines, and it has only about six soft rays. The third spine in both fins is enlarged and has a rough posterior edge. The upper jaw has two barbels on each side, which readily distinguish the carp from all American forms.

The carp is a native of the temperate parts of Asia, especially of China, from whence it was introduced into Europe, Java, and also into America. Exactly when the first carp were brought to America has been a subject for discussion. It is claimed that they were introduced into the Hudson River many years before they were brought in by the United States Fish Commission in 1877, but this report apparently never was definitely verified. A few specimens of scale carp were brought from Germany by a Mr. Poppe, of Sonoma, Calif., some years before they were introduced by the United States Fish Commission. In the Chesapeake vicinity, however, the carp was first introduced in 1877, when 227 leather and mirror carp and 118 scale carp were brought directly from Germany by a representative of the United States Fish Commission and placed in ponds especially prepared for their reception in Druid Hill Park, Baltimore, Md. About a year later several carp ponds were constructed in Washington, and a part of the brood stock originally placed in Druid Hill Park was transferred to Washington. Other small lots were imported in 1879 and 1882 and placed in the aforementioned ponds. Young fish were shipped from these sources to various applicants, resulting in the general distribution of the carp to all suitable waters of the United States.

The expectations from the introduction of the carp were great. Prof. S. F. Baird, Commissioner of Fisheries, stated at the time of introduction (1879, pp. 41 and 42):

> I have for a long time attached much importance to the introduction of carp into the United States of America as supplying an often-expressed want of a fish for the South, representing the more northern trout and capable of being kept in ponds. In the carp this desideratum is amply met, with the additional advantage that the same water will furnish a much larger amount of fish food in the aquatic plants, roots, seeds, etc., to be found, while feeding may be accomplished by means of leaves, seeds, pieces of cabbage and lettuce, by crumbs of bread, or by boiled corn and potatoes or other cheap substances. * * * There is no ditch, or pond, or milldam, or any muddy, boggy spot capable of being converted into a pond of more or less size that will not answer for this fish. Except for unforeseen casualties, I fully believe that within 10 years to come this fish will become, through the agency of the United States Fish Commission, widely known throughout the country and esteemed in proportion.

Prof. Baird's expectations concerning the multiplication and distribution of this fish have been fully met, but the fish is not esteemed in the same proportion. In the markets of the Chesapeake Bay region, as elsewhere, it is considered an inferior food fish. During recent years, however, it has gained in favor, and the demands for it are increasing. Throughout the Mississippi Valley it is commercially one of the most important food fishes.

It has attained a small commercial importance in the lower Potomac, where the pound-net fishermen catch them in April and May. Fishermen of Lewisetta, Va., brought in six on one April 25, the largest weighing 25 pounds. At Love Point, Md., haul seiners consider it one of their most profitable fish during May. It is also taken, although sparingly, in the lower Patuxent and Choptank Rivers.

The carp is omnivorous, but its principal food probably consists of plants. Hessel (1878, p. 865) says: "The carp lives upon vegetable food as well as upon worms and larvæ of aquatic insects, which it turns up from the mud with the head; it is very easily satisfied and will not refuse the offal of the kitchen, slaughterhouse, and breweries, or even the excrement of cattle and pigs." Three stomachs examined by Linton from specimens taken at Havre de Grace, Md., contained only vegetable matter, mostly the fruit of eelgrass.

In this country the carp has not infrequently been accused of destroying our native fishes. In some localities this has become a popular belief, but investigators have been unable to find much incriminating evidence. It is a well-known fact that since the introduction of the carp our native fishes have become fewer in many streams, and that the carp is becoming abundant. A very natural and logical conclusion, with such evidence alone at hand, is that the carp is responsible for the decrease of the native species. It must be remembered, however, that a similar decrease has taken place in many of our marine fishes. For such decrease other causes must be sought, as no introduction of foreign species of strictly marine fish has taken place. It is not argued that the carp does not at times, through the uprooting of vegetation, destroy nests of other fish, nor that it at times eats the spawn of other fish, or that it destroys some of the young fish of other species; on the other hand it must be remembered that our native species, too, prey upon each other and upon the carp, very probably to a much greater extent than the carp preys upon them. The carp, being largely herbivorous, gains much of its sustenance from plants; whereas many of our native fishes are strictly carnivorous, requiring animal foods, and where the young carp is present it not infrequently furnishes a considerable portion of the food of the carnivorous fishes. From this standpoint the presence of carp appears to be a distinct advantage. It seems necessary, in the light of our present knowledge, to seek the reason for the decline in our fresh-water food fishes elsewhere. For a complete and admirable account of the carp and the various accusations that have been made against it in America see the report of the Bureau of Fisheries for 1904, pages 523 to 641, under the title "The German carp in the United States," by Leon J. Cole. Overfishing, fishing during the spawning season, the construction of obstructions in streams (prohibiting the free passage of fish to and from their natural spawning and feeding grounds), and, most important of all, the pollution of streams are undoubtedly the important factors in bringing about the diminution of our native food fishes.

The carp prefers rather quiet waters that support an abundance of vegetation, but it is not limited thereto, as it is not infrequently taken in rather swiftly flowing streams. Although the carp is essentially a fresh-water fish, it does enter brackish water, and in the Old World, according to Hessel (1878, p. 869), it even frequents salt water. In the Chesapeake the carp is found abundantly in fresh water, sparingly in brackish water, but not at all in the salter parts of the bay.

Spawning takes place in the spring and may extend over a considerable period of time. The eggs are deposited among vegetation; they are adhesive and usually adhere to vegetation in lumps. Field notes made by Lewis Radcliffe state that the ovaries of 4 to 5 pound carp contain from 400,000 to 500,000 eggs and that a 16½-pound fish contained ovaries weighing 5 pounds with over 2,000,000 eggs. During warm weather the eggs hatch in from 12 to 16 days. Under favorable conditions the young grow rapidly. Hessel (1878, p. 873), in speaking of carp culture in Europe, says: "The normal weight which a carp may attain to in three years, whether it be scale carp, mirror carp, or leather carp, is an average of from 3 to 3¼ pounds; that is, a fish which has lived two summers, consequently is 18 months old, will weigh 2¾ to 3¼ pounds the year following." The carp is said to attain a great age—100 to 150 years—and a weight of 80 to 90 pounds, but such statements generally are based upon insufficient evidence. Hessel (1878, p. 874) says: "It is a well-known fact that two large carps, weighing from 42 to 55 pounds, were taken several years ago on one of the Grand Duke of Oldenburg's domains in northern Germany." Smith (1907, p. 106) makes the following statement: "The carp attains a relatively large size, examples weighing upward of 60 pounds being known in Europe and fully 40 pounds in the United States, although full sexual maturity is attained by the second or third year, when the fish weigh only 3 or 4 pounds."

The following weights were secured: Length, 17½ inches, 2 pounds 12 ounces; 20 inches, 4 pounds 8 ounces; 22½ inches, 6 pounds 5 ounces; 26 inches, 9 pounds 3 ounces.

Habitat.—Temperate Asia; introduced into Europe, Java, England, United States, Canada, Mexico, Costa Rica, Ecuador, the Hawaiian Islands, etc.

Chesapeake localities.—(*a*) Previous record: Apparently none from salt or brackish water. (*b*) Specimens in present collection: From brackish water, Spesutie Island, Havre de Grace; Love Point; and Blackistone Island, Md. Highest recorded salinity, 15.66 per mille.

37. Genus NOTEMIGONUS Rafinesque. Roaches

Body strongly compressed; back and belly curved; belly behind ventrals forming a keel; head small, conic; mouth small, oblique; barbels wanting; pharyngeal teeth 5—5; alimentary canal short, not much longer than the body; scales moderate; lateral line complete, decurved; dorsal origin behind ventrals; anal fin rather long, with 13 or more rays.

48. Notemigonus crysoleucas (Mitchill). Golden shiner; Shiner; "Dace"; Chub; Bream.

Cyprinus crysoleucas Mitchill, Rept., Fish., N. Y., 1914, p. 23; New York.
Stilbe americana Uhler and Lugger, 1876, ed. I, p. 171; ed. II, p. 145.
Notemigonus crysoleucas Bean, 1883, p. 367; Smith and Bean, 1899, p. 182.
Abramis crysoleucas Jordan and Evermann, 1896–1900, p. 250, Pl. XLV, fig. 111; Fowler, 1912, p. 52.

Head 4 to 4.75; depth 2.85 to 4.25; D. 9 or 10; A. 14 to 16; scales 46 to 52. Body in adult deep, rather strongly compressed, the back elevated and the ventral outline strongly decurved, more elongate and not as strongly depressed in young; head small, somewhat depressed above; snout short, blunt, its length 3.55 to 4.6 in head; eye 2.55 to 4.1; interorbital 2.25 to 2.9; mouth very oblique, the lower jaw slightly in advance of the upper; maxillary failing to reach anterior margin of eye; pharyngeal teeth in one row, usually with five teeth, occasionally with only four, each tooth with a prominent, nearly right-angled hook at the tip; scales moderate, rather deep in adult, 23 to 25 rows in advance of dorsal; lateral line complete, decurved; dorsal fin rather small, the anterior rays longest, reaching past the posterior rays when deflexed, the origin of fin a little nearer upper anterior angle of gill opening than base of caudal; caudal fin forked, both lobes pointed; anal fin rather long, the outer margin concave, its base 1.2 to 1.55 in head; ventral fin inserted nearly an eye's diameter in advance of dorsal, reaching origin of the anal in the young, proportionately shorter in the adult; pectoral fins pointed, the upper rays longest, 1.05 to 1.3 in head.

Color in adult bluish-green above, with metallic luster, gradually merging into bright silvery on lower part of sides; upper surface of head brownish; fins plain or sometimes yellowish and occasionally dusky. A gravid male, 6 inches long, had a pale yellow dorsal and caudal and bright yellow anal, ventral, and pectoral fins. Smith (1907, p. 89) describes a fish 7¾ inches long as having, in addition to the yellow color, crimson ventrals and the anal dull orange with a black margin. The young have less of the metallic luster and they have a distinct black lateral band, extending from the eye to the base of the caudal.

Many specimens of this species were preserved, ranging from 33 to 215 millimeters (1⅝ to 8½ inches) in length. This minnow is locally very abundant, occurring in the tide waters principally in the upper parts of Chesapeake Bay, whether fresh or brackish, and on various kinds of bottom, but more usually where vegetation is present. The adult of this minnow is readily recognized by the very oblique mouth, deep, compressed body, the long anal fin, the strongly decurved lateral line, and by the bright golden and silvery colors. The young, however, are not so readily distinguished, for they are not much deeper than other minnows of related genera, and they have a black lateral band like many of the species of this family. The strongly oblique mouth and the long anal fin serve as the most reliable characters in separating the young from related minnows. The scales in advance of the dorsal fin are somewhat reduced, from 22 to 25 rows crossing the back in front of the origin of the dorsal. In most of the related minnows the scales are larger, and fewer rows cross the back in advance of the dorsal fin. The peritoneum in this species is silvery with dusky punctulations. The air bladder is large and has a constriction a little in advance of the middle of its length, from which arises a very small tube, which extends forward to the throat. The alimentary canal is about as long as the total length of the fish.

The food in six specimens examined consisted of algæ, fragments of higher plants, and débris. Many grains of sand, probably taken by accident, also were present in some of the stomachs examined. Linton examined five stomachs and found amphipods, mollusks, and débris.

Spawning takes place during the spring. Gravid fish were taken at Havre de Grace, Md., on May 8 to 10, 1922.

This species reaches a larger size than the other minnows of this family occurring in the Chesapeake vicinity. The maximum length given in various publications is 1 foot, but the largest individual taken in the Chesapeake was 8½ inches long. This minnow is considered excellent bait in the South for black bass and pike or pickerel. The large individuals are used for home consumption and are said to make good pan fish. When confined in cisterns or shallow wells the golden shiner feeds on mosquito larvæ and successfully prevents mosquito production. The weights of Chesapeake Bay fish were as follows:

Length, in inches	Weight, in ounces	Length, in inches	Weight, in ounces
5	0.7	6¾	2.0
5¼	.8	7	2.3
5½	.9	7¼	2.7
5¾	1.3	7½	3.1
6	1.4	8	3.7
6¼	1.6	8½	4.8

Habitat.—Nova Scotia, west to the Dakotas and south to Florida and Texas on both sides of the Alleghanies, frequenting weedy ponds and sluggish streams.

Chesapeake localities.—(*a*) Previous records: "Maryland" (Uhler and Lugger, 1876), Havre de Grace, Md. (Bean, 1883), Little Bohemia Creek, Bohemia Mills, Bohemia Bridge, Elk Neck, North East, Stony Run, Conewingo, Susquehanna River, and Broad Creek (Fowler, 1912). (*b*) Specimens in collection: From Havre de Grace, Baltimore, Annapolis, Love Point, Solomons Island, Md., and Lewisetta, Va., taken with 30 and 300 foot collecting seines and in one instance with a pound net from April to November. Highest salinity 14.4 per mille.

38. Genus HYBOGNATHUS Agassiz. Shiners; Gudgeons

Body elongate, somewhat compressed; mouth horizontal; the jaws normal, the lower one with a slight protuberance in front, the upper one protractile; no barbels; pharyngeal teeth 4—4; alimentary canal elongate, three to ten times the length of body; peritoneum black; scales large; lateral line complete; dorsal fin inserted in advance of ventrals; anal short.

49. Hybognathus nuchalis Agassiz. "Gudgeon"; Silvery minnow.

Hybognathus nuchalis Agassiz, American Jour. Sci. and Art., 1855, p. 224; Quincy, Ill.
Hybognathus regius Uhler and Lugger, 1876, ed. I, p. 177; ed. II, p. 150.
Hybognathus nuchalis Jordan and Evermann, 1896–1900, p. 213; Smith and Bean, 1899, p. 182; Fowler, 1912, p. 52.

Head 4.1 to 5; depth 3.56 to 4.95; D. 9 or 10; A. 9 or 10; scales 37 to 40. Body rather slender, compressed; caudal peduncle moderate, its depth 1.5 to 2.6 in head; head rather long and low; snout conical, 3 to 3.5 in head; eye 3.05 to 3.35; interorbital space 2.35 to 3.35; mouth small, a little oblique, slightly inferior; maxillary not quite reaching eye; pharyngeal teeth in one row, consisting of four teeth; scales moderate, 13 or 14 rows crossing the back in advance of dorsal fin; lateral line complete, slightly decurved; origin of dorsal a little nearer tip of snout than base of caudal, the anterior rays of fin longest, reaching past the posterior ones when deflexed; caudal fin moderately forked, the lobes of about equal length; anal fin similar to the dorsal, its origin about 1.5 times diameter of eye behind the end of base of dorsal; ventral fins moderate, inserted a little behind vertical from origin of dorsal; pectoral fins pointed, the upper rays longest, 1.05 to 1.35 in head.

Color greenish above, sides silvery, lower parts pale. Some specimens have a slight indication of a plumbeous lateral band, at least posteriorly. The fins pale, the dorsal and caudal slightly dusky.

Nine specimens of this species, ranging from 70 to 157 millimeters (2¾ to 6¼ inches) in length, were taken in brackish water in the upper part of Chesapeake Bay. The adults of this species are very similar to *Notropis hudsonius amarus*, from which, however, they may be distinguished by the black peritoneum and the long convoluted intestine. *N. hudsonius amarus*, furthermore, usually has an indication of a black spot at base of caudal, which is never present in *H. nuchalis*.

The food of this species consists of plants. Only fragments were present in stomachs examined. This fish spawns early in the spring. Large specimens taken in November already have the ovaries somewhat distended with eggs easily visible to the unaided eye.

This minnow reaches a somewhat larger size than *N. hudsonius amarus*, the largest specimen at hand being 6¼ inches in length, which is probably the maximum size attained. This minnow is used to a limited extent for food and also for bass bait. The food it provides for the larger predatory fishes, however, constitutes its chief economic importance. It is said to be abundant in the fresh-water streams of the Chesapeake region and is taken in company with *Notropis hudsonius amarus*.

Habitat.—New Jersey and southward to Texas and in the Mississippi Valley northward to the Dakotas.

Chesapeake records.—(*a*) Previous records: None definitely from brackish water. (*b*) Specimens in collection from the vicinity of Havre de Grace, Md. (Northeast River, Susquehanna River, and Spesutie Island), 30-foot seine, August 27 to 31 and November 10 to 12, 1921; highest salinity 2.23 per mille.

39. Genus NOTROPIS Rafinesque. Shiners

Body elongate, subcylindrical or compressed; abdomen rounded; mouth terminal or slightly inferior; no barbels; pharyngeal teeth in one or two rows, the main row with four teeth on each side; lateral line present and usually complete; scales rather large; vertical fins short; the dorsal situated over or posterior to the ventrals. The shiners comprise a large genus of fresh-water fishes, only a few of which venture into brackish water and none of which enter salt water.

KEY TO THE SPECIES

a. Lateral line complete; scales 37 to 41; no dark lateral band, except in very young; base of caudal usually with a dark spot ..... *hudsonius amarus*, p. 125

aa. Lateral line incomplete, usually extending only to end of base of dorsal fin; scales 33 to 36; a prominent dark lateral band extending around tip of snout to base of caudal ..... *bifrenatus*, p. 126

50. Notropis hudsonius amarus (Girard). Spawn-eater; Silver-fin; Shiner; "Gudgeon."

Hudsonius amarus Girard, Proc., Ac. Nat. Sci., Phila., 1856, p. 210; Chesapeake Bay.
Hybopsis hudsonius Uhler and Lugger, 1876, ed. I, p. 175; ed. II, p. 149.
Notropis hudsonius amarus Jordan and Evermann, 1896–1900, p. 270; Smith and Bean, 1899, p. 182; Fowler, 1912, p. 52.

Head 3.8 to 4.8; depth 3.6 to 5.8; D. 9 or 10; A. 9 or 10; scales 37 to 41. Body rather slender, compressed; caudal peduncle quite long and slender, its depth 2 to 2.8 in head; head rather long; snout conical, 3.05 to 4.2 in head; eye 2.5 to 3.4; interorbital space 2.4 to 3.5; mouth somewhat oblique, terminal or nearly so in young, slightly inferior in adults, lower jaw included; maxillary not quite reaching anterior margin of eye; pharyngeal teeth usually in two rows, the second row sometimes wanting, with one or two teeth when present, the main row usually with four, rarely with only three teeth, the teeth in the main row rather large and prominently curved near the tips; scales moderate, 14 to 16 rows crossing the median line of back in advance of the dorsal fin; lateral line complete, somewhat decurved; origin of dorsal slightly nearer tip of snout than base of caudal, the third and fourth rays longest, reaching past the succeeding rays when the fin is deflexed, about equal to length of head; caudal fin forked, the lobes of about equal length; anal fin similar to the dorsal; but the rays not quite as long, its origin more than an eye's diameter behind the end of base of dorsal in large examples, less than an eye's diameter behind end of dorsal base in young, somewhat nearer base of caudal than tips of pectorals in adults, equidistant from base of caudal and base of pectorals in very young; ventral fins inserted a little behind vertical from origin of dorsal, reaching to or a little past origin of anal in very young, not nearly reaching anal in large individuals; pectoral fin rather pointed, the upper rays longest, 1.05 to 1.4 in head.

Color greenish above, sides silvery, lower parts pale. Young with a dark, plumbeous lateral band extending forward through eye and across snout and ending in a dark caudal spot. The lateral band and finally the caudal spot, also, almost wholly disappear with age. The fins are all plain translucent.