Description.—The hickory shad differs rather noticeably from the sea herring in that the point of origin of its dorsal fin is considerably in front of the mid-length of its trunk; in its deep belly (a hickory shad 13½ in. long is about 4 in. deep but a herring of that length is only 3 in. deep); in the fact that its outline tapers toward both snout and tail in side view (fig. 15); and in that its lower jaw projects farther beyond the upper when its mouth is closed; also, by the saw-toothed edge of its belly. Also, it lacks the cluster of teeth on the roof of the mouth that is characteristic of the herring. One is more likely to confuse a hickory shad with a shad or with the alewives, which it resembles in the position of its dorsal fin, in the great depth of its body, in its saw-toothed belly and in the lack of teeth on the roof of the mouth. But it is marked off from all of these by its projecting lower jaw. There is also a small difference in outline, its head tapering more to the snout, as seen in side view (fig. 45). It has only about half as many gill rakers (19 to 21 on the lower limb of the first gill arch) as either the alewife or the blueback; and its upper jaw, reaching back only about as far as opposite the center of its eye, is shorter than that of the shad in which it reaches as far as the rear edge of the eye.

Under favorable circumstances its color, also, is characteristic, for it is faintly marked on the sides with dusky longitudinal stripes, and the tip of its snout is dusky.

Size.—This is the largest of our anadromous herrings next to the shad, growing to a length of 2 feet. A fish about 15 inches long weighs a pound, one of 18 inches, 2 pounds.

Habits.—Nothing is known of the habits of the hickory shad in the sea to differentiate it from its close relatives of the herring tribe except that it is more of a fish eater. Launce, anchovies, cunners, herring, scup, silversides, and other small fish, squid, fish eggs, and even small crabs have been found in the stomachs of hickory shad at Woods Hole, as well as sundry pelagic Crustacea. It will strike a small spinner or other artifical lure, and it gives a good fight when hooked. In the southern parts of its range it is described as running up fresh streams, with the alewives in late winter and early spring to spawn.[64] But it appears not to do so in the streams tributary to Chesapeake Bay, though it is found in practically all of them. This opens the interesting possibility that the "green" fish found in Chesapeake Bay, leave the Bay, perhaps to spawn in salt water.[65]

General range.—Atlantic coast of North America from the Bay of Fundy to Florida.

Occurrence in the Gulf of Maine.—The hickory shad is a southern fish, with the Gulf of Maine as the extreme northern limit to its range. It is recorded in scientific literature only at North Truro; at Provincetown; at Brewster; in Boston Harbor; off Portland; in Casco Bay; and from the mouth of the Bay of Fundy (Huntsman doubts this record), and it usually is so uncommon within our limits that we have seen none in the Gulf ourselves. But in 1932 anglers, trolling for striped bass and mackerel off the Merrimac River, met a run of hickory shad.[66]

It is much more plentiful west of Cape Cod, being common from spring throughout summer and early autumn at Woods Hole, where as many as 3,500 have been taken at a single lift of one trap. In 1919 the Massachusetts catch of hickory shad, practically all from the south coast, amounted to 12,800 pounds, and none are listed for Massachusetts for any subsequent year.

Alewife *Pomolobus pseudoharengus* (Wilson) 1811 [approximate date]

GASPEREAU; SAWBELLY; KYAK; BRANCH HERRING; FRESH-WATER HERRING; GRAYBACK

Jordan and Evermann, 1896–1900, p. 426.

Description.—The alewife is distinguishable at a glance from the sea herring by the greater depth of its body, which is three and one-third times as long as deep (an alewife of 13½ inches is about 4 inches deep; a herring that long has a depth of only 3 inches) also by the position of its dorsal fin, the point of origin of which is considerably nearer to the tip of the snout than to the point of origin of the central rays of the tail fin. Furthermore, the alewife is much more heavily built forward than the herring, and the serrations on the midline of its belly are much stronger and sharper (hence the local name "sawbelly"), so much so that a practiced hand can separate

[64] Smith (N. C. Geol. Econ. Surv; vol. 2, 1897, p. 121) describes it as doing so in the streams tributary to Pamlico Sound, N. C., where it is plentiful.

[65] Hildebrand and Schroeder, Bull., U. S. Bur. Fish., vol. 43, 1928, p. 84.

[66] The Museum of Comparative Zoology received one from this run from Dr. J. C. Phillips, caught by him off the northern end of Plum Island, October 2, 1932.

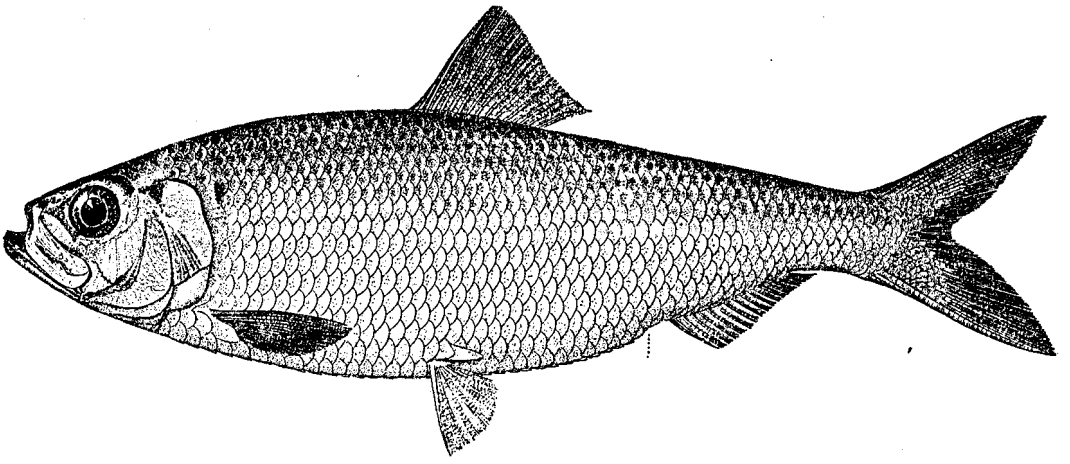

FIGURE 46.—Alewife (*Pomolobus pseudoharengus*), Chesapeake Bay region specimen. From Goode. Drawing by H. L. Todd.

herring from alewives in the dark. The most useful distinctions between the alewife and the blueback are that in the former the eye is broader than the distance from its forward edge to the tip of its snout and the back grayish green, while in the latter the eye is only about as wide as the distance from front of eye to tip of snout, and the back is dark blue (p. 107). Also the lining of the abdominal cavity is pale grayish or pinkish white in the alewife, but is usually dusky or blackish in the blueback. But this distinction may not hold in all cases.

Alewives are distinguishable from young shad by their smaller mouths with shorter upper jaws; also by the fact that the lower jaw of the alewife projects slightly beyond the upper when the mouth is closed, and by the outline of the edge of the lower jaw, the forward part of which is deeply concave in the alewife but nearly straight in the shad. The lack of teeth on the roof of the mouth distinguishes the alewife, with its brethren the hickory shad (p. 100) and blueback (p. 106) from the sea herring, anatomically.

Color.—The alewife, like the herring, is grayish green above, darkest on the back, paler and silvery on sides and belly. Usually there is a dusky spot on either side just behind the margin of the gill cover (lacking in the herring) and the upper side may be faintly striped with dark longitudinal lines in large fish. The sides are iridescent in life, with shades of green and violet. The colors change, to some extent, in shade from darker to paler, or vice versa, to match the bottom below, as the fish run up stream in shallow water.

Size.—The alewife grows to a length of about 15 inches, but adults average only about 10 to 11 inches long and about 8 to 9 ounces in weight; 16,400,000 fish taken in New England in 1898 weighed about 8,800,000 pounds.

Habits.—The alewife, like the shad and the salmon makes its growth in the sea, but enters fresh water streams to spawn. This "anadromous" habit, as it is called, forced itself on the attention of the early settlers on our coasts. In the words of an eyewitness, "experience hath taught them at New Plymouth that in April there is a fish much like a herring that comes up into the small brooks to spawn, and when the water is not knee deep they will presse up through your hands, yea, thow you beat at them with cudgels, and in such abundance as is incredible." [67] And they are no less persevering in their struggles upstream today. Numbers of them are to be seen in many streams, any spring, alternately swimming ahead; resting in the eddy behind some irregularity of the bottom; then moving ahead again, between one's feet if one happens to be standing in midstream. And they are much more successful than the shad in surmounting fishways of suitable design. During the early runs sometimes one sex predominates, sometimes the other, but the late runs consist chiefly of males, as a rule, and these are said to outnumber the females greatly on the spawning grounds. We have no firsthand observations to contribute on this score.

Alewives are decidedly general in their choice

[67] Capt. Charles Whitborne, in "The True Travels of Capt. John Smith," 1616, vol. 2, p. 250.

of streams, running indifferently up rivers as large as the St. John, Merrimac and Potomac, or streams so small that one can almost leap across, and only a few inches deep. In large rivers they run far upstream—how far they may do so we do not know—or their journey may be one of only a few yards, as it is in the artificial cuts that are kept open through barrier beaches to allow the fish access to fresh water ponds behind the latter.

The alewife spawns in ponds, including those back of barrier beaches (if there are openings to the sea, natural or artificial) and in sluggish stretches of streams, never in swift water, each female depositing from 60,000 to 100,000 eggs or more, according to her size.[68] Spawning lasts only a few days for each group of fish.

The spent fish run down stream again so soon after spawning that many of them pass others coming up, as we have often seen; fish on their return journey to salt water are familiar sights in every alewife stream.

The adults, when entering streams to spawn, make the change from salt water to fresh within a short time without damage; this is equally true of the spent fish on their return to the estuaries. But Dr. Huntsman informs us that they appear unable to endure repeated changes between salt water and fresh, and that great numbers are killed in this way in the estuaries under certain conditions of tide. The strain of spawning leaves them very thin, but they recover rapidly after they reach salt water. We have seen spent alewives that had already put on considerable fat, taken from a trap at Provincetown as early in the season as July 16 (in 1915).

Spawning ordinarily takes place at temperatures of about 55 to 60°. The eggs are about 0.05 inches in diameter, pink like those of the sea herring, and they stick to brush, stones, or anything else they may settle upon.[69] Incubation occupies about 6 days at 60°. The young alewives, which are about 5 mm. long when hatched, growing to 15 mm. when a month old, soon begin to work their way downstream. They have been seen descending as early as June 15 in the more southerly of Gulf of Maine streams; successive companies of fry move out of the pond and down with the current throughout the summer; and by autumn the young alewives have all found their way down to salt water when 2 to 4 inches long. We have seined young alewives as long as 4 to 4½ inches (102–115 mm.) in salt water near Seguin Island, Maine, at the end of July, but others, only 3 to 3⅝ inches long (78–92 mm.), near Mt. Desert Island as late as the first of October. Thenceforth the alewife lives in salt water until sexual maturity.

Hildebrand and Schroeder[70] found that little alewives in Chesapeake Bay had grown to about 4½ to 5 inches long by the time they were 1 year old.

The rate of growth of the older alewives, in salt water, has not been traced. But experiments in planting adult alewives in ponds in which there were none before, led, long ago, to the conclusion that they became sexually mature at 3 or 4 years of age, for none of their progeny returned until 3 or 4 years after the original plant. Specific instances, cited by Belding[71] are:

(1) Three years after a large number of alewives were hatched in Keene's Pond, Maine, tributary to the Calais River, from a "plant" of mature fish, a run of adult fish entered Keene's Pond stream where none had ever been seen before; this case was reported by the U. S. Bureau of Fisheries. (2) The establishment of a fishery, in the same way at Plymouth, Mass., in 4 years after restocking in 1865; and (3) G. M. Besse obtained results in 3 years in ponds in Wareham, Mass.

The fact that alewives have been known to return, for spawning, to streams in which their parents had been planted, lends support to the "parent stream" theory; i. e., that alewives, like shad, tend to spawn in the stream system in which they were hatched. But a much more intensive study is needed of this interesting question before any categorical statement can be made, as to how generally this is true; and to what extent their return depends on their never having wandered far afield.

Food.—The alewife is chiefly a plankton feeder like the herring; copepods, amphipods, shrimps, and appendicularians were the chief diet of specimens examined by Vinal Edwards and by Linton

[68] The average number of eggs in 644 females taken in the Potomac was 102,800 (Smith, N. C. Geol. and Econ. Survey, vol. 2, 1907. p. 123).

[69] The development of the eggs, larval stages, and young fry are described by Ryder (Report, U. S. Comm. of Fish. (1885), 1887, p. 505) and by Prince Contr. Canad. Biol. (1902-1905), 1907, p. 95).

[70] Bull. U. S. Bur. Fish., vol. 43, 1928, p. 91.

[71] Rept. Alewife Fish. Mass., Mass. Dept. Conservation, Div. Fish. and Game, 1921, p. 18.

at Woods Hole. However, they also take small fish, such as herring, eels, launce, cunners, and their own species, as well as fish eggs. Unlike herring, alewives often contain diatoms even when adult. Alewives fast when they are running upstream to spawn, but when the spent fish reach brackish water on their return they feed ravenously on the shrimp that abound in the tidal estuaries and which they can be seen pursuing. We have often hooked alewives on an artificial fly at such times.

Movements at sea.—The alewife is as gregarious as the herring, fish of a size congregating in schools of thousands of individuals (we find record of 40,000 fish caught in one seine haul in Boston Harbor) and apparently a given school holds together during most of its sojourn in salt water. But they are sometimes caught mixed with menhaden, or with herring. Alewives, immature and adult, are often picked up in abundance in weirs here and there along the coast,[72] and it is likely that the majority remain in the general vicnity of the fresh water influence of the stream-mouths and estuaries from which they have emerged, to judge from the success of attempts to strengthen or restore the runs of alewives in various streams, mentioned above. But it is certain that some of them wander far afield, for catches of up to 3,000 to 4,000 pounds per haul were made by otter trawlers some 80 miles offshore, off Emerald Bank, Nova Scotia (lat. about 43° 15′ N., long. about 63° W.) at 60 to 80 fathoms, in March 1936.[73]

Odd alewives were reported from Georges Bank and the South Channel in March, June, August, and November of 1913. Some (up to 78 per haul) were trawled by *Albatross III* about 25 to 60 miles out off southern New England in May 1950; also 18 adults, 10 to 11 inches long, 70 odd miles off Barnegat, N. J., on March 5, 1931; and we saw 60 alewives trawled at the 25-fathom line off Marthas Vineyard [74] in late June, 1951 by the *Eugene H.* Where these wanderers come to shore to spawn, if they succeed in doing so at all, is an interesting question.

It seems likely from various lines of evidence that alewives tend to keep near the surface for their first year or so in salt water, and while they are inshore when older. But practically nothing is known as to the depths to which they may descend if (or when) they move offshore, there being no assurance that those taken by trawlers were not picked up, while the trawls were being lowered or hauled up again.

General range.—Gulf of St. Lawrence and northern Nova Scotia south to North Carolina, running up into fresh water to spawn; landlocked races also exist in Lake Ontario, in the Finger Lakes of New York, and in certain other fresh-water lakes.[75]

Occurrence in the Gulf of Maine.—When the white man crossed the Atlantic probably there was no stream from Cape Sable to Cape Cod but saw its annual run of alewives unless they were barred by impassable falls near the mouth.

And while its numbers have declined during the past two centuries and its range has been restricted, both by actual extirpation from certain streams by overfishing, by the pollution of the river waters by manufacturing wastes, and by the erection of dams that it cannot pass, the alewife is a familiar fish still, all along around our coast [76] and yields an abundant catch in many of our streams. Alewives are taken commonly about Yarmouth, Nova Scotia; in the Annapolis Basin; in Minas Channel; and farther still, up the Bay. Alewives still run in most of the streams tributary to the Bay of Fundy, many in the St. John. A few are taken in the weirs in Passamaquoddy Bay; while young ones have been taken around Campobello Island; as deep as 50 fathoms. They enter the large river systems all along the coasts of Maine and New Hampshire, likewise many small streams, the requirements being that these shall lead to ponds or have deadwaters of sufficient extent along their courses, and no dams or falls that the alewives can not surmount. At Boothbay Harbor, for instance, a considerable number of alewives annually run, or did run, up to spawn in Campbell's Pond, a small body of water that is dammed off from the harbor, and reached by a fishway only 15 feet long. This is the shortest alewife stream of which we know.

In 1896, when the alewife fishery was the subject of inquiry by the Bureau of Fisheries,[77] catches

[72] Huntsman (Contr. Canad. Biol., [1921] 1922, p. 58) reports its young at Campobello Island, Bay of Fundy, in December and March.

[73] Reported by Vladykov, Copeia, 1936, No. 3, p. 168. One vessel brought in about 10,000 pounds.

[74] At lat. 40° 58′ N.; long. 70° 32′ W.

[75] Such a race has been reported in Cobbett Pond, Rockingham Co., N. H. by Kendall (Occ. Pap. Boston Soc. Nat. Hist., vol. 7, No. 8, 1908, p. 38) and by Bailey (Biological Survey Merrimac Watershed, New Hampshire Fish and Game Dept., 1938, p. 162).

[76] Belding (Rept. Alewife Fish. Massachusetts, Mass. Dept. Conserv., 1921) has given a very instructive report on the alewife in Massachusetts.

[77] Smith, Rept. U. S. Comm. Fish. (1898) 1899, pp. 31–43.

large enough to be worth special notice were reported from the mouths of the St. Croix, Dennys, Machias, Medomak, Penobscot, St. George, Pemaquid, Damariscotta, and Kennebec Rivers; from Casco Bay; and from sundry other shore localities in Maine; from the Piscataqua River system in New Hampshire; from the mouth of the Merrimac, and from Cape Cod Bay. Few alewives enter the Merrimac, now, so polluted is it, and so obstructed by dams.[78] And Belding found them running in only about 9 or 10 streams on the Gulf of Maine coast of Massachusetts in 1920, out of 27 streams there that had formerly supported considerable alewife fisheries.[79]

At present, we learn from John B. Burns, of the Massachusetts Division of Marine Fisheries, only a few alewives manage to run up the Merrimac past the fish ladder at Lowell; there is a small but regular run in the Parker River; a few in the Ipswich; a good run in the Essex; a few in the Saugus; perhaps some in Weymouth Back River;[80] a small run in Wier River, Hingham (really a brook); a few in Bound Brook, Cohasset; a large run in Herring Brook, Pembroke (tributary to North River) yielding about 1,000 barrels yearly; increasing numbers in Jones River, Kingston, which had been restocked previous to 1938 when a fish ladder was installed; several thousand run yearly up Barnstable Mill Pond Brook; an improving run in Stony Brook, Brewster, where a ladder was built in 1945, and a good run in Herring River (really only a brook) in Wellfleet, Cape Cod.

The first alewives ordinarily appear early in April in the few streams tributary to Massachusetts Bay that they still frequent, and equally early (March or April) in the St. John River, New Brunswick, according to McKenzie;[81] but their date of arrival varies considerably from stream to stream, according to local conditions. Thus few are seen in the streams of Maine until late April or early May; the first alewives appeared in 1915, for example, in Campbell's Creek, Booth Bay Harbor, on April 20. And the earliest good runs on the Nova Scotia shores of the open Gulf and of the Bay of Fundy may come as early as April (streams of Yarmouth, Annapolis, Hants, and Colchester Counties), in May (Digby and King's County streams), or not until June (Cumberland County.[82] Successive runs follow thereafter, all around the Gulf, until well into June, the later runs, going up, passing the earlier spawners coming down. In 1915, we saw this happening in Campbell's Creek, Boothbay, on May 20. And alewives have been seen, descending, as late as August 20, in Massachusetts streams.

The extreme range of temperature within which eggs are spawned, in Gulf of Maine tributaries, is not known; probably the bulk of production takes place between about 55° and about 60°.

Numerical abundance.—In 1896[83] reported catches were 2,677,972 individual alewives (1,356,755 lb.) for Cape Cod Bay and for the Merrimac River combined; 526,500 (293,671 lb.) for New Hampshire streams; and 5,832,900 (3,388,326 lb.) from the rivers and streams and coast of Maine. The reported catch was 5,843,000 pounds[84] for the New Brunswick shore of the Bay of Fundy that year; 1,609,400 pounds for the Nova Scotia side and for the west coast of Nova Scotia, or about 10,510,000 and about 2,895,000 individual fish, respectively, assuming that the average weight was about the same as that for the alewives of Maine. We thus arrive at a total catch for the Gulf of Maine of something like 22 million individual fish at that time and actually somewhat more, for the canvass certainly was not 100 percent complete.

The run was much greater then in the St. John River system than in any other Gulf of Maine river and doubtless is still. The Damariscotta River, ranking second, was about one-third as productive as the St. John; the Merrimac, St. George, and Penobscot Rivers only something like one-tenth as productive each. Casco Bay yielded about one-sixth as many alewives as the St. John River, the shore line of Cape Cod Bay about one-fifth as many.[85] And the catch of the St. John River system (including Kennebecasis Bay) still was about five times as great in 1931 as that for any of the other counties of New Bruns-

[78] Fishways recently constructed now allow a few to ascend beyond Lowell' Massachusetts.

[79] See his report on the Alewife Fishery of Mass. (Mass. Dept. of Conservation, Div. Fish. and Game, 1921) which gives much information as to the status of the alewife in Massachusetts streams.

[80] Stocked with 28,000 adult fish in 1949, and fish ladders under construction.

[81] Rept. Biol. Board Canada (1931) 1932, p. 34.

[82] According to McKenzie, Rept. Biol. Board Canada (1931) 1932, p. 34.

[83] A special study of the alewife fishery was made for that year, see Smith, Rept. U. S. Comm. of Fish. (1896) 1899, pp. 33-43.

[84] The Canadian catches for the year were reported in barrels; the conversion factor used is 200 pounds per barrel.

[85] Reported catches for 1896 were about 4,234,000 pounds for the St. John River system; 1,390,612 pounds for the Damariscotta River, 385,804 pounds for the St. George River, 308,844 pounds for the Penobscot, 472,500 pounds for the Merrimac, 701,287 pounds for Casco Bay, and 884,255 pounds for Cape Cod Bay.

wick or of Nova Scotia that border on the Bay of Fundy or on the open Gulf.[86]

The alewife population of the Gulf is much smaller, today, than it was half a century ago. Thus the catch was only about one-half as great for the Bay of Fundy in 1945 and 1946 [87] as it had been in 1896, and about one-third as great for Maine (1,224,600 lb.) while the Merrimac River, yielding 472,500 pounds in 1896, yielded less than 3,000 pounds in 1945.[88] And though alewives may seem almost incredibly numerous when crowding into some stream, they made but a sparse population, even in their days of greatest plenty, when spread over the coastal waters of our Gulf, as compared to the sea herring.

Importance.—Alewives are excellent food fish and they are marketed both fresh and salted, and are preferred by many to the sea herring. They are good bait for cod, haddock, and pollock; and their scales commanded a high price for use in the manufacture of artificial pearls for a brief period during the first world war and for a few years afterward.[89] By far the greater part of the catch of alewives is made in the lower reaches of the streams that they enter to spawn, in weirs, in dip nets or in haul seines according to locality. Most of those taken in outside waters (as in Casco and Cape Cod Bays) are either gill netted or are picked up in the fish traps.

[86] McKenzie, Rept. Biol. Board Canada (1931) 1932, p. 34.

[87] 5,051,100 pounds and 4,517,500 pounds, respectively.

[88] The reported catch for Essex County, Massachusetts, in that year was 2,700 pounds, only a part of which was from the region of the Merrimac.

[89] For details, see Report, Division of Fish and Game, Mass. (1920) 1921, p. 140.

Blueback *Pomolobus aestivalis* (Mitchill) 1815
GLUT HERRING; SUMMER HERRING; BLACKBELLY; KYACK

Jordan and Evermann, 1896–1900, p. 426.

Description.—Bluebacks and alewives are difficult to distinguish; experienced fishermen who recognize the existence of the two separate fish cannot always tell them apart, so closely do they resemble one another in general appearance. The most obvious external difference between them is that the back of the blueback is definitely blue green, that of the alewife gray green. But this applies only to fresh-caught fish; preserved specimens do not differ much in color, or fish that have been on ice for more than a short time. Another external difference is that the eye of the blueback is only about as broad as the distance from front of eye to tip of snout (or slightly broader), but is appreciably broader than that in the alewife; the blueback, too, with body about 3½ times as long as deep, is a slightly more slender fish (on the average) than the alewife, and its fins are a little lower, but the two species probably intergrade in both these respects.

The most dependable distinction between the two (though requiring the use of a knife) is that the lining of the belly cavity is sooty or blackish in the blueback, but pearl gray or pinkish gray in the alewife. We have yet to see a specimen that could not be named as the one or the other on this basis alone, unless so poorly preserved that the original shade of the cavity could no longer be determined.

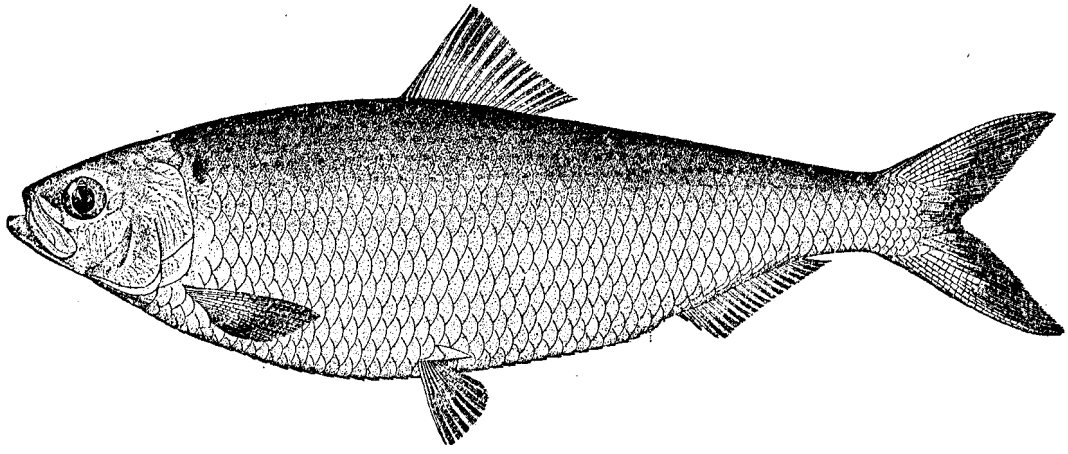

FIGURE 47.—Blueback (*Pomolobus aestivalis*), Chesapeake Bay region specimen. From Goode. Drawing by H. L. Todd.

Color.—Dark blue or bluish gray above, the sides and belly silvery, with coppery reflections at least in some waters; lining of the belly sooty or blackish.

Size.—The blueback attains about the same size as the alewife, i. e., 15 inches; the adults average about 11 inches in length and about 7 ounces in weight.

Habits.—The blueback, like the alewife, makes its growth in salt water, but runs up into fresh water to spawn. And its breeding habits do not differ in any important particular from those of the alewife, except that it "runs" later in the season, does not run up as far above tidewater, and does not spawn until the water is much warmer, 70° to 75° instead of 55° to 60°.[90] The eggs, about 1 mm. in diameter, sink like those of the alewife, and stick to anything they may chance to touch. Incubation occupies only about 50 hours at a temperature of 72°. The young are 30 to 50 mm. long within a month and already show most of the diagnostic characters of the adult. Evidently they soon find their way down to the sea, for bluebacks of 50 mm. have been seined in abundance in Rhode Island waters late in July.[91] Nothing whatever is known of their later rate of growth. The spent fish, return to sea shortly after spawning as do alewives. Practically nothing is known of their movements in the sea, except that they are schooling fishes. The fact, however, that 7 were trawled by the *Albatross II* on March 5, 1931 about 100 miles off Cape May, N. J., suggests that the blueback moves out from land and passes the cold season near the bottom.

We need only note further that the blueback is as gregarious as the herring or alewife; that it is equally a plankton feeder, subsisting chiefly on copepods and pelagic shrimp, as well as on young launce and, no doubt, on other small fish fry.

General range.—This is a more southern fish than the alewife, occurring along the American coast as far south as northern Florida; as far north as southern New England in abundance, perhaps less regularly in the Gulf of Maine though widespread there, and known definitely as far north as Cape Breton, Nova Scotia:[92] it spends most of its life in salt water but runs up into fresh water to spawn.

Occurrence in the Gulf of Maine.—Although fishermen have recognized the existence of two distinct species of alewives at least since 1816, it is difficult to arrive at a just idea of the status and migrations of this fish in our Gulf, because fish reported as "bluebacks" at sea sometimes turn out to be alewives, while the late runs of alewives are often referred to as "bluebacks." It seems, however, that schools of bluebacks are to be expected anywhere between Cape Sable and Cape Cod. Thus we have seen "gaspereau" fresh caught at Yarmouth, Nova Scotia, that appeared to be bluebacks.[93] Huntsman had specimens from St. John Harbor and Shubenacadie River; they are reported, at least by name, from the St. Croix River; from Dennys River, Eastport; Bucksport; Casco Bay; Small Point; Freeport; and sundry other localities along the coast of Maine, as well as from the shores of Massachusetts Bay, including Cape Cod.

L. W. Scattergood of the U. S. Fish and Wildlife Service has sent us about 40 typical bluebacks, about 3¾ to 5½ inches (92–124 mm.) long taken at Hodgdon Island, Sheepscot River, Maine, June 14, 1951; and we once saw thousands of fish taken from a trap near Gloucester, most of which we judged to be bluebacks from their color.[94] A few fish were reported as "bluebacks" from Georges Bank during the investigation of 1913, and while there is no way, now, of checking whether these actually were bluebacks or alewives, the fact that we saw 10 bluebacks about 1 foot long, trawled by *Albatross III* at the 45 fathom line off southern New England, in mid-May, 1950,[95] shows that they may spread as far offshore as alewives.

No definite information is at hand as to how regularly alewives run into our Gulf of Maine streams, for spawning; or what streams they enter at all.

No distinction is made, commercially, on our coast between the blueback and the more abundant alewife; it is equally useful for bait and for food.

[90] The early development and larval stages of the blueback are described by Kuntz and Radcliffe (Bull. U. S. Bur. Fish., vol. 35, 1918, pp. 87–134).

[91] In Chesapeake Bay, Hildebrand and Schroeder (Bull. U. S. Bur. Fish., vol. 43, 1928, p. 88) found that while most of the young bluebacks pass out to sea during the summer and fall, some remain in the deeper holes over the winter. By the following March when about a year old these are about 3½ to 4 inches long; those in the sea may grow faster than this.

[92] Dr. A. H. Leim has sent us four typical bluebacks about 12 inches long, taken at Cape Breton, Nova Scotia, in 1950.

[93] We had no chance to examine them critically.

[94] We did not then appreciate the desirability of positive identification.

[95] Lat. 40° 06′; long. 71° 38′ W.

Shad *Alosa sapidissima* (Wilson) 1811 [Approximate date]

Jordan and Evermann, 1896–1900, p. 427.

Description.—The shad is a typical member of the herring tribe in all respects with soft-rayed dorsal and anal fins of moderate size, the former situated above the ventrals and well forward of the middle of the body. It has a deeply forked tail and large scales that are loosened easily. Unlike the sea herring, the shad has no teeth on the roof of the mouth; adults have no teeth at all, although young shad have small ones in the jaws which may persist until the fish is a foot or so long. The shad agrees with the hickory shad, alewife, and blueback, in its deep body and sharp saw-edged belly. But it differs rather noticeably from the hickory shad in its longer mouth, with upper jaw reaching to below the rear edge of the eye, and in the fact that the tip of its lower jaw is entirely enclosed within the tip of the upper when its mouth is closed. The most clear cut character distinguishing shad from alewife and blueback is that the upper outline of the shad's lower jaw is very slightly concave, without a sharp angle, the outline of theirs deeply concave with a pronounced angle. Furthermore the lining of the shad's belly is very pale.

Color.—Dark bluish or greenish above, white and silvery low on sides and on belly, with a dusky spot close behind the rear edge of the gill cover, and usually with one or two longitudinal rows of indistinct dusky spots behind it.

Size.—The shad is the largest of the herrings that regularly visit our Gulf, growing to a length of 2½ feet. In the Bay of Fundy, according to Leim [96] shad weigh about ⅛ pound at 8 inches; about ⅜ pound at 12 inches; about 1⅛ pounds at 15 to 16 inches; about 2½ pounds at about 20 inches; and about 4½ pounds at 23 to 24 inches, though with variations according to their condition. Adult males weigh from 1½ to 6 pounds; females from 3½ to 8 pounds. Shad are occasionally reported to 12 pounds, and the older writers mention shad of 14 pounds, but none so large has been credibly reported in the Gulf of late years.

Habits.—The shad, like the alewife, spends most of its life at sea, and makes most of its growth there, but runs up into fresh rivers to spawn, the spent fish soon returning to salt water, and its fry soon running down also. During their stay in the sea shad are schooling fish, often in thousands, and they never reenter fresh water until they return to spawn, though they sometimes do appear in brackish estuaries. Schools of shad are often seen at the surface in spring, summer, and autumn. In winter they disappear from sight. Probably the shad of the year winter near the mouths of their parent streams; the larger sizes somewhat farther out and deeper. The most direct evidence as to the depths to which they may descend is that shad have been trawled at about 50 fathoms off Nova Scotia in March (see footnote 22, p. 112), and at 26 to 68 fathoms off southern New England in May (footnote 23, p. 112).

Food.—The shad, like other herrings, is primarily a plankton feeder. We have found shad taken in the Gulf of Maine in summer full of copepods (chiefly *Calanus*), and the stomach con-

[96] Contrib. Canad. Biol., N. Ser., vol. 2, 1924, p. 245, fig. 41.

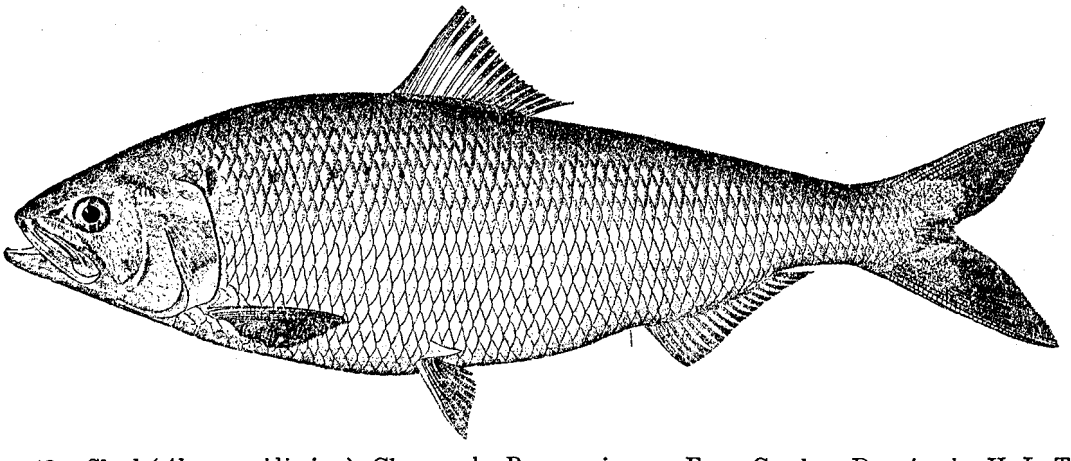

FIGURE 48.—Shad (*Alosa sapidissima*), Chesapeake Bay specimen. From Goode. Drawing by H. L. Todd.

tents of fish from the Nova Scotia Coast of the Bay of Fundy examined by Willey [97] consisted chiefly of the copepod genera *Arcatia* and *Temora* with other smaller ones, of mysid shrimps and of the larval stages of barnacles; while Leim [98] found that the shad in the open Bay of Fundy feed chiefly on copepods and mysids. Shad are also known to feed as greedily on the pelagic euphausiid shrimps as herring do, on fish eggs, and even on bottom dwelling amphipods, showing that they forage near the ground at times.

Occasionally they eat small fish, but these are only a minor item in their general diet.[99] Shad, it appears, take little or no food just prior to spawning. But they will often take an artificial fly, or a live minnow when running upstream to spawn.[1] During the past few years, crowds of anglers have caught many on flies in the Connecticut River, and doubtless could in the few Gulf of Maine streams to which shad still repair (p.110).

Reproduction and growth.[2]—The sexually mature fish enter the streams in spring or early summer when the river water has warmed to 50° to 55°. Consequently the shad run correspondingly later in the year passing from south to north along the coast, commencing in Georgia in January; in March in the waters tributary to Pamlico and Albemarle Sounds; in April in the Potomac; and in May and June in northern streams generally from the Delaware to Canada. In the Kennebec, according to Atkins,[3] the first shad appear (or did) late in April, with the main run in May and June; the first ripe females are caught the last week in May and they begin to spawn about June 1, most of them doing so during that month, a few in July, and possibly an occasional fish as late as August. Probably these dates applied equally to the Merrimac in the good old days when shad were plentiful there, but the season is somewhat later in the St. John, also in the Shubenacadie as might be expected; i.e., from mid-May until the end of June.[4]

In large rivers they run far upstream. In the St. John River, New Brunswick, they ascend about 200 miles to the grand falls even today according to Leim, and they still run up 300 miles (or did recently) in the Altamaha in Georgia; for 375 miles in the St. Johns River, Florida. But they could run up only about 35 miles at present in the Penobscot, where they formerly ascended some 90 miles, or 44 miles (to Augusta) in the Kennebec, which they formerly ascended 108 miles (to Carratunk Falls), though none enter either of these rivers now, so far as we know. And the dams at Lawrence, only 20-odd miles upstream, now stop any stray shad that may still enter the Merrimac, which they formerly ascended for 125 miles to Lake Winnepesaukee.[5]

In the Shubenacadie, shad spawn mostly in temperatures higher than about 54°, and spawning is interrupted if the water chills below that, temporarily.

The fish select sandy or pebbly shallows for spawning grounds, and deposit their eggs mostly between sundown and midnight. Females produce about 30,000 eggs on the average, though as many as 156,000 have been estimated in very large fish. The spent fish, now very emaciated, begin their return journey to the sea immediately after spawning. In the Kennebec they were first seen on their way down about June 20 and constantly thereafter throughout July; in the St. John spent fish are running down in July and August. According to Atkins they begin feeding before reaching salt water and recover a good deal of fat before moving out to sea.

The eggs are transparent, pale pink or amber, and being semi-buoyant and not sticky like those of other river herrings they roll about on the bottom with the current. The eggs hatch in 12 to 15 days at 52° (12° C.), in 6 to 8 days at 63° (17° C.), which covers the range characteristic of Maine and Bay of Fundy rivers during the season of incubation. And Leim has made the interesting discovery that larval development is more successful in brackish than in pure fresh water, with about 7.5 parts of salt per thousand as about the most favorable salinity.

The larvae are about 9 to 10 mm. long at the time of hatching, growing to about 20 mm., at 21

[97] Contrib. Canad. Biol., N. Ser., vol. 1, 1923, p. 316.

[98] Contrib. Canad. Biol., N. Ser., vol. 2, 1924, p. 231.

[99] Leidy (Proc. Acad. Nat. Sci. Philadelphia, Ser., 2, 1868, p. 228) found 30 small sand eels (*Ammodytes*) in the stomach of a shad, probably caught in Delaware Bay.

[1] Bean (Bull. 60, Zool., vol. 9, New York State Mus., 1903, p. 207) commented on this long ago.

[2] Accounts of the breeding habits of the shad have been given by Ryder, Rept. U. S. Comm. Fish. (1885) 1887, p. 523; by Prince (Supp. 6, Rept. Dept. Marine Fish. Canada, Fish. Branch. 1907, pp. 95-110; in the Manual of Fish Culture, published by the U. S. Bur. of Fish., 1887; and more recently by Leim (Contrib. Canadian Biol. N. Ser. vol. 2, 1924, pp. 184-202).

[3] Fish. Ind. U. S., Sect. 5, vol. 1, 1887, pp. 683-684.

[4] Leim, Contrib. Canad. Biol., N. Ser., vol. 2, No. 11, 1924, p. 182.

[5] Stevenson (Rept. U. S. Comm. Fish., (1898) 1899, p. 111) has given a table of the distances to which shad ascended various rivers then, and formerly from the Penobscot in Maine to the St. Johns in Florida.

to 28 days. Shad larvae resemble alewife larvae, being extremely slender with the vent almost as far back as the base of the tail.[6] The young shad remain in the rivers until fall, when they move down to salt water; they are now 1½ to 4½ inches long, resembling their parents in appearance.

According to Leim's investigation, based on scale studies and length frequencies, shad in the upper Bay of Fundy, average about 5 to 6 inches long when one year old; 9 to 10 inches long at 2 years; 13 to 14 inches at 3 years; 15 to 16 inches at 4 years; and 18 to 19 inches at 5 years. The two largest he examined, about 24½ inches (62 cm. and 63 cm.) long, appeared to be 7 and 6 years old, respectively. They may grow somewhat faster in the open Gulf of Maine, to judge from the greater abundance of pelagic crustaceans on which they feed (p. 109). Most of the spawning fish are 5 years old in the Shubenacadie, and presumably in other Gulf of Maine rivers; the oldest 8 or 9 years old.

General range.—Atlantic coast of North America from the southeastern coast of Newfoundland,[7] which shad have been known to reach as strays, and the estuary of the St. Lawrence River, where there is a considerable population of them,[8] to the St. Johns River in Florida; also represented in the Gulf of Mexico by a closely related species. The shad has been successfully introduced on the Pacific coast of the United States. It runs up rivers into fresh water to spawn.

Occurrence in the Gulf of Maine.—When the first settlers arrived in New England they found seemingly inexhaustible multitudes of shad annually running up all the larger rivers and many of the smaller streams, with the tributaries of the Gulf of Maine hardly less productive than the Hudson or Delaware. But one stream after another was rendered impassable by the construction of dams near the mouth, for shad cannot or will not run up through fishways that are readily used by alewives. Indeed, they have been practically wiped out in the Merrimac River, as appears from the following compilation:[9]

Year	Number of shad caught, reported, or estimated	Year	Number of shad caught, reported, or estimated
1789	830,000	1888	None
1805	540,000	1889	18
1835	365,000	1890–1892	None
1865	50,000	1893	2,020
1871–1873 (average)	1,942	1894	2,750
1880	2,139	1895	94
1885	130	1896	7

The Gulf of Maine rivers to which shad are known to resort regularly today are the Annapolis, Petit Codiac, Shubenecadie, and St. John, tributary to the Bay of Fundy; perhaps the St. Croix;[10] the only Maine rivers that see regular runs of a few shad are the Nonesuch and the Sheepscot.[11]

A few shad may enter other Gulf of Maine streams in some years if not yearly, and bright spots in the shad picture are that a considerable number of adult shad ran up the South River in Marshfield, Massachusetts, on the southern shore of Massachusetts Bay in 1950, and that there has been a run of something like 2,000 shad yearly in Mill Creek, Sandwich, Mass., for the past four years.[12] How successfully they may have spawned in either of these streams is not known.

It appears that most of the shad hatched in the rivers tributary to the Bay of Fundy, and the spent fish from there, remain in or near the estuaries where they take to salt water; and that most of the adults that survive the strain of spawning return to the parent stream to spawn again. Thus it is only in St. Marys Bay, in Annapolis Basin, in Cobequid Bay and Minas Basin, in Chignecto Bay and at the mouth of the St. John as well as for a few miles westward, that large Fundian shad are caught in any numbers.[13] The fact, on which Leim [13a] comments that "there is not a single record of a shad ever having been taken" at Grand Manan island, although this "lies almost directly in the path of any body of

[6] Leim (Contr. Canad. Biol., N. Ser., vol. 2, No. 11, 1924, p. 195) gives a detailed comparison of shad with alewife larvae.

[7] The most northerly record of a shad, on which we have chanced, is one taken in Bull's Bay, near St. Johns, Newfoundland.

[8] See Vladykov (Contr. Dept. Fish., Quebec, No. 30, 1950, pp. 121–135, and Natural. Canad., vol. 77, 1950, pp. 121–135) for a study of the movements of the shad in the St. Lawrence estuary.

[9] From Stevenson, Rept. U. S. Comm. Fish. (1898) 1899, p. 262.

[10] The St. Croix once had a large run of shad. None were seen there for 8 or 9 years prior to 1915, but they were there in some numbers in 1915 and 1916, according to investigations by H. F. Taylor of the U. S. Bureau of Fisheries; their present status there is not known. They have been entirely extirpated from the Saco, where they were abundant formerly, probably from the Penobscot and Kennebec, and certainly from the Merrimac, as noted above.

[11] Information from Dr. C. E. Atkinson, U. S. Fish and Wildlife Service.

[12] Reported to us by John B. Burns of the Massachusetts Division of Fisheries and Game.

[13] Leim (Contr. Canad. Biol. N. Ser., vol. 2, No. 11, 1924, fig. 2) gives a chart showing the location of shad catches for the Bay of Fundy.

[13a] Contr. Canad. Biol. N. Ser., vol. 2, No. 11, 1924, p. 173.

fish going in or out of the Bay of Fundy," is especially significant as emphasizing the localization of the St. John shad near the parent river.

The behavior of the St. John river shad raises an interesting question, as to the source of the young fish that sometimes congregate in the Bays and among the islands along the coast of Maine (Casco Bay especially), for there seem to be too many of them, in some years, to be credited to the small runs that still frequent the rivers of Maine (unless runs may have been overlooked of late in other rivers there).

Immature shad, up to 2 to 2½ pounds in weight are observed more or less commonly in Cape Cod Bay near Provincetown in summer or autumn and in the inner parts of Massachusetts Bay (sometimes taken in the traps at Beverly or Manchester), and off Cape Ann.[14] Spent shad up to 10 pounds in weight (averaging about 5 pounds), are sometimes reported by fishermen off the coast of Maine west of Penobscot Bay; near the Isles of Shoals; off York Beach, and off Cape Ann, in summer, autumn, and even in December.[15]

The few mature shad with ripening sexual organs that are picked up by the haddock netters between Cape Ann and Portland in April and May, most often about the Isles of Shoals and Boon Island,[16] probably are headed for the rivers of Maine.

Larger numbers of fish are seined in September and October, in the neighborhood of Mount Desert Island, where they have been the object of a frozen fish industry in some years.[17] These, like the green fish mentioned above, seem far too numerous to be accounted for by the small production that still takes place in the rivers of Maine. Some few of them, it seems, are Bay of Fundy fish, for one of a batch tagged near Mount Desert Rock in August 1947, was recaptured in Kings County, New Brunswick (St. John River system) the following June, and a second in the Petitcodiac River that July, while a third, tagged farther west on the coast of Maine in August or September 1948 was recaptured in the St. John River in May 1950. But it seems established that most of the medium-sized shad and larger now found in our Gulf are immigrants from the south, growing and fattening on the rich supply of plankton they find there, but returning to the rivers west and south of Cape Cod to spawn.

Direct evidence of this is that one tagged in Chesapeake Bay was recaught at Race Point, at the tip of Cape Cod, 39 days later; [18] one also was recaptured near Gloucester and another near Portland that had been tagged in the Hudson River, while 3 out of 1,380 tagged in New York Bay were recaptured in the Bay of Fundy after 37 days, 75 days, and 85 days, respectively, and one tagged off Fire Island, N. Y., was recaught at St. John, New Brunswick, after 39 days.[19] On the other hand, 18 shad, from a batch of 236 that were tagged near Mount Desert Rock in August 1947 were recaptured the next spring scattered along in different stream systems from the Connecticut to the Altamaha in Georgia. Others, from this same batch, were recaptured in the Connecticut, in the Hudson, on the coast of New Jersey, and in the Pamlico River, N. C., during the next two springs. And three others, from a batch of 431 tagged farther west along the coast of Maine in the summer and autumn of 1948, were recaptured in the Hudson River; three in Chesapeake Bay, and one in the Pamlico River, N. C.[20]

The shad that take part in this intermigration must winter somewhere between their northern feeding grounds whence they have vanished wholly by mid-autumn, and their southern breeding streams near which they do not appear until spring. But it is not yet known where they pass the cold months, how deep down they go, how far offshore, or how active they are then.

Still other shad are known to make very long journeys that can hardly be fitted into any regular migratory pattern, and from which they may never find their way back. Thus one that was tagged in the lower St. Lawrence River was recaught on Brown's Bank 258 days later; a second, from that same batch, was recaught in Cumberland basin, near Amherst, Nova Scotia, at the head of the Bay of Fundy after 322 days; a third at Province-

[14] 502 barrels (about 100,400 lb.) were taken in one set of mackerel pounds at Provincetown in June 1910; the traps picked up numbers of shad of about 14 inches from June 20 to July 6, 1921, at Magnolia and Beverly, where the catch was 10,300 pounds in 1945; and 14 shad 11 to 15¾ inches long were taken in one set of traps at Barnstable, on Cape Cod Bay, October 3, 1950.

[15] 135,000 pounds of these large spent fish were caught near Gloucester in the autumn of 1915; 125 barrels of 2- to 5-pound shad, some spent, near Seguin Island, July 19, 1925.

[16] A series of shad from that region, examined by the late W. W. Welsh in April and May 1913, averaged 5 pounds, all with well-developed sex organs.

[17] About 250,000 pounds were brought in to the local freezers yearly in 1913, 1914, and 1915.

[18] Vladykov, Trans. Amer. Fish. Soc., vol. 67, 1938. p. 64.

[19] Information supplied by C. E. Atkinson, U. S. Fish and Wildlife Service.

[20] Information supplied by E. H. Hollis of the U. S. Fish and Wildlife Service.

town at the tip of Cape Cod, some 1,200 miles away from where it had been tagged 444 days previous.[21] And one, from a batch of weir-caught fish tagged on the coast of Maine, August–September, 1948, was recaught in the Medway River, outer coast of Nova Scotia, a second, in the Miramichi River, tributary to the southern side of the Gulf of St. Lawrence in 1950, and a third, off Tor Bay, eastern Nova Scotia in 1951.

To what extent the seasonal journeys of the shad are passive with the dominant circulatory movements of the water, and to what extent (if any) they are self-directed is perhaps the most interesting question that now faces us in our studies of the shad of the Gulf of Maine.

Shad have been trawled 50 to 60 miles out, off eastern Nova Scotia;[22] have often been reported 40 to 50 miles out off the coast of Maine; also 25 to 90 miles out, off southern New England,[23] and we saw one trawled by the *Eugene H* in late June, 1951, on the southern part of Georges Bank (lat. 40°52′N., long. 67°40′W.), about 110 miles from the nearest land. Evidently they may wander as far offshore as alewives do; perhaps even as far as herring.

Shad reared in different regions may, perhaps, prove to differ enough in racial characters for recognition when taken at sea, but this is a question for the future.[24]

Abundance.—The stock of shad in the Gulf is but a shadow in comparison with that of colonial days.

In 1896, the only year for which detailed information is available as to the numbers taken in different streams, 290,122 shad were reported as caught in the Kennebec system, 9,000 in the Pleasant River, about 3,000 in the Harrington River, only 114 in the Penobscot and 12 in the St. Croix; 100 in the Piscataqua and 7 in the Merrimac.[25] In that same year the catch was about 1,059,000 pounds for the Nova Scotia shore of the open Gulf and for the Bay of Fundy;[26] 1,404,477 pounds for the rivers and coast of Maine; about 122,932 pounds (32,782 fish) for the Gulf of Maine coast of Massachusetts, or a total of about 2,586,400 pounds for the Gulf as a whole. With shad averaging about 3¾ pounds in weight,[27] this corresponds to about 690,000 fish.

But the yearly catch was only about one-third as great for the period 1916–1919 as it had been in 1896, whether for the United States shores of the Gulf or for the Canadian.[28] And it was of about that same order of magnitude in 1931, i. e., 677,540 pounds for the Gulf as a whole (157,763 pounds for Maine, 147,277 pounds for Massachusetts, 237,200 pounds for the Bay of Fundy and West Nova Scotia region). Since that time, the catches have ranged between 10,400 pounds and 306,000 pounds for the Massachusetts coast of the Gulf and between 9,300 pounds and 1,106,800 pounds for Maine, a fluctuation so extreme (no regional correlation appearing) as to suggest that market conditions were the chief governing factor. On the other hand the catches for the Canadian shores of the Gulf increased rather consistently from 1931 to a total of 1,287,600 pounds in 1939 then declined to around 780,000 pounds for 1944 and 1946, a rise and fall regular enough to suggest a corresponding fluctuation in the actual abundance of the shad. The average yearly catch for the period 1944–1946 combined, was about 20,000 pounds for Massachusetts, about 224,050 pounds for Maine, and about 780,000 pounds for the Bay of Fundy and western Nova Scotia.

Thread herring *Opisthonema oglinum* (LeSueur) 1817

Jordan and Evermann, 1896–1900, p. 432.

Description.—The thread herring is distinguishable at a glance from all the herrings that regularly inhabit the Gulf of Maine by the prolonged last ray (usually about as long as the body is deep) of its dorsal fin. It resembles the gizzard shad of

[21] See Vladykov, Nat. Canad., vol. 77, 1950, p. 121, for a detailed account of his tagging experiments on St. Lawrence River shad.

[22] Vladykov, Copeia, 1936, No. 2, p. 168, reports between 25 and 30 shad of 4–6 pounds, taken per haul, by otter trawlers in March, 1935, southwest of Middle Ground, about lat. 44°25′ N., long. 61°05′ W., at about 50 fathoms.

[23] Two shad were trawled by *Albatross III* on the eastern part of Nantucket Shoals at 68 fathoms, and 46 others at 9 stations distributed thence westward to the offing to Montauk Point (long. 71°52′ W.) at 26–64 fathoms, May 11–18, 1950.

[24] Vladykov and Wallace (Trans. Amer. Fish. Soc., vol. 67, 1937–1938, pp. 52–66) believe that Shubenacadie, Delaware River and Chesapeake Bay shad differ significantly in average number of vertebrae, of mid ventral scales and of pectoral fin rays. But Warfel and Olsen (Copeia, 1947, pp. 177–183) doubt whether any distinction can be drawn between shad in various streams along our North Atlantic coast, at least as far as average number of vertebrae goes.

[25] Stevenson, Rept. U. S. Comm. Fish (1898) 1899 pp. 265–269.

[26] These catches were reported as "barrels" presumably of 200 pounds each.

[27] Stevenson, Rept. U. S. Comm. Fish (1898) 1899, p. 121.

[28] About 460,000 pounds for the United States coast of the Gulf and about 374,000 pounds for the Bay of Fundy and in western Nova Scotia combined in 1916–17.

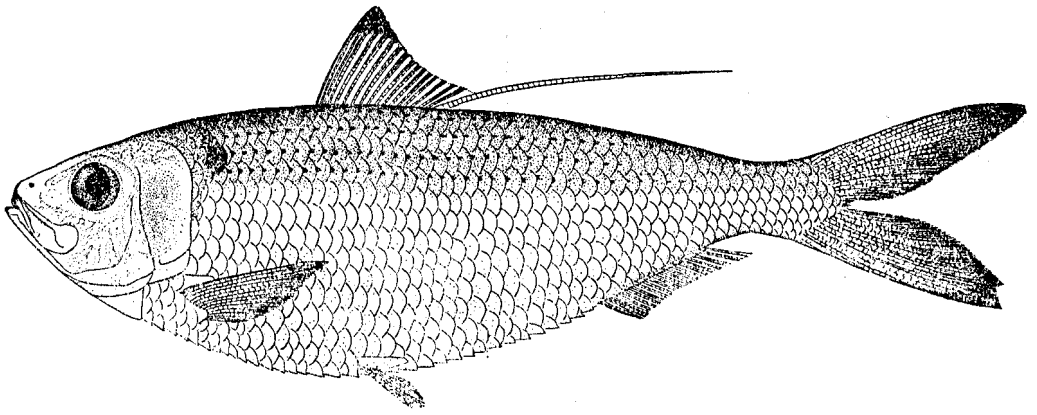

FIGURE 49.—Thread herring (*Opisthonema oglinum*). Drawing by Louella E. Cable.

fresh and brackish waters farther south in this respect, but the two differ rather conspicuously in various details. In the thread herring, the upper edge of the tail fin is about 1½ times as long as the head (only about as long as the head in the gizzard shad); the point of origin of the dorsal fin is a little in front of the origin of the ventral fins (a little behind in the gizzard shad); the distance from the origin of the ventrals to the origin of the anal fin is at least 1½ times as long as the base of the anal (only about ¾ to ⅘ in the gizzard shad); and the anal fin is very low, with its first few rays a little shorter than the eye (about 1½ times as long as the eye in the "gizzard"). There is no danger of confusing a thread herring with a young tarpon with which it shares the prolonged dorsal ray, for its dorsal fin originates in front of the ventrals, while the two fish are far apart in general appearance. This is a rather thin fish, its body about 2½ to 3 times as long (to the base of the tail) as deep; the belly is sharp and saw edged; the tail deeply forked as in our other herrings. There are 18 to 19 rays in the dorsal fin, 22 to 24 in the anal.

Color.—Bluish above, silvery on sides and belly. The scales along the back have dark centers, forming longitudinal streaks, and there is a faint dark spot just behind the upper margin of the gill cover; the dorsal and caudal fins have black tips.

Size.—Maximum length about 12 inches.

General range.—Atlantic coast of America in tropical and subtropical latitudes, south to Brazil, straying northward to Chesapeake Bay, and occasionally as far as southern Massachusetts.

Occurrence in the Gulf of Maine.—A thread herring is caught off southern New England occasionally; they were even reported as rather common in Buzzards Bay and in Vineyard Sound during the summer of 1885. But there is only one record of it within the Gulf of Maine, a single specimen 7 inches long, taken off Monomoy Point, at the southern angle of Cape Cod, in August 1931.[29] Being a tropical fish, it is not apt to reach the Gulf except as the rarest of strays.

Menhaden *Brevoortia tyrannus* (Latrobe) 1802

POGY; MOSSBUNKER; FAT BACK

Jordan and Evermann, 1896–1900, p. 433.

Description.—This fish is universally called "pogy" in the Gulf of Maine but no less than 30 common names are in use south of Cape Cod. It is flattened sidewise like all our other herrings, has a sharp-edged belly, and is as deep proportionally as the shad (body about 3 times as deep as long), though the general form is altered when the fish are fat. The very large scaleless head, which occupies nearly one-third of the total length of the body, gives the menhaden an appearance so distinctive that it is not apt to be mistaken for any other Gulf of Maine fish. It is likewise distinguishable from all its local relatives by the fact that the rear margins of the scales are nearly vertical (not rounded), and are edged with long comblike teeth instead of being smooth. The dorsal fin originates over the ventrals or very slightly behind them. We need only point out further that the pogy is toothless, its tail deeply forked, its ventral fins very small, its dorsal and anal of moderate size, its mouth large and gaping back as far as the hind margin of the eye, and that the tip of its lower jaw projects beyond the upper.

[29] Reported by MacCoy, Bull. Boston Soc. Nat. Hist., No. 61, 1931, p. 21.

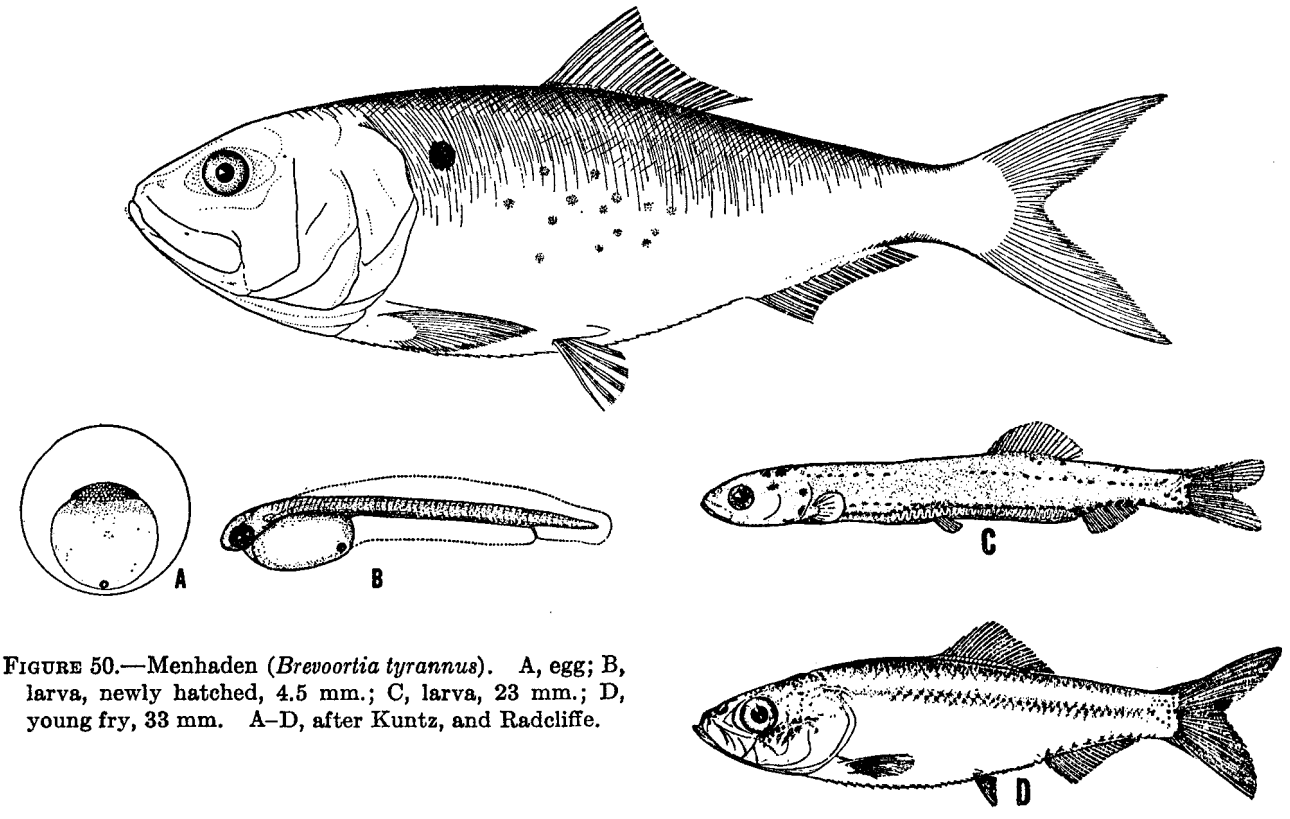

FIGURE 50.—Menhaden (*Brevoortia tyrannus*). A, egg; B, larva, newly hatched, 4.5 mm.; C, larva, 23 mm.; D, young fry, 33 mm. A–D, after Kuntz, and Radcliffe.

Color.—Dark blue, green, blue gray, or blue brown above, with silvery sides, belly, and fins, and with a strong yellow or brassy luster. There is a conspicuous dusky spot on each side close behind the gill opening, with a varying number of smaller dark spots farther back, arranged in irregular rows.

Size.—Adult menhaden average 12 to 15 inches in length, and from two-thirds to one pound in weight. One 18 inches long was taken at Woods Hole in 1876, and a fish 20 inches long has been reported. The heaviest of which we have heard was one of 1 pound 13 ounces, taken at Orient, N. Y.

Habits.—The menhaden, like the herring, almost invariably travels in schools of hundreds or thousands of individuals, swimming closely side by side and tier above tier. In calm weather they often come to the surface where their identity can be recognized by the ripple they make, for pogies, like herring, make a much more compact disturbance than mackerel do, and "a much bluer and heavier commotion than herring, which hardly make more of a ripple than does a light breeze passing over the water," as W. F. Clapp has stated to us. Also, pogies as they feed frequently lift their snouts out of water, which we have never seen herring do, while they break the water with their dorsal fins, also with their tails. And the brassy hue of their sides catches the eye (as we have often seen), if one rows close to a school in calm weather.

It is chiefly on warm, still, sunny days that the menhaden come to the surface, sinking in bad weather; and they are said to come up more often on the flood tide than on the ebb. It is also said (this we cannot vouch for) that the fish work inshore on the flood tide and offshore on the ebb.

Food.—The menhaden, formerly thought to subsist on mud, is now known to feed chiefly on microscopic plants (particularly diatoms) and on the smallest Crustacea.[30] It sifts these out of the water with a straining apparatus in the shape of successive layers of comb-like gill rakers as efficient as our finest tow nets. No other Gulf of Maine fish has a filtering apparatus comparable to that of the pogy, nor has it any rival in the

[30] For a detailed account of the food and of the branchial sieve of the menhaden, see Peck (Bull., U. S. Fish Comm., vol. 13, 1894, pp. 113-124, pls. 1-8.

Gulf in its utilization of the planktonic vegetable pasture. Menhaden feed, as Peck described, by swimming with the mouth open and the gill openings spread. We have often seen specimens in the aquarium at Woods Hole doing this.[31] And we have watched small ones in Chesapeake Bay, swimming downward as they feed, then turning upward, to break the surface with their snouts, still with open mouths.

The mouth and pharyngeal sieve act exactly as a tow net, retaining whatever is large enough to enmesh, with no voluntary selection of particular plankton units. The prey thus captured (as appears from the stomach contents) includes small annelid worms, various minute Crustacea, schizopod and decapod larvae, and rotifers, but these are greatly outnumbered as a rule by the sundry unicellular plants, particularly by diatoms and by peridinians. And the food eaten at a given locality parallels the general plankton content of the water, except that none of the larger animals appear in the stomachs of the fish on the one hand, nor the very smallest organisms (infusoria, and certain others such as the coccolithophorids) on the other. The menhaden, in short, parallels the whalebone whales, the basking shark, and the giant devil rays in its mode of feeding, except that its diet is finer because its filter is closer meshed.

Peck has calculated from observations on the living fish that an adult menhaden is capable of filtering between 6 and 7 gallons (about 24 to 28 liters) of water per minute, and while the fish do not feed continuously this will give some measure of the tremendous amount of water sifted and of plankton required to maintain the hordes in which these fish congregate. The abundance of microscopic plants in the water of bays and estuaries, and along the coast has often been invoked to explain the concentration of menhaden close to shore.

Enemies.—No wonder the fat oily menhaden, swimming in schools of closely ranked individuals, helpless to protect itself, is the prey of every predaceous animal. Whales and porpoises devour them in large numbers; sharks are often seen following the pogy schools; pollock, cod, silver hake, and swordfish all take their toll in the Gulf of Maine, as do weakfish south of Cape Cod. Tuna also kill great numbers. But the worst enemy of all is the bluefish, and this is true even in the Gulf of Maine during periods when both bluefish and menhaden are plentiful there (p. 384). Not only do these pirates devour millions of menhaden every summer, but they kill far more than they eat. Besides the toll taken by these natural enemies, menhaden often strand in myriads in shoal water, either in their attempt to escape their enemies or for other reasons, to perish and pollute the air for weeks with the stench of their decaying carcasses.

Breeding and growth.—Very little is known about the breeding habits of the menhaden, except that it spawns at sea and that the chief production of eggs takes place south of our limits. According to observations at Woods Hole,[32] the main body of the fish off southern New England spawn in June, continuing through July and August; even into October as in 1915, when the *Grampus* collected eggs and larvae in Nantucket Sound and westward from Martha's Vineyard in that month. And reports of spent fish in the Gulf of Maine in July and August, with others approaching maturity, suggest that the menhaden is a summer spawner there also. We have found no eggs in our townettings north of Cape Cod (young fry were taken in abundance in Casco Bay in October 1900), probably because our work there was carried on during a series of poor menhaden seasons. From Chesapeake Bay southward the spawning season appears to be late in the autumn, and in early winter.

Menhaden eggs are buoyant and resemble those of the European pilchard (*Clupea pilchardus*), but are easily distinguished from the eggs of any other Gulf of Maine fish by their large size (1.5 to 1.8 mm. in diameter), broad perivitelline space, small oil globule (0.15 to 0.17 mm.), and very long embryo. Incubation is rapid (less than 48 hours), as Welsh found by experiment. The newly hatched larvae are 4.5 mm. in length, growing to 5.7 mm. in 4 days after hatching. The dorsal and caudal fins first become visible at a length of 9 mm.; at 23 mm. all the fins are well developed; scales are present at 33 mm.; and at 41 mm. the fry show most of the characters of the adult, except that their eyes are much larger, proportionately. The youngest larvae much resemble young herring, but the fins are formed, the tail becomes forked, and

[31] Apparently Ehrenbaum (as quoted by Bullen, Jour., Mar. Biol. Assoc. United Kingdom, vol. 9, 1910–13, pp. 394–403) was not acquainted with the habits of menhaden when he wrote to the effect that no fish eat plankton indiscriminately, or swim about habitually with open mouth when feeding.

[32] By Kuntz and Radcliffe, Bull. U. S. Bur. Fish., vol. 35, 1918, p. 119, who describe the eggs and larvae.

the body deepens at a much smaller size, a menhaden of 20 mm. being as far advanced in development as a herring of 35 mm., which makes it easy to distinguish the older larvae of the two fish.

Welsh concluded from examination of great numbers of fry and from measurements and scale studies of fish of various ages that menhaden hatched in summer (which would apply to any fry that might be produced in the Gulf of Maine) are 2¼ to 3¼ inches (6 to 8 cm.) long by their first winter; and average about 6⅜ inches (16 cm.) by their second winter; fall-hatched fish are 1¼ inches (3 cm.) and about 5 inches (about 13 cm.) long, in their first and second winters, with every gradation between the two depending on the precise season when the fish are spawned.[33] Apparently sexual maturity is attained in the season following the third winter, and a few of the older fish that Welsh examined showed as many as 9 to 10 winter wings on their scales.

General range.—Coastal waters along the Atlantic coast of America from Nova Scotia to eastern Florida; represented in the Gulf of Mexico, and southward to northern Argentina, by a series of named forms that differ from our northern menhaden in ways that would not be apparent to any one but to a trained student of fishes.[34]

Occurrence in the Gulf of Maine.—The Gulf of Maine is the northerly limit for the menhaden; St. Mary Bay on the west coast of Nova Scotia is its most easterly known outpost. Prior to about 1850 the pogy seems to have been common at the mouth of the Bay of Fundy; it was, indeed, reported by Perley as far up the bay as St. John, and fishermen spoke of it as abundant near Eastport up to 1845–1850. But it seems to have abandoned Fundian waters altogether[35] since then except for an occasional straggler, and very few menhaden have been noticed east of Mount Desert and Jonesport of late years.

Perhaps the most interesting aspect of the occurrence of the menhaden in the Gulf of Maine is that it fluctuates tremendously in abundance there from year to year, periods of great plenty alternating with periods of scarcity or entire absence from our waters. Thus they were extremely abundant off the coasts of Massachusetts and Maine, every summer, for some years prior to 1875, when a considerable fishery developed for them in Maine. Very few, however, were taken in the Gulf during the cold summer of 1877 until September and October, when they were reported as about as abundant as normal; practically none appeared north of Cape Cod in the year 1879; and they were so scarce along the coast of Maine for the next six years that it caused comment when an occasional one was caught. In 1883, for instance, a few were reported to the U. S. Fish Commission though no schools were seen and many people thought they had gone permanently. But they were once more reported abundant off Maine and Massachusetts in 1886; they were so plentiful as far east as Frenchman Bay in 1888 that the menhaden fisheries were revived; they were as plentiful in Maine waters in 1889 as they had ever been (more than 10 million pounds taken there) and they were still so numerous in 1890 that four fertilizer factories were established, and nearly 90 million fish were taken during that season. But this period of abundance was short-lived, less than half as many fish being caught in Maine waters (about 41 million) in 1891 as the year before, while few menhaden were taken or seen north of Cape Cod in 1892. They were plentiful enough, however, in 1894, for a single steamer to seine about a million fish off the Kennebec during that summer, while 582,131 fish were taken in Boston Harbor in 10 days' fishing during the last half of that August.

Menhaden were scarce again in the Gulf during the period 1895–1897 but abundant again in 1898, when about 7 million pounds were taken along the Maine coast. They were scarce in 1902 (Maine catch about 300,000 lb.); reported as abundant again north of Cape Cod, in 1903, especially in Boston Harbor; rare north of Cape Cod from 1904 to 1921, when odd schools were seined along the Massachusetts and Maine coasts in some summers, while few or none were seen in others. They reappeared, however, in such abundance again in the southwest part of the Gulf in the summer of 1922 that 18 steamers fished for them successfully for some weeks in Massachusetts Bay, when upwards of 1,500,000 pounds were landed by the larger fishing vessels, besides what the small boats brought in. And they were so plentiful at

[33] Young menhaden that we collected at Woods Hole on September 23, 1942, were 3½ to 4 inches (91–99 mm.) long; others taken in Salt Pond, Falmouth, Mass., on November 24, 1949, were 4¾ to 5 inches long.

[34] See Hildebrand (Smithsonian Misc. Coll., vol. 107, 1948, No. 18 for a revision of the genus *Brevoortia*). One named species, *B. brevicaudata* Goode 1878, is known only from Noank, Conn.; we doubt its validity.

[35] According to Huntsman (Contr. Canad. Biol., (1921) 1922, p. 59) one was taken in St. John Harbor in August, 1919.

least as far north as Boothbay Harbor, that about 2,500 barrels were frozen there, though no large schools were reported east of that point.

The appearance of menhaden in such abundance in the Gulf after so many years' absence prompted the Bureau of Fisheries to send the steamer *Halcyon* to Massachusetts Bay that August, and her towings indicated the presence of much greater quantities of diatoms than is usual at that season, evidence that the fish found a better pasture in Massachusetts Bay than in any summer since 1912. But we hesitate to assert that it was an unusually rich food supply that attracted them past Cape Cod.

However this may have been, there were not enough menhaden in the Gulf to be of any commercial importance from the middle 1920's to the middle 1940's. But so many visited Massachusetts Bay, in 1946 and 1947 that local boards of health were forced to clean some of the bathing beaches of the fish that drifted ashore from schools netted for lobster bait. There were a good many in Maine waters in 1948 (reported catch 145,000 pounds);[36] more still in 1949, when more than 5,000,000 pounds were taken there; and about 8,000,000 pounds off Gloucester,[37] and when small fry, 2–3¾ inches (52–95 mm.) were taken in the Sheepscot River, December 5–11, suggesting that some had been reared in the Gulf that year. But this peak of abundance lasted no longer than the peak had in the early 1920's, for there seem to have been far fewer menhaden in Maine waters in 1950 than in 1949, as there certainly were in Massachusetts Bay, where we did not chance to sight a single school, and very few were reported.

In the years when menhaden come, they appear in Massachusetts Bay about mid-May; off the Maine coast during the last half of May or first part of June. They are most abundant during July, August, and early September, and most of them depart from the coast of Maine by the middle of October, from the Massachusetts Bay region by early November; and it is unusual to find a single menhaden along these shores after the middle of that month, although small ones have been taken in the Sheepscot River as late as the first third of December.

The universal belief among fishermen, that the seasonal appearances and disappearances of menhaden in the Gulf of Maine result from a definite migration from the south around Cape Cod in the spring and a return journey in the autumn, probably is well founded.

The brevity of the peaks of abundance, the fact that they come at such long intervals, and especially the great local scarcity of young fish, are arguments against the possibility that menhaden are permanent inhabitants of our gulf, though a few fry may be produced there in favorable summers, as happened in 1949 (p. 117).

Menhaden are warm water fish, and our studies of the temperatures of the Gulf of Maine corroborate earlier observations to the effect that they never appear in spring until the coastwise water has warmed to 50° or more, or in abundance until the temperature is several degrees higher, which is in accord with Bean's [38] experience that menhaden will not survive in an aquarium if the water chills below 50°. No doubt, it is the falling temperature of autumn that forces the menhaden to leave the coasts of northern New England.

In menhaden years the fish occur all along the shores of the Gulf of Maine from Cape Cod to Penobscot Bay, even to Mount Desert. Their chief centers of abundance always lie in Massachusetts Bay within a mile or so of land, partic, ularly off Barnstable and in the mouths of Boston and Salem Harbors; in Casco Bay; and among the islands, thence to Penobscot Bay. But we have never heard of them entering water that is appreciable brackish, and in some years they may congregate as much as 40 to 50 miles offshore, as happened in 1878, for instance. But we have heard no report of menhaden in the central part of the Gulf or on the off shore Banks. The menhaden are thin when they arrive on our coasts in spring, but they put on fat so rapidly that while the average yield of oil per thousand Gulf of Maine fish was about 12 gallons for the whole summer season of 1894, it rose to 14½ gallons for Boston Harbor fish in August, and to 16 or 18 gallons in September. It is generally accepted, furthermore, that fish taken on the New England coast, south or north, always average larger and fatter than those caught farther south.

Commercial importance.—The menhaden is one of the most important, commercially, of the fishes of the Atlantic Coast of the United States, being used for the manufacture of oil, fertilizer and fish

[36] Reported by Scattergood, and Trefethen, Copeia, 1951, pp. 93-94.
[37] Reported by Scattergood, Trefethen, and Coffin, Copeia, 1951, p. 298.
[38] Rept. New York State Mus., 60, Zool. 9, 1903, p. 213.

scrap.[39] In 1946, when the catch for the Gulf of Maine was only about 20,000 pounds, the total catch for the Atlantic and Gulf States was 851,129,000 pounds; the value of the catch to the fishermen was $7,439,573; the value of the products made from menhaden was $18,196,573. Considerable numbers are used locally on the Middle Atlantic coast for bait. But the menhaden is so oily that it is unlikely to become popular as a food fish. Practically the entire catch of menhaden is taken by purse seines and in pound nets; they never bite a baited hook.

THE ANCHOVIES. FAMILY ENGRAULIDAE[40]

The anchovies are small herring-like fishes; but they are easily distinguishable from the herrings by the fact that their mouths are not only very much larger and gape much farther back, but are on the lower side of the head, and are overhung by the upper jaw, which projects like a short piglike snout in some species. Two anchovies are known to occur in the Gulf of Maine; both are stragglers from the south.

KEY TO GULF OF MAINE ANCHOVIES

1. Anal fin originates under the front of the dorsal; the silvery lateral band is diffuse; 24 to 27 anal fin rays ----------Anchovy, p. 118.
   Anal fin originates under the rear rays of the dorsal; silvery lateral band bright and well defined; 20 or 21 anal fin rays----------Striped anchovy, p. 119.

Anchovy *Anchoa mitchilli* (Cuvier and Valenciennes) 1848

WHITEBAIT

Jordan and Evermann (*Stolephorus mitchilli*), 1896–1900, p. 446.

Description.—The only Gulf of Maine fishes with which one might confuse an anchovy are young herring, smelt, or silversides, but it is easily distinguished from the former by the wide mouth, as just noted; by its much larger eye; by the relative positions of the fins with the dorsal wholly behind the ventrals instead of over them and with the latter originating close behind the tips of the pectorals when these are laid back against the body; and by its much longer anal fin. The lack of an adipose fin behind the dorsal is sufficient to separate anchovy from smelt at a glance, while the silversides (*Menidia*) have two dorsal fins instead of one. The anchovy has large, thin, easily detached scales and a deeply forked tail. This species may be distinguished from the striped anchovy by the fact that its anal fin originates under the front of the dorsal; by its more or less diffuse lateral band of silver; by its more numerous anal fin rays (24 to 27 contrasted with 20 or 21 for the striped anchovy), and by its relatively small size, for it seldom exceeds 3 inches in length. The body is about 4 to 5 times as long as deep in both anchovies.

Color.—This is a whitish silvery, translucent little fish, its most characteristic marking being an ill-defined silvery band scarcely wider than the pupil of the eye, running from the gill opening back to the caudal fin. There are also many dark dots on body and fins.

Size.—Seldom more than 3½ inches long.

General range.—Coast of the United States from Maine to Texas, chiefly west and south of Cape Cod.

[39] For an account of the menhaden industry, see Harrison, Inv. Rept. No. 1, U. S. Bureau of Fisheries, 1931.

[40] For a recent review of the American anchovies see Hildebrand, Bull. Bingham Oceanographic Coll., vol. 8, art. 2, 1943.

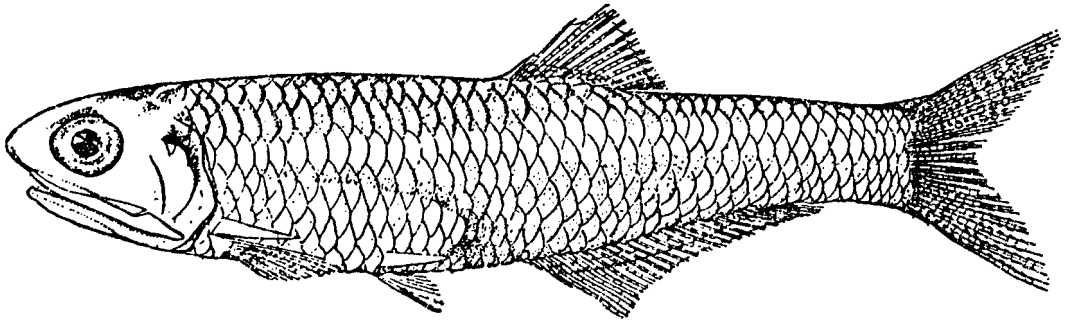

FIGURE 51.—Anchovy (*Anchoa mitchilli*).

Occurrence in the Gulf of Maine.—We mention the anchovy because it has been taken in Casco Bay and at Provincetown. It has no real place in the Gulf of Maine fauna, seldom straying past Cape Cod, though it is abundant about Woods Hole and thence westward and southward. Stragglers may be expected most often in the Gulf in midsummer for it appears from May to October in southern New England waters. Sandy beaches and the mouths of rivers are its chief resorts. An account of its embryology and larval development is given by Kuntz.[41]

Striped anchovy *Anchoa hepsetus* (Linnaeus) 1758

Jordan and Evermann (*Stolephorus brownii*), 1896–1900, p. 443.

Description.—This anchovy resembles the preceding species closely, but its anal fin is shorter (20 or 21 rays) and originates under the last rays of the dorsal, and it has a very bright and well defined silvery band along each side. It is a larger and more robust fish than the other anchovy, often more than 4 inches long.

Color.—The bright silvery lateral band, already mentioned, is the most prominent marking on this fish. Fresh specimens are pale gray and iridescent, the upper surface of the head with some green and yellow; and the back has dusky dots. The dorsal and caudal fins are more or less dusky on some specimens.

Size.—Commonly 4 to 5 inches long, maximum length about 6 inches.

General range.—Abundant from Chesapeake Bay to the West Indies, and south to Uruguay; north as a stray to Maine and to the outer coast of Nova Scotia;[42] a more southerly fish than the other anchovy.

Occurrence in the Gulf of Maine.—The claim of this species for mention in the Gulf of Maine is based on one record off the mouth of the Penobscot River, near Portland, October 8, 1930.[43] One specimen was saved and identified, and the herring fishermen who brought it in stated that there were "lots of them" on that date. It is not likely that the striped anchovy is other than a straggler to the Gulf, else it would have been found there before this. As it is a gregarious fish, nearly always traveling in small schools, it is not astonishing that they may be found together in some numbers, on occasion, even out of their usual range.

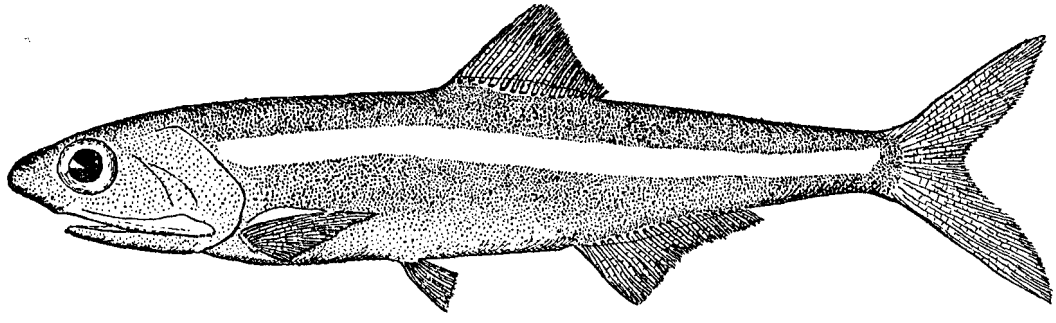

FIGURE 52.—Striped anchovy (*Anchoa hepsetus*), Somers Point, N. J., specimen 100 mm. long.

THE SALMONS. FAMILY SALMONIDAE

The salmons are soft-rayed fishes with no spines in any of the fins, with the ventrals situated on the abdomen far behind the pectorals, and with a fleshy rayless "adipose" fin on the back behind the rayed dorsal fin. The presence of this adipose fin, and its situation, separates them from all other Gulf of Maine fishes except for the smelt, capelin and the argentine, the pearlsides (p. 144), and some of the lantern, viper, and lancet fish tribes (p. 141).[44] The blunt noses, stout bodies, and nearly square tails of the salmons distinguish them at a glance from the sharper-nosed, slender, forked-tailed smelts, their large mouths and smaller eyes from the argentine; the absence of luminescent organs distinguishes them from the

[41] Bulletin, U. S. Bur. of Fish., vol. 33, 1915, p. 13.

[42] Five were taken in Bedford Basin, Halifax, Nova Scotia, on September 29, 1931 (Vladykov, Proc. Nova Scotia Inst. Sci., vol. 19, 1935, p. 3).

[43] Kendall, Bull. Boston Soc. Nat. Hist., No. 58, 1931.

[44] Sundry other deep-sea fishes have adipose fins.

pearlsides, while the lantern, viper, and lancet fishes are of different general aspect.

Four salmons [45] occur in the Gulf of Maine, or have recently, one of which, the sea trout, resorts to tidal estuaries at the mouths of a few of our streams; a second and a third—the humpback salmon and the silver salmon—were introduced from the Pacific coast, leaving the Atlantic salmon as a characteristic inhabitant of the open waters of the Gulf of Maine.

KEY TO GULF OF MAINE SALMONS

1. Scales so small that they are hardly visible; back with vermiculate markings; teeth on roof of mouth confined to a group in front.....Brook trout, p. 120
   Scales large enough to be easily visible; back without vermiculate markings; a row of teeth runs back along the mid line of the roof of the mouth.....2
2. Anal fin with only 8–10 rays.....Salmon, p. 121
   Anal fin with 12 rays or more.....3
3. Back and lower half of tail fin, as well as its upper half, conspicuously marked with large black spots Humpback salmon, p. 131
   Back with very small black spots or none at all; no black spots on lower half of tail fin.Silver salmon, p. 133

Brook trout *Salvelinus fontinalis* (Mitchill) 1815

SEA TROUT; SALTER

Jordan and Evermann, 1896–1900, p. 506.

Description.—Although brook trout vary widely in general form in different streams, they are usually salmon-like in shape when taken in salt water, that is, about one-fourth as deep as long, tapering gracefully to a small head. The nose of a trout, however, is blunter than that of a salmon, and its head is longer in proportion, the total length of the fish (not counting the caudal fin) being about four and one-half times that of the head,[46] while its mouth (gaping back of the eye) is relatively larger. The general arrangement of the fins, including the "adipose," parallels that of the salmon, but the ventral fins stand under the middle of the dorsal, thus farther forward in relation to the latter than in its larger relative. All the fins, too, are relatively larger, particularly the ventrals; as a rule the anal has one less ray in the trout (usually 8) than the salmon, but the number of dorsal rays (about 11) is the same. The tail of the sea trout is less forked than that of a young salmon of equal size.

Examination of the scales and of the teeth is the most positive means of distinguishing brook trout (in European terminology this is a "charr") from young salmon, for the teeth on the roof of the mouth of the trout are confined to a cluster near the front, instead of extending backward in a row along its midline as in the salmon; and the scales of the trout are so tiny as hardly to be visible whereas those of the salmon are large and easily seen.

Color.—Trout living in salt water almost wholly lack the yellow and red tints so conspicuous on their freshwater relatives. They are steel blue or bottle green on the back, with cheeks and sides silvery like a salmon and with a white belly. The sides above the lateral line are more or less dotted with pale yellow spots, but the dark vermiculate markings so characteristic of the fresh-water brook trout are rarely seen on the trunk of sea run fish, though evident as wavy crossbars on the dorsal

[45] A specimen of one of the whitefishes (probably *Coregonus quadrilateralis* Richardson) was taken in the mouth of the Sissibou River, St. Mary Bay, Nova Scotia, September 1919 [Huntsman, Contr. Canad. Biol., (1921) 1922, p. 59] straying down from fresh water. Whitefish have an adipose fin, like the true salmons, but have a very small mouth, and are flattened sidewise, and herring-like in appearance, rather than salmon-like.

[46] Some trout are longer headed.

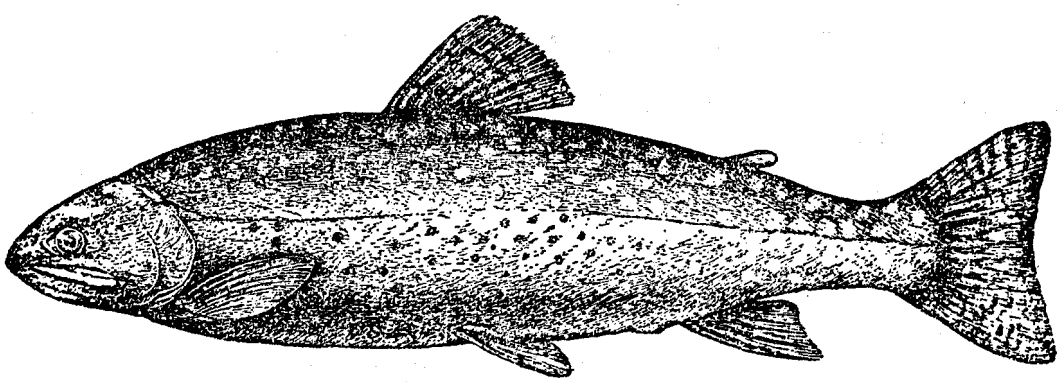

FIGURE 53.—Brook trout (*Salvelinus fontinalis*), about 15¾ inches long.

fin and on the corners of the caudal fin. The sides and flanks below the level of the lateral line usually are strewn with small pale vermillion dots, but the ventral fins are often plain white; at most, the pink edging so conspicuous in trout caught in fresh water is faint on fish in salt water.

General range.—Eastern North America, north to the outer coast of Labrador, west to Minnesota, and southward to Georgia along the Allegheny Mountains.

Occurrence in the Gulf of Maine.—Brook trout are plentiful in many of the river systems and smaller streams that empty into the Gulf of Maine. Some of the trout in some of these seek salt water after the breeding season, to remain there over the winter. This applies particularly to the brooks that flow through the sands of Cape Cod, several of those on its southern slope being famous for their sea-trout fishing. These, however, lie outside our present province, and only a couple of small streams on the Massachusetts Bay side of the Cape still support a race of trout that run down to the sea regularly. One or two small brooks tributary to Ipswich Bay, and the Merriland River, emptying between Wells and Kennebunkport, Maine, are the only places between Cape Ann and Cape Elizabeth where we have heard of sea run trout.

We cannot say how generally sea trout may now exist in the streams of eastern Maine, but according to Evermann [47] trout once inhabited the tidal portions of many of the brooks that empty into Casco Bay, and they still may. Some of good size are caught also in the Belfast River waters, tributary to upper Penobscot Bay.[48] Huntsman found no definite evidence of trout in salt or brackish water on the New Brunswick side of the Bay of Fundy, but local inquiry has elicited the information that there are fish of this habit in a few streams (notably in Salmon River) on the north and west coasts of Nova Scotia, where many streams formerly held sea run trout that have been fished out long since.

The "sea trout" are indistinguishable from the ordinary brook trout anatomically.[49] They are simply fish that have the habit of running down to salt water, and most of the trout never leave fresh water, even in streams offering free access to the sea, cold enough throughout their lengths, and harboring these "salters" (as they are called on Cape Cod). All who have given special attention to our sea trout are agreed on this. It is still an open question whether the habit is hereditary or whether it is acquired independently by each individual fish. We incline to the first view, chiefly because sea trout are slow in reestablishing themselves in any stream where they have been brought to a low ebb by hard fishing. The trout that follow this habit grow much more rapidly on the abundant rations the salt estuaries provide than do most of their relatives that remain in the brook. Sea fish weigh from 1 to 3 pounds in streams where few of the fresh-water trout exceed half a pound.

On Cape Cod the sea trout go down to salt water in November immediately after spawning, to winter there. They begin to run again in April, and all of them are in brackish or fresh water by mid-May. But it is said that they do not appear until later in the Nova Scotia streams tributary to the Bay of Fundy (we cannot vouch for this).

While in salt water (at least along Cape Cod) the trout feed chiefly on shrimps or on gammarid Crustacea, on mummichogs (*Fundulus*), and on other small fish. Trout never stray far from the stream mouths; hence they have no place [50] in the fish fauna of the open Gulf.

Salmon *Salmo salar* Linnaeus 1758

ATLANTIC SALMON; SEA SALMON; SILVER SALMON; BLACK SALMON; PARR; SMOLT; GRILSE; KELT

Jordan and Evermann, 1896–1900, p. 486.

Description.—The Atlantic salmon is a graceful fish, about one-fourth as deep as long, deepest below the dorsal fin, whence it tapers toward both head and tail; and oval in cross section. Its head is small (about one-fifth, or less of the fish's length, not counting the caudal fin), its nose is blunt, eye rather small, and its mouth gapes back to below the eye. The dorsal fin (about 11 rays) stands about midway between tip of snout and base of tail fin; the ventrals are under the rear end of the dorsal. The anal is similar in form to the dorsal but has only about 9 rays (7 to 10 have

[47] Rept. U. S. Comm. Fish., (1904) 1905, p. 105.

[48] Towne, Striped Bass Survey, Maine Development Comm. and Dept. Sea and Shore Fisheries, 1940, p. 21.

[49] There is another species of sea trout (*Salvelinus alpinus*) in northern Canadian waters which is very plentiful along the coast of northern Labrador.

[50] Trout are taken about Woods Hole, occasionally, in winter.

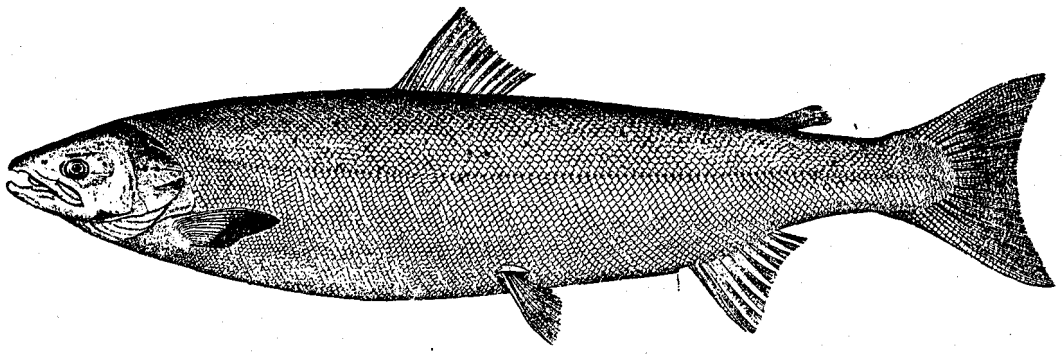

FIGURE 54.—Salmon (*Salmo salar*). Drawing by H. L. Todd.

been recorded), whereas the humpback has 14 anal rays or more. The tail is only very slightly emarginate in adults, and is almost square in large fish, but is more forked in fish that have been at sea for not more than one year ("smolts" and "grilse").

Color.—The salmon is silvery all over while in the sea, with brownish back and with numerous small black crosses and spots on head, body (chiefly above the lateral line), and fins. The young fish (or "parr") are conspicuously marked with 10 or 11 dark crossbars while in fresh water, alternating with bright red spots, much like young trout. Fish that have been at sea for only one year (grilse) are marked with a larger number of black spots than the older fish.

Size.—The largest salmon we find mentioned was an English fish of 83 pounds. None even approaching this size is recorded from our side of the Atlantic, where a 50-pounder is unusual, though fish of 40 pounds are not uncommon in some of the larger rivers emptying into the Gulf of St. Lawrence. Very few fish reach 40 pounds in the Penobscot or St. John Rivers, and 30-pounders are unusual there, the usual run being 10 to 12 pounds. Taking one river with another, large and small, 10 pounds may be set as a fair average of the mature Gulf of Maine fish. A 2-foot fish will weigh about 6 pounds, one of 3 feet, 16 to 20 pounds, with allowance for individual and seasonal variation.

Remarks.—The teeth and the scales afford the most certain distinction between small salmon and the New England sea trout (p. 120). In the salmon the roof of the mouth is armed both with a cluster in front and with a row of stout conical teeth running back along the mid-line, easily felt with the finger, whereas the sea trout has the forward group only. The scales of the salmon are so large that they are seen easily, whereas those of the trout are so minute that they are hardly visible. Old salmon sometimes lose the teeth on the roof of the mouth, but large size and large scales identify them at a glance.

It should also be easy to tell an Atlantic salmon from a humpback (should any of the latter still exist in our Gulf) for the black spots on the upper part of the body of the humpback and on its tail fin are more close set and much larger and conspicuous than the dark markings on a salmon. A more precise difference is that an Atlantic salmon never has more than 10 rays in its anal fin, whereas the humpback always has at least as many as 12, while most of them have 13 to 17.

The danger will be greater of confusing smallish Atlantic salmon with silver salmon, if the attempts now in progress to establish the latter in our Gulf should succeed, for the two fish look much alike. A reliable criterion is, again, the number of rays in the anal fin, for the silver salmon always has as many as 13 of these, an Atlantic salmon never more than 10.

Life history.[51]—It is no wonder that the life of the salmon has been the subject of much scientific study and that a whole literature has grown up about it. As everybody knows, the salmon lives the greater part of its life in the sea and makes most of its growth there but spawns in fresh water.

The salmon are silvery and very fat when they enter fresh-water on the spawning journey, but

[51] Huntsman (Bull. Biol. Board Canada, 21, 1931) has published an extensive study of the life history of the salmon of the Maritime Provinces of Canada, from which we have drawn freely in the following account. See also Huntsman and others (Migration and Conserv. of Salmon, Pub. No. 8, Amer. Assoc. Adv. Sci., 1939) for discussions of the movements of the salmon in Canadian and Newfoundland waters; also Lindsay and Thompson (Rept. Newfoundland Fish. Res. Comm., vol. 1, No. 2, 1932) for an account of the biology of the salmon in the rivers and around the coasts of Newfoundland.

they lose condition gradually as they work upstream, for they feed very little in fresh water, if at all; they make no attempt, for example, to capture the parr they meet. Most anglers believe that they may occasionally snap up a small fish or other tempting morsel. Many are caught on artificial flies, while every salmon angler knows that they will sometimes take a hook baited with angleworms or with prawns. It has been suggested that salmon recover the feeding habits of their youth to some extent after they have spent some time in the river, for they often rise to floating insects. But the stomachs of salmon caught in fresh water never contain anything but a little yellowish green fluid. And the fact that they keep better with bellies intact than if opened and gutted suggests that the secretion of effective digestive juices has ceased.

The maturing salmon of both sexes lose their silvery sheen in fresh water during the summer months, to take on a dull brownish or reddish hue, while the belly suffuses with some tint of red, large black spots develop, and the male not only becomes variously mottled and spotted with red or orange, but his jaws elongate, the lower becoming so hooked that only the tips come together. His body becomes slab-sided, his fins thicken, and his skin is covered with slime, until altogether he is but a caricature of the beautiful silvery creature that came in from the sea.

In small streams salmon may spawn only a short distance above the head of tide; but they may run upstream for more than 200 miles in large rivers that are not obstructed, as they do in the St. John system in New Brunswick. In Gulf of Maine rivers they spawn in October and early November, on sandy or gravelly bottom, the females smoothing a shallow trough or redd and covering the eggs with gravel.

As it is with the life of the salmon in the sea that we are concerned here, the reader is referred to Belding [52] and to Kendall [53] for recent accounts of the mating actions of the males and females. The spent fish, known as "kelts," "slinks," or "black salmon," are thin, weak, and so exhausted that many of them die. Most of those that survive in small rivers drop down at once to the sea after spawning. But many of them linger over the winter in large rivers, improving somewhat in condition and becoming more silvery, though they take little food. If they survive the winter (which many do not, for spawning leaves them thin and exhausted) they drop downstream to salt water the following spring.[54]

The large (6 to 7 mm.) thick-shelled eggs lie loose on the bottom and develop so slowly in the low temperature of winter that hatching does not take place until late in the following April or early in May. The newly hatched larvae are 15 to 18 mm. (0.6–0.7-inch) long, and carry a very large yolk sac for about 6 weeks, hiding among the pebbles of the spawning bed and taking no food. When the yolk sac is absorbed the little fish, now known as "parr," begin to swim and feed.

Parr live in fresh water for longer or shorter periods according to locality or to other factors not well understood. In the St. John,[55] and in the rivers of Minas Basin, most of them remain for 2 summers and 2 winters, running down to the sea the third summer. But Huntsman has found that some few stay in the Fundian rivers for 3 years. Most of the salmon of the Penobscot spend 2 years as parr, a few 3 years, according to Kendall. It is even possible that some may linger in Gulf of Maine rivers for 4, 5, or even 6 years, as is known to happen in Norway. And Dr. Huntsman informs us that some of the male parr in the rivers of the Chignecto Peninsula become sexually mature before visiting the sea.

Parr may be moving downstream any time from late spring to autumn, but most of them probably make the journey in June and July in Gulf of Maine streams, when they are 5 to 6 inches long. They put off their barred and spotted pattern as they near tidewater, to assume the silvery coat worn by the salmon during his sojourn in the sea. They are now known as "smolts."

Salmon, small or large, are voracious while in salt water, feeding altogether on live bait, chiefly on fish and on crustaceans. Among fishes available to them in this side of the Atlantic, launce, herring, alewives, smelt, capelin, small mackerel, haddock, small sculpins, and even flatfish have all been reported as entering into their diet in one place or another. Salmon caught off Norway are sometimes packed full of herring, and a hook

[52] Trans. Amer. Fish. Soc., vol. 24, 1934, p. 211.

[53] Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, p. 65-68.

[54] They are voracious now, and fly-fishing for these "black salmon" as they are called, is a favorite sport nowadays, especially in Miramichi waters tributary to the Gulf of St. Lawrence.

[55] Huntsman, Bull 21, Biol. Bd. Canada, 1931, p. 31, based on studies by Kerr and by Blair.

and line fishery is carried on for salmon in the Baltic, with herring for bait, while in British waters salmon are sometimes caught on hooks baited with launce and with pieces of mackerel. Launce and capelin had been the chief diet of thousands of salmon opened by Comeau[56] in the northern side of the Gulf of St. Lawrence. And it is probable that the salmon of the Bay of Fundy and open Gulf of Maine feed chiefly on herring (herring up to 5 inches long have been found in salmon stomachs near Eastport) and on launce, taking alewives or any other small fish as occasion offers, including smelts and mummichogs (*Fundulus*), when they first enter the estuaries.[57]

Salmon also feed greedily on euphausiid shrimps (fish entering the Penobscot have been found full of "shrimp," probably euphausiids); to some extent on pelagic amphipods (*Euthemisto*), while sand fleas (gammarid crustacean) are described as ranking with launce and herring as salmon food in the North and Baltic Seas. Salmon are also credited with eating crabs.[58]

Smolts, on the other hand, fall prey to any large predaceous fish (they have been found in the stomachs of pollock), but salmon are so heavy and strong after one or two years' sojourn in salt water that only fish as large as tuna, swordfish, or the larger sharks can menace them. Their worst enemy is the harbor seal, which is a common inhabitant of the northeastern coasts of the Gulf of Maine and of the Bay of Fundy.

The young smolts grow so rapidly on the abundant diet the sea affords that they usually reach a length of at least 16 inches and a weight of anywhere from ½ to 7 pounds after one year at sea. They are now known as "grilse." And older salmon continue to put on length and weight very fast, as long as they remain in salt water. Thus, several St. John fish which were tagged and released in the river in the autumn after spawning and which were recaptured the following summer after wintering in the sea had gained 2 to 8 pounds in weight, one of them more than 6 inches in length. Others which spent two uninterrupted years in the sea (as shown by their scales) averaged about 10 pounds heavier and 6 inches longer when recaptured.[59] But they grow much less rapidly in winter than in summer. And they hardly grow at all during the years when they spawn if they enter the river early in season, though they continue growing until later if they enter late. Hence the size of a salmon depends more on the number of times it has spawned and on the date when it enters its river than on its age.

Most of the exceptionally large fish of 40 to 50 pounds are virgin females entering fresh water for the first time, but some are fish that have already spawned once. An interesting case is that of a 45-pound 2-ounce fish, caught in the Moisie River, on the north shore of the Gulf of St. Lawrence, June 1950, by E. E. Steedman, the life history of which had been as follows:[60] hatched spring 1942; went to sea June 1945; returned to river and spawned there in 1948; returned to sea autumn 1948; remained there until June 1950; then returned to the river, to be caught on a "Lady Amherst" fly; age 8 years.

Some salmon become "river mature" and return to spawn after only one year at sea; these, known as grilse, are distinguishable from the older fish by more forked tail, more slender body, thinner scales, and more numerous spots that are blue rather than black.[61] Some spawn 2 or 3 years in succession, and hence never grow large; others spawn twice in alternate years; a few three times, very few oftener. It follows from this that large salmon are to be found in the sea throughout the year, though fewer of them in summer when the spawning fish are in the rivers, than in winter when the whole stock is in salt water except for the "parr," a few immature grilse (p. 129), and such of the spent fish as winter in the rivers. Some spawn only once after 3, 4, or even 5 years at sea, growing to a great size meantime. But very few salmon live to be more than 8 or 9 years old, including the time spent in fresh water as parr.

Our ignorance of the way of life of the salmon in the sea has recently been characterized as abyssmal. Certainly they are swift swimmers, and the nature of the catches suggests that they

[56] Life and Sport on the North Shore, 1909, Quebec.

[57] Kendall (Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, p. 34) found smelts in Penobscot salmon, alewives in salmon from the St. John.

[58] See Kendall (Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, pp. 33-34) for a recent survey of the diet of salmon in general; the Gulf of Maine fish in particular, with references. Eichelbaum (Cons. Perm. Internat. Explor. Mer, Rapports et Proc. Verb., vol. 21, 1916, p. 84) records the contents of many salmon from the Baltic and from the North Sea.

[59] Huntsman (Bull. Biol. Board Canada, No. 21, 1931) gives an interesting account of these tagging experiments, from which this summary is drawn.

[60] As worked out from its scales by Dr. D. L. Belding, and reported in Field and Stream, August 1951, p. 10.

[61] It is commonly stated that this applies chiefly to the males. But Huntsman (Bull. Biol. Board Canada, No. 21, 1931, pp. 18-19) has found that grilse of both sexes spawn in the small rivers at the head of the Bay of Fundy.

live scattered for the most part. But at least one case has come to our notice of a school seen, and some of them netted.[62] While salmon often leap in the esturaries on their return journey and in the rivers, we have never heard of one doing so at sea. And they keep so constantly to the mid-depths that they are seldom seen at the surface, except in the estuaries. But this rule has its exceptions, for the school mentioned above was sighted at the surface, where they were mistaken for pollock. On the other hand, there is no reason to suppose that many of the Gulf of Maine salmon descend to any great depth, winter or summer. The weirs, gill nets, and other gear that yield so many in various regions, are all operated in rather shoal water (the Baltic hook-and-line-fishery is carried on at about 1½ fathoms). Dr. Huntsman informs us that salmon are taken on hand lines in mid-winter in the Bay of Fundy. They are caught occasionally on long lines in the Gulf, and otter trawlers get stray salmon on the offshore Banks (p. 126), proof that at least some may go as deep as 50 fathoms or so, while diet (p. 124) proves that they sometimes feed near bottom if not actually on it.

General range.—Coastal waters of both sides of the North Atlantic, entering rivers to spawn. On the European side its range extends northward well within the Arctic Circle; southward to the Miño River, at the boundary between Spain and Northern Portugal, perhaps with a few reaching the Duero River, midway of Portugal.[63] It occurs in a few rivers in western Greenland.[64] On the American side salmon ran up all suitable rivers, formerly, from northeastern Labrador to the Housatonic emptying into Long Island Sound; perhaps the Hudson also. The northern limit of the commercial fishery for it on the American side is only about latitude 54° N. (Indian Harbor, north shore of Hamilton Inlet). And while it is known to range to Hudson Strait,[65] reports of it from stream mouths northward from Hamilton Inlet seem often to have been based on the sea run form of the Arctic charr *Salvelinus alpinus*, which also grows large in the sea.[66]

Occurrence in the Gulf of Maine.—When the white man first came to New England and to the Maritime Provinces, he found salmon in every large stream not barred by impassable falls, from Cape Sable to Cape Cod; i. e., in all the Nova Scotia and New Brunswick Rivers, tributary either to the open Gulf of Maine or to the Bay of Fundy, and in the following rivers in New England: St. Croix, Dennys, Orange, East Machias, Pleasant, Narraguagus, Union, Penobscot, St. George, Medomak, Sheepscot, Androscoggin, Kennebec, Royal, Presumpscot, Saco, Mausam, Piscataqua, and Merrimac.[67] One New England river, however, after another was so obstructed by dams after the beginning of the past century, that salmon regularly entered only the St. Croix, Dennys, East Machias, Machias, Penobscot, Sheepscot, Kennebec, and Androscoggin by the 1880's. The Kennebec was still an important salmon river as late as 1895. But by 1925 the Dennys and the Penobscot alone, of the rivers of Maine, saw regular runs, with a few fish in the St. Croix where pollution by sawdust was not as bad then as it had been, perhaps with an occasional fish in other streams.

The fate of the salmon in the Merrimac [68] typifies its history in the rivers from which it is now barred. Salmon spawned plentifully in the upper tributaries, especially in the Pemigewasset, as late as 1793 (in 1790 the run was so abundant in the lower river that 60 to 100 a day was the usual catch with a 90-yard seine near the mouth at Amesbury), but the completion of the dam at Lawrence in 1847 completely barred the upper reaches of the river. For some years thereafter salmon congregated below the Lawrence dam in spring and summer, vainly endeavoring to ascend, but there has been no run of salmon in the upper Merrimac since 1859 or 1860, when the last salmon hatched above the dam had lived its span of life, nor have any spawned there since then with the possible exception of a few that have been lifted over the dam by hand.

[62] Kendall, Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, p. 32.

[63] This is the southern European limit given by Berg (Zoogeographica. vol. 1, Pt. 2, 1932, p. 112.

[64] Jensen, Fauna of Greenland, vol. 1, Pt. 3, Fishes, 1923, pp. 3 and 4, Copenhagen.

[65] Vladykov (Contrib. Canad. Biol., N. Ser., vol. 8, No. 2, 1933, p. 18, fig. 1) shows a locality record near Fort Chimo, and there are salmon in the rivers of the eastern part of Ungava Bay.

[66] Blair (Res. Bull. 12, Dept. Nat. Resources Newfoundland, 1943, pp. 5-17) gives a detailed account of the salmon rivers of the outer Labrador coast, Strait of Belle Isle to Hamilton Inlet.

[67] Atkins (1887, Fish. Ind. U. S., Sect. 5, vol. 1, p. 679) has collected much information on the local history of salmon in northern New England.

[68] Lyman and Reed, Rept. Comm. Fish. Massachusetts (1865) 1866, Senate Doc. 8, pp. 36-41.

Enough salmon to yield a supply of eggs for artificial hatching continued to enter the lower Merrimac up to 1893 and there seems to have been what almost might be described as a run there in 1896, when salmon were seen leaping below the Lawrence dam nearly every day from June 10th to July 25th, often 10 or 20 at a time, and a few were lifted over. But we have not learned of a single sea-run salmon seen in the Merrimac since 1901, though watch has been kept for them by the wardens of the Massachusetts Division of Fisheries and Game,[69] and it is not likely that salmon would still run in the Penobscot were it not for the artificial propagation that is carried on there by the U. S. Fish and Wildlife Service. But the salmon situation now shows signs of improvement, for the run in the St. Croix has increased; salmon have reestablished themselves in the Narraguagus and provide sport there for many anglers since one obstructing dam has washed out and another opened. Enough salmon run regularly in the Dennys to attract anglers and a few also in the Machias and Pleasant Rivers. The Fisheries Commission of the State of Maine, and the U. S. Fish and Wildlife Service, are now concerned with the possibility of improving the runs in these streams, and of reestablishing runs of salmon in other Maine rivers.

Along the Canadian shores of our Gulf a few salmon still run in the Tusket, Salmon, and Annapolis Rivers; many in the Shubenacadie River in Nova Scotia, some in the Petitcodiac, and great numbers in the St. John River in New Brunswick, which still is a famous salmon river.

Movements in the Gulf.—After the smolts reach salt water they are found for a time in the river mouths and about estuaries. No doubt the little salmon (too small to sell) that are caught in summer and autumn in weirs at Matinicus Island have come from the Penobscot a month or two previous. They drop out of sight in winter, as do the older and larger salmon as well. But there is no reason to suppose that many of them go far out to sea in the Gulf. Odd salmon stray, it is true, as much as 90 to 100 miles seaward off the outer coast of Nova Scotia,[70] while otter trawlers pick up odd salmon from time to time in the South Channel, and even on Georges Bank up to 160 miles or more at sea from Cape Cod.[71] But the great majority of the salmon that are caught in the Gulf are taken within 25 miles of the land.

The Gulf of Maine salmon also appear to continue rather closely localized as a whole, not only within the coastal belt, but within the zone of fresh-water influence from the particular rivers or river systems from which they come. So few, for example, are caught near Cape Sable that there can be no general movement around the Cape by the fish that spawn in the rivers of the outer coast of Nova Scotia. Most of the fish that go to sea via Minas Channel from the Shubenacadie, and the few from smaller streams that discharge into Minas Basin, seem to remain along the Nova Scotia shore within a distance of 30 to 40 miles to the westward. And while tagging experiments have proved that some of them scatter more widely; i. e. to Cobequid Bay, to the estuary of the St. John River, to the Annapolis Basin, and to St. Mary's Bay, few of them leave the Bay of Fundy[72] (for some that did, see p. 127).

The much more numerous salmon from the St. John appear to hold rather closely to the tongue of low salinity that extends westerly from the mouth of the river, keeping out from the shore, for hardly any salmon are caught either on the New Brunswick shore to the eastward, except for a few near the head of the Bay (doubtless the product of the Chignecto Bay river system) or farther west than Point Lepreau, or around Grand Manan Island which stands directly in the route of any fish moving westward out of the northern side of the Bay of Fundy. Thus it appears that a radius of, say, 40 to 50 miles would enclose the wanderings of most of the St. John River fish.

The evident failure of salmon from the St. John to follow the myriads of sardine sized herring into Passamaquoddy Bay is especially interesting. The weirs there pick up a few salmon, the presence of which can be credited to the small run in the St. Croix River. And the numbers of salmon that are caught thence westward along the coast of Maine[73]

[69] A few small "salmon" reported of late in the Merrimac probably were the landlocked form, running down from tributaries stocked with this fish.

[70] Three reports of salmon caught on Western Bank have appeared in the daily press since 1925 to our knowledge, and Kendall (Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, p. 33) reports one caught on La Have Bank 100 miles from Halifax, and another 60 miles off Cape Sable.

[71] Kendall (Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, pp. 31–33) lists a number of such cases.

[72] Huntsman, Ann. Rept. Fish. Res. Board Canada, (1947) 1948, p. 37, and unpublished notes.

[73] The average was only 3,000 pounds (perhaps 300 fish) for the years 1939, 1940, 1943, 1944. Statistics are not readily available for 1941 and 1942.

are not larger than can be credited to such of the Maine rivers as still have runs of salmon.

It seems certain, also, that only odd salmon from the Penobscot and from the rivers farther east ordinarily disperse westward and southward beyond Casco Bay, for while the average catch for the coast of Maine east of that point has averaged about 12,000 pounds (some 1,200 fish) for the 10 most recent years of record[74] combined, the corresponding 10-year average for the whole western side of the Gulf from Cape Elizabeth to the elbow of Cape Cod was only 600 to 700 pounds, or some 60 to 80 fish at most, with more than 100 pounds reported in only 5 of the 10 years and none in 3 of the years. Further evidence of a more general kind that Gulf of Maine salmon do not scatter far as a rule is that they appear about the river mouths in spring so soon after the ice goes out that they cannot have come from any great distance.

A few do stray as far as Cape Cod Bay in most years; witness catches of one to 5 or 6 fish (10–55 pounds) in 14 out of 16 years by 8 traps, at North Truro, Cape Cod, during the period 1935 to 1950, in the months of May, June, July, September, and November.[75]

A year comes from time to time when a considerable number are taken off the coast of Massachusetts. The most recently recorded instance of this sort fell in 1937, when floating traps along the North Shore of Massachusetts Bay picked up 4,400 pounds of salmon. All of these were taken close inshore. But the 1,600 or so salmon (16,050 lb.) that were reported for Massachusetts in 1928 (the big year next previous) seemingly were farther out at sea, for all of them either hooked on long lines (10,134 lb.), or were taken in otter trawls. These must have come from as far as the Penobscot, if not from the Bay of Fundy, which is equally true of the salmon that are caught around Marthas Vineyard from time to time.[76] One, however, of about 10 pounds, reported in the North River, Marshfield, in the summer of 1938, and a few seen jumping in the Parker River (also in Massachusetts) in the summer of 1951, may have been the product of attempts to stock these streams. Occasional salmon that have been taken along the New Jersey coast and off Delaware[77] may have been the product of attempts to stock the Hudson.

Salmon, also, of 25 to 50 pounds that are sometimes caught in Minas Channel at the head of the Bay of Fundy, must come from afar, as Dr. Huntsman points out,[78] probably from the Gulf of St. Lawrence, there being no run of fish so heavy in any Bay of Fundy river or in any Maine river.

It is not astonishing that some salmon should stray far afield in Gulf of Maine waters, for marked salmon have been known to make much longer journeys, elsewhere. Thus fish marked in the southern side of the Gulf of St. Lawrence have been recaught on the north shore of the Gulf; in Newfoundland; and in the Strait of Belle Isle.[79] One marked at Bonavista on the east coast of Newfoundland was retaken 98 days later in the Margaree River, Cape Breton Island, Nova Scotia, 550 miles away[80] by the shortest possible route. One marked in Minas Channel at the head of the Bay of Fundy went out around Nova Scotia to Chedabucto Bay on the northeast, near the Gut of Canso, a journey of at least 440 miles.[81] Five, tagged in the Annapolis River system, were recaught on the east coast of Newfoundland, a minimum distance of 900 miles, while a sixth, from the same lot, was taken at Ramah on the outer coast of Labrador, more than 1,000 miles still farther away to the northward.[82] This last is the most spectacular case of wandering yet reported for any Gulf of Maine or Gulf of St. Lawrence salmon.

What is chiefly interesting about the large catches that are sometimes made off Massachusetts is their demonstration that so many fish may occasionally wander so far afield. And this applies not only to large salmon but to smolts in their first year at sea, for salmon so small that they must have run down to salt water but a few months previous have been taken in Cape Cod Bay in October.

It is not likely that these wandering salmon return at all to their home rivers; probably they

[74] 1933, 1935, 1937, 1938, 1939, 1940, 1943, 1944, 1945, and 1946.

[75] Information contributed by the Pond Village Cold Storage Co.

[76] In the spring of 1915 about 75 (including fish up to 35 lb.) were taken at Gay Head and in the neighborhood of Woods Hole

[77] Smith (Bull. U. S. Fish. Comm., vol. 14, 1895, p. 99) reports salmon seined among some mackerel off Delaware in 1893.

[78] Bull. 51, Biol. Board of Canada, 1936, p. 9.

[79] See Huntsman, Pub. Amer. Assoc. Adv. Sci. 8, 1932, p. 35, for summary of these records.

[80] Huntsman, Science, vol. 95, 1947, p. 381.

[81] Huntsman, Ann. Rept. Fish. Res. Bd. Canada, (1947) 1948, p. 37.

[82] Huntsman, Science, vol. 85, 1937, p. 314; Pub. 8, Amer. Assoc. Adv. Sci., 1939, p. 35.

are lost permanently from the breeding population. But the much greater numbers that remain localized not very far from their parent streams are believed to follow about the same routes on their return journeys that they followed when they went to sea. Thus, only a few are caught on the Nova Scotia shore between the entrance to St. Mary's Bay and Digby Gut, but fish en route to the Shubenacadie River system are taken in some numbers as they follow the shore of Annapolis and Kings Counties (the Annapolis River also yields a few salmon in its lower course, and some are taken in the Annapolis Basin). Similarly, salmon approaching the St. John River strike the coast about Point Lepreau (about 23 miles to the west) and support an important fishery from there to the mouth of the river.

A question closely bound to the movements of salmon to the sea is: what proportion of them return to spawn in the very rivers in which they were hatched? It seems demonstrated by a variety of evidence, especially by the recapture of tagged fish, that the majority do return. Huntsman, for example, reports[83] an extraordinary instance, of a kelt taken from the Sackville River on the outer coast of Nova Scotia that was tagged and released in the Shubenacadie River system at the head of the Bay of Fundy, and then found its way out of the Bay, around the Nova Scotia coast, and back again to the Sackville, where it was recaptured. We can only speculate how it directed its course, and why it did not turn in to the mouth of any of the other salmon rivers it passed en route. On the other hand, marked fish are sometimes caught in strange rivers. Fish, for instance, that were tagged in Minas Channel have been caught later in the St. John River.[84] And odd fish appear from time to time in rivers where no salmon have been hatched for many years (in the Merrimac for instance).

In short, the parent-stream theory does not always hold. Probably the truth is that while most of the fish never stray far away and do return to the home stream, wanderers that chance, in the spring, to be in the physical state leading to maturity may enter any unpolluted stream they encounter, no matter how far from home.

Dr. Huntsman's studies, carried on through many years, make it increasingly probable that the journeyings of our salmon in salt water are not the result of purposeful swimming in a definite direction, but that they tend to drift with the current as herring do (p. 97), so that the direction in which they travel depends chiefly on the depth at which they happen to be, in relation to the differential circulation of the water at different levels. If so, the St. John River fish tend to drift out with the river water as they scatter. And most of them do appear to remain more or less concentrated in the mid-depths where the principal mixing takes place between the river discharge and the water of the open Bay of Fundy, some 20 to 30 miles from St. John Harbor, living where they find an abundance of herring of various sizes as food. Here Dr. Huntsman[85] calculates the space for them is so great that no two of the approximately 50,000 fish that comprise the total yearly catch need be closer to each other than three-quarters of a mile in a layer of water 5 feet thick; so there is no crowding. But the tagging experiments have shown that the fish that go to sea from Minas Channel, where the outflow is not so definitely localized, scatter more widely, some of them drifting right around the Bay of Fundy with the anti-clockwise circulation.[86]

The situation is not so clear for the coast of Maine, partly because of the paucity of present-day information, partly because the several rivers there that once had runs of salmon are so closely spaced along the coast that it is not possible to evaluate their individual contributions to the yearly catches.

With the relationship between salmon journeys and water movements so extremely complex, all we dare say in this regard is that the inshore drift of the deeper layers (characteristic of circulation of the estuarine type) and the slackening of the offshore drift of the fresher surface water that is to be expected as the spring freshets diminish, may be the cause, at least in part, for bringing the salmon into the estuaries, and close inshore elsewhere, in spring. But the nature of the stimulus that impels a salmon to enter fresh water, and then fight his or her way upstream, remains a mystery.

It is not known whether all the salmon move inshore in spring, or only those that are destined

[83] Ann. Rept. Fish. Res. Bd. Canada (1947) 1948, p. 38.
[84] Huntsman, Ann. Rept. Fish. Res. Bd. Canada (1948) 1949, p. 40.
[85] Bulletin 21, Biol. Bd. Canada, 1931, p. 96.
[86] This was shown by Huntsman, Ann. Rep. Fish. Res. Bd. Canada (1947) 1948, p. 37.

to spawn that year, plus a certain number of immature grilse that have passed 1 year at sea. And Dr. Huntsman[87] has pointed out that the movement of the salmon riverward may be very slow; thus the salmon may take as much as a month to cover the 20-odd miles to the head of tide in the Petitcodiac River, while some of those that enter the estuary of the St. John River in autumn pass the winter there (probably in a lethargic state) before moving up to the head of tide 80 miles distant. In any case, only such fish as are approaching sexual maturity (irrespective of age), and some immature female grilse, run far up into the rivers; all the others remain in salt water, or at most they do not run above the head of tide, as has often been remarked.

The majority of the Gulf of Maine salmon become "river-mature" as it is called, long before the spawning season, for while none of them spawn before October, some of them enter fresh water as early as March and April. But the chief runs come later, varying in date, not only from river to river, but from year to year in a given river. In the Penobscot, some fish may enter in March; they are to be expected in the lower reaches after the first week in April; more come in May, perhaps two-thirds in June, with a few fish entering later still. Available information is to the effect that few enter the Narraguagus and Dennys Rivers until well into May, the chief runs there coming in June, with some entering as late as September. We have not been able to obtain definite dates for the spring and early summer runs in the St. John River. But it seems that salmon continue to enter the latter until well into the autumn, judging from catches of fish so fat that they must have come in recently from the sea. Salmon enter other streams tributary to the Bay of Fundy from May on. As a rule the large salmon come earliest, the grilse not until later, probably because it is not until later that the latter have reached the degree of fatness associated with river maturity. Accordingly, the heaviest runs in the Shubenacadie, mostly grilse (p. 130), are said to come from August until late in the autumn.

Every salmon fisherman is familiar with the fact that salmon enter in "runs" that are spaced irregularly in time, and that vary in date from year to year, depending on the height of water in the river and on the strength of the current. Freshets tend to bring them in; if the current becomes too strong they simply hold position, to breast it again as the flow slackens. The fish that are in the estuary remain there during the periods between freshets, waiting, as it were, for the message from upstream that starts them on their way. And the salmon within the river are similarly quiescent during periods of low water and weak current. This is the chief reason why salmon angling is so uncertain a sport, even in the best of rivers.

A good deal of discussion has centered about the question whether the earliest fish stay in fresh water from then until spawning time (a matter of 6 months) or whether there is more or less movement in and out of the river mouths at the beginning of the season. The latter view may be correct for the small streams, but it seems safe to say that after the run is well under way in late May or early June no fish return from fresh to salt water until autumn. Tagging experiments carried out in Canadian rivers have also yielded the very interesting information that no matter when a salmon runs upstream in one year, it may do so either early or late in the next.[88]

It is a matter of common knowledge that salmon average larger in some rivers than in others, and growth studies based on the scales have shown that these differences are due chiefly to the average ages of the fish that enter. In the St. John, as Huntsman has pointed out,[89] there are three principal groups of salmon: (a) male grilse, averaging about 6 pounds, that are mature and fated to breed that same autumn; (b) the ordinary spawners that have passed two years or more at sea; these average 10 to 15 pounds in weight and enter from May to August, the late comers running heavier than the early comers; most of them are virgins, but some of them have already spawned once or twice; (c) immature female grilse, averaging about 9 pounds, that enter from November to January. Few, however, return to spawn in the rivers of Maine until they have passed 2 years at sea; not more than 3 or 4 grilse to 70 adults were taken in the St. Croix, for example, when there still was a good run there, and not more than 1

[87] Progress Report, Atlantic stations, Biol. Bd. Canada, 8, 1933, p. 6; and unpublished notes.

[88] Fifty-fifth Annual Report of the Fisheries Branch, Department of Marine and Fisheries, Canada, (1921–22) 1922, p. 19.

[89] Nature, vol. 141, 1938, p. 421; Pub. 8, Amer. Assoc. Adv. Sci., 1939, p. 34.

grilse to 500 adults in the Dennys and Penobscot Rivers.[90]

The average weight of the salmon caught in the Penobscot was about 11½ pounds in 1905 (6,378 fish), 9 to 10 pounds in 1919 and 1920 (3,920 fish),[91] or a little less than in the St. John. The heaviest Penobscot fish of which we found definite record of late years weighed a little more than 35 pounds.[92] The fish in the rivers flowing into the head of the Bay of Fundy run much smaller, as Perley pointed out long ago, and recent studies show that most of them spawn first as grilse, i. e., after only one year at sea; a few, having spawned after one year at sea, return to spawn again a year later; and the percentage of larger and older fish is very small there. This, Huntsman points out,[93] contrasts with the prevalent 6-year-old fish in the Miramichi, which discharges into the southern side of the Gulf of St. Lawrence, and with 7- or 8-year-old fish in the Grand Cascapedia, tributary to the Bay of Chaleur. Various explanations have been advanced to account for these differences from river to river, none of them convincing in our opinion.

It also appears to be true (as often stated) that a larger proportion of the salmon are annual spawners in small streams, where most of the spent fish drop downstream again soon after spawning, than in large rivers where many of these "kelts" remain in fresh water over the winter. A plausible explanation is that kelts that return to the sea immediately after spawning have less opportunity to grow (though they recover condition sufficiently to spawn again the following summer) than such as await the spring to go downstream, and that spend a whole year at sea instead of one winter only between two succesive spawnings. This, however, does not account for the fact that it is almost invariably the large rivers that yield the very large maiden fish that have spent 4 years at sea, or more.

Abundance.—The early extirpation of salmon from the Merrimac, Saco, Kennebec system, and various rivers to the eastward naturally resulted in a great decrease in the abundance of salmon in the open Gulf, clearly reflected in the catches. Data are not available for early years when all the rivers still offered free access. But the yearly catch had been reduced to about 100 to 500 fish in the St. Croix by about 1887; 200 to 1,000 each in the Dennys and in the Kennebec, and 5,000 to 15,000 in the Penobscot. The catch along the Maine coast, which had been a little more than 150,000 pounds in 1889 (more than seven-eighths of this in or about the approaches to the Penobscot), was only about 86,000 pounds in 1905 (of this 74,000 lb., or 6,378 fish from the Penobscot); was about 20,000 pounds in 1919 (13,557 lb. or 1,322 fish from the Penobscot); and was only 14,744 pounds (12,700 lb. or 1,221 fish from the Penobscot) in 1928. As 70 to 90 percent of the Maine catch comes from Penobscot River or Bay, the following table of salmon caught there in certain years from 1896 to 1928 is pertinent:

Year	Number of fish	Pounds	Year	Number of fish	Pounds
1896	6, 404	80, 225	1918	1, 653	17, 212
1898	3, 225	42, 560	1919	1, 322	13, 557
1901	6, 821	86, 055	1920	1, 598	15, 135
1903	4, 859	67, 470	1928	1, 221	12, 700
1905	6, 378	74, 158			

The Maine catch then increased again to about 88,000 pounds in 1930 and to about 70,000 in 1931, suggesting a better run in the Penobscot, and varied between 16,000 and 40,000 pounds through the period 1932–1938.[94] But the average reported catch for Maine for the period 1939 to 1947[95] was only about 3,600 pounds (maximum 9,300, minimum 600), the average Massachusetts catch for the same period only about 100 pounds (maximum 400, minimum 0). Thus the output of salmon from the rivers of Maine (none from the rivers of Massachusetts) has been only about one-fiftieth as great during the past few years as it was some 60 years ago.

The numbers of salmon have held up much better in the Canadian waters of the Gulf, thanks to wise measures of conservation such as limiting netting at the mouths of the rivers, and keeping the streams free for access by fishways at the dams. The average yearly catches, from 1870 to 1946,

[90] See Kendall (Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, pp. 58-60) for age determinations of Penobscot salmon.

[91] Radcliffe. Rept. U. S. Comm. Fish. (1921) 1922, p. 146.

[92] Kendall, Mem. Boston Soc. Nat. Hist., vol. 9, No. 1, 1935, p. 32.

[93] Bull. 21, Biol. Board Canada, 1931. p. 19.

[94] No data are available for 1934 or 1936.

[95] No data for 1941.

were as follows for the west coast of Nova Scotia and for the Bay of Fundy combined:

Years	Pounds	Years	Pounds
1870–1879	655, 200	1910–1919	540, 000
1880–1889	292, 700	1920–1929	470, 300
1890–1899	634, 000	1930–1939	424, 000
1900–1909	576, 800	1940–1946	278, 000

The Canadian catch in the open Gulf and in the Bay of Fundy may be expected to run about 400,000 to 600,000 pounds at the present time, taking one year with another, or something like 40,000 to 60,000 fish, which is perhaps 100 times as great as that for the entire coastline of Maine and of Massachusetts. And the distribution of the catches shows that the St. John River contributes something like four-fifths of this, or a yearly average of some 50,000 fish,[96] contrasting with only a few hundred fish for the Penobscot in a poor year, and perhaps up to 8,000 in a good.

Salmon anglers are only too familiar with the fact that the number of fish that enter even the best of salmon rivers is much smaller in some years than in others. During the 16-year period, 1931–1946, the commercial catches reported for St. John Harbor and St. John River (best salmon river tributary to the Gulf of Maine) were good in 1931 (164,000 lbs.); in 1935 (149,300 lbs.); in 1936 (148,600 lbs.); in 1937 (172,700 lbs.); and in 1943 (157,500 lbs.); but were poor in 1939 (48,500 lbs.); in 1945 (60,000 lbs.) and in 1946 (54,500 lbs.). The yearly average for this period was 116,000 pounds.

[96] Huntsman (Bull. 21, Biol. Board Canada, 1931) has made a very interesting analysis of catches for the Bay of Fundy as a whole, as well as for the St. John, for the Chignecto system, and for the Minas system, separately.

In the Minas system the fishery produced as much as 383,800 pounds in 1907, 283,400 pounds in 1917, and 226,500 pounds in 1918; but since then, up to 1946, the best catches have been only 160,700 pounds in 1919, 165,100 pounds in 1923, and 143,300 pounds in 1925, while the poorest were 28,100 pounds in 1938 and 26,600 pounds in 1945. The average yearly catch from 1917 to 1930 was 133,000 pounds, and from 1931 to 1946, 48,000 pounds.

The reader will notice at once that the big years have not been the same for these two bodies of salmon. It seems sufficiently established that yearly and regional differences, such as these, result in the main from corresponding differences in the numbers of smolts that reach salt water in any given year. And recent investigations in Canadian waters make it likely that the factor chiefly responsible is the height of the water from summer to summer, or over periods of several summers, which of course reflects the yearly variations in rainfall. If the water is high the parr are protected from the birds that prey upon them and are more easily able to escape the trout, so that many survive to descend to the sea and to return one, two, or three years later. If the water in the river is low the parr are more at the mercy of kingfishers, mergansers, and trout, so that fewer of them live to reach salt water, and there are fewer of them to return as grilse or as older fish.

Humpback salmon *Oncorhynchus gorbuscha* (Walbaum) 1792

Jordan and Evermann, 1896–1900, p. 478.

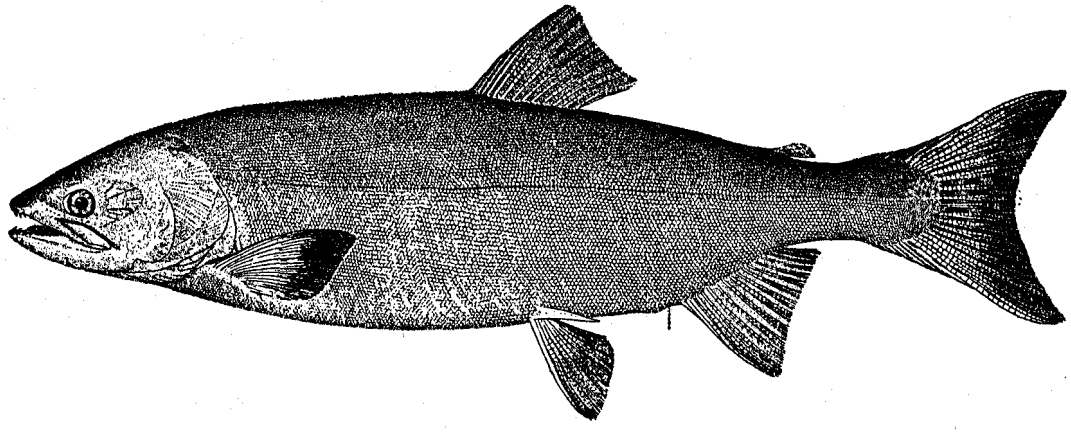

FIGURE 55.—Humpback salmon (*Oncorhynchus gorbuscha*).

Description.—The humpback is of the familiar salmon outline while living in the sea, the body being deeper than thick, with rounded belly. The head is naked but the body is covered with scales large enough to be seen easily. The dorsal fin stands about midway of the body above the ventrals, and the flaplike adipose fin is over the rear end of the anal fin. It agrees so closely with the Atlantic salmon in all this that the one might easily be taken for the other, were it not that the anal fin of the humpback invariably has 14 rays or more, whereas that of the Atlantic salmon has only about 9 rays. Also, the humpback is a stouter-bodied fish than the Atlantic salmon. The male humpback (like all the Pacific salmons, and the Atlantic salmon to a lesser degree) undergoes a very noticeable change in form in the spawning season, with the body deepening and developing a prominent hump in front of the dorsal fin; the jaws elongating and becoming hooked at the tip and the teeth increasing in size.

Color.—The back and tail of the humpback are bottle green with poorly defined black spots, while it is in the sea. These spots are particularly conspicuous on the tail, where they are oval in outline and as much as a third of an inch in longest diameter. These spots are one of the distinctive marks, whereby the humpback can be distinguished from all other salmons. The sides and belly are silvery, with a faint pinkish tinge. Young humpbacks are unique among salmon in being of practically adult coloration without "parr" marks (p. 122).

Size.—The humpback is the smallest of the Pacific salmons and much smaller than the Atlantic salmon, adults averaging only about 5½ pounds in weight and 20 to 25 inches in length. Males weigh to about 11 pounds and females to about 7½ pounds.

General range.—Pacific coast of North America and of northern Asia, from Oregon northward on the American side. This is the most abundant salmon in Alaska. It runs up fresh rivers to spawn, which it does but once and then dies. It has been introduced in the rivers of Maine.

Occurrence in the Gulf of Maine.—The history of the introduction of this west coast salmon to New England waters is as follows:

Humpback salmon eggs seem first to have been planted in Maine rivers in 1906. In the autumn of 1913 a large consignment of humpback eggs was shipped to the Craig Brook and Green Lake (Maine) hatcheries, and the approximately 7,000,000 fingerlings hatched therefrom were distributed in the Penobscot, Androscoggin, Damariscotta, Dennys, Pleasant, Union, Medomak, Georges, and St. Croix Rivers. A year later some 5,000,000 young fish were liberated. A third plant was made in 1915; a fourth of 6,235,808 fingerlings in 1916; and a fifth of about 1,000,000 in the Dennys and Pembroke Rivers in 1917.[97]

The results of this attempt at acclimatization were first seen in the summer and fall of 1915 when fishermen reported large numbers of mature humpbacks along the Maine coast, and when humpbacks ran in the Dennys River (where many were caught) from August 15 until September 24, some probably spawning there, for the bodies of spent fish were seen drifting downstream. Humpbacks again entered the Pembroke and Dennys Rivers during August, September, and October of 1917 with a few reported from the Penobscot, St. Georges, Medomak, and St. Croix, the result of the plant of 1915. And at least 2,000 mature fish were seen that summer in the Dennys alone, where many were caught averaging about 5 pounds, and one as heavy as 10 pounds 9 ounces. Definite information is lacking for 1918. But even larger numbers entered the Dennys and Pembroke Rivers in the autumn of 1919 than in 1917, with smaller runs in the Penobscot, Machias, St. Croix, and Medomak Rivers. Enough spawned that year in the Dennys and Pembroke Rivers for the fish-culturists of the Bureau of Fisheries to artificially fertilize half a million eggs there. And humpbacks were caught in the weirs in Passamoquoddy and Cobscook Bays during that season.

Adult fish were taken again in the weirs in 1920,[98] and one fish was caught in a weir as far from its native river as Lanesville, Mass. (near Cape Ann) [99] at some time during the summer of 1921.

Large numbers of eggs were collected again from wild fish between 1922 and 1926, the resultant fry being returned to the Dennys and other rivers nearby. Artificial propagation was abandoned then, for it seemed that the species was estab-

[97] More detailed accounts of these and successive plantings will be found in the annual reports of the U. S. Commissioner of Fisheries for the years 1914 to 1928.

[98] Reported catch, Washington County, Maine, 1920, 310 pounds.

[99] It was forwarded to the Massachusetts Commissioners as reported by C. E. Grant of Gloucester.

lished.[1] But natural reproduction seems not to have been successful enough for the humpback to maintain itself in the few Maine rivers open to it, much less to increase in numbers, for very few have been reported since about 1926 or 1927, and none that we have heard of for some years past.

Silver salmon *Oncorhynchus kisutch* (Walbaum) 1792
COHO SALMON

Jordan and Evermann, 1896–1900, p. 480.

Description.—The silver salmon resembles a rather stout Atlantic salmon closely in its general shape, also in the relative size and position of its fins, and in their shapes. But a safe morphological criterion for distinguishing the one from the other is that the silver always has at least 12 rays in its anal fin, and some of them have as many as 17, whereas most of the Atlantic salmons have only 8 or 9 anal rays, and never more than 10. The color is a help also, in this connection, for while a silver is silvery down its sides, like an Atlantic salmon, it is more closely sprinkled with small black spots along its back and on the upper part of its tail fin than is an Atlantic salmon. These spots, too, are always roundish or oval in a silver, never in the form of crosses. On the other hand, the black spots are much smaller and much less conspicuous on a silver salmon than on a humpback, and the lower half of the tail fin, which is as conspicuously spotted as the upper half on a humpback, usually has no spots on a silver salmon.

Size.—Up to 3 feet in length.

General range, habits, and occurrence in the Gulf of Maine.—The native range of the silver salmon is from northern California to northwestern Alaska, where it is an important food fish, and where anglers take many of them, both by trolling and by fly fishing. Like other Pacific salmons, it runs up into fresh streams to spawn, dying thereafter. Most of the young remain about one year in fresh water, but a few do not move out to sea until they are in their third year. Most of them return to fresh water at the end of the third summer at sea, a few, however, by the end of the second summer in salt water, a few others not until the fourth summer.

Our only reason for mentioning the silver salmon is that a plant of its fry and fingerlings that was made in the Duck Trap stream, tributary to the western side of Penobscot Bay, near Lincolnville, Maine, resulted in the return of 150 mature fish to Duck Trap stream in 1944, and perhaps of more of them. But nothing more was heard of them thereafter, and no returns have been reported up to this writing (Nov. 1, 1951) from other plants that were made in Maine waters[2] in 1948.

THE SMELTS. FAMILY OSMERIDAE

The smelts are small salmons in all essential respects, except that their stomach has few pyloric caecae, or none, whereas there are large numbers of such caecae in their larger relatives of the salmon family. However, it is not necessary to look so deeply to learn whether a fish be smelt or very young salmon, for the former all have pointed noses and are very slender, whereas the young of our four salt-water salmons—humpback, silver Atlantic, and sea trout—are much stouter, with blunt noses. In most cases, too, the shape of the tail would suffice of itself to separate smelt from salmon smolt, for it is never as deeply forked in the latter as in the smelts.

Two smelt fishes occur in the Gulf of Maine: the smelt (very common), and the capelin (a sporadic visitor from the north). The argentine (p. 139) is so closely related to the smelts that it is included in the following key.

[1] Rept. of U. S. Comm. Fish. (1928), Pt. 1, 1929, p. 379.

[2] In Tunk stream, Duck Trap stream, Chandler River, and Bald Hill Cove Brook.

KEY TO GULF OF MAINE SMELTS AND ARGENTINES

1. The dorsal fin originates over the tips of the pectorals; the mouth is very small ..... Argentine, p. 139
   The dorsal fin situated far behind the pectorals; the mouth is large 2
2. Upper jaw almost as long as lower; teeth large; there is a group of strong fangs on the tongue; the pectoral fins have 12 rays or fewer ..... Smelt, p. 135
   Lower jaw much longer than upper; teeth so small as hardly to be visible; no fangs on tongue; the pectoral fins have 15 to 20 rays ..... Capelin, p. 134

Capelin *Mallotus villosus* (Müller) 1777

Jordan and Evermann, 1896–1900, p. 520.

Description.—The capelin is an even slenderer fish than the smelt, its body being only about one-sixth to one-seventh as deep and about one-twelfth as thick as it is long, and of nearly uniform depth from gill cover to anal fin (except in the case of females when their abdomens are distended with spawn), whereas the smelt is usually deepest about its mid-length (at least if the fish is fat), which gives the two species characteristically different aspects. The head of the capelin is pointed like that of the smelt, the mouth gaping back to below the center of the very large eye with the tip of the lower jaw projecting noticeably beyond the upper. The scales are minute, much smaller than those of the smelt and more numerous (about 200 per row on the sides of the body); the teeth so small as to be hardly visible to the naked eye, and the tongue fangs, so characteristic of the smelt (p. 135), are lacking here. The outline of the adipose fin likewise helps separate capelin from smelt, for it is low in the former and about half as long as the anal, but short and high in the latter. The pectoral of the capelin is broader also, usually with 15 or more rays.

The capelin exhibits a pronounced sexual dimorphism; the male has much the longer pectoral fins; and the base of his anal is elevated on a pronounced hump, whereas it follows the general outline of the belly in the female. In males, too, the scales in one of the longitudinal rows immediately above the lateral line, and in another row along each side of the belly, are pointed, distinctly larger than the other scales, and become longer still at spawning time when each pushes up the skin as a finger-like process; they form four ridges that are very evident when the fish is held in the hand.

Color.—The capelin is transparent olive to bottle green above, like a smelt, but its sides are uniformly silvery below the lateral line and the scales are dotted at the margins with minute dusky specks (in the smelt there is a distinct silvery band on each side); the belly is white. Back and head darken at spawning time.

Size.—Few capelin are more than 6½ to 7½ inches long.

Habits.[3]—Capelin are most in evidence during the spawning season, when they come inshore in multitudes along arctic-subarctic coasts. They spawn on gravel or pebbly bottom, chiefly close below tideline, many of them in the wash of the waves in the beach; many are stranded then on the beach between waves. But eggs have also been reported from as deep as 35 to 40 fathoms. Each female while spawning is accompanied by two males that crowd her between them; but she may have only one companion.[4] Spawning takes place chiefly at temperatures of 43° to 50° F. (6°–10° C.) and more actively by night than by day.

The eggs are reddish, about 1/25-inch (1 mm.) in diameter, and so sticky that they cling to each other like herring eggs, and to the gravel and pebbles with which they are intermingled by the swash of the waves. They hatch in about 15 days at a temperature of 50° F. (10° C.). And they will tolerate a salinity as low as 7 per mille,

[3] Interesting accounts of the habits of the capelin and of its rate of growth in Newfoundland waters have been given recently by Jeffers (Ann. Rept. Biol. Board Canada (1930), 1931, pp. 7–18); by Sleggs (Rept. Newfoundland Fish. Res. Comm., 1, No. 3, 1933); and by Templeman (Bull. Newfoundland Government Lab., 17 (Research), 1948.

[4] According to Lanman, Rept. U. S. Comm. Fish. (1872–1873) 1874, p. 225.

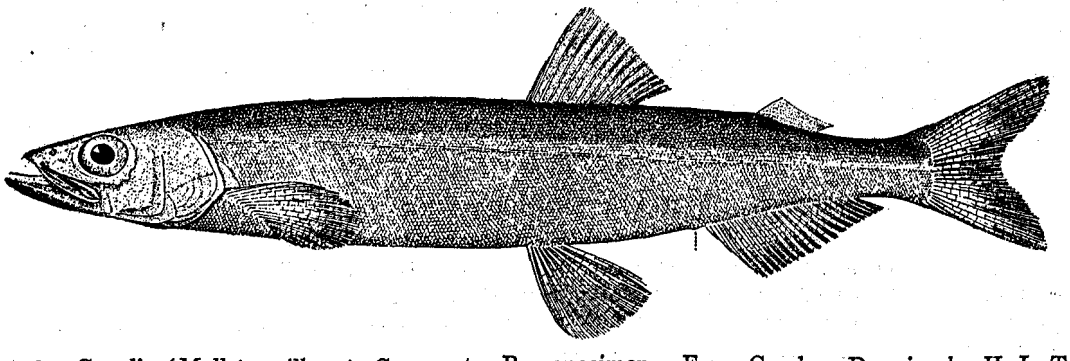

FIGURE 56.—Capelin (*Mallotus villosus*), Grosswater Bay specimen. From Goode. Drawing by H. L. Todd.

as Dr. Jeffers writes us. The larvae, described as 5 to 7 mm. long at hatching, are very slender and resemble those of smelt, herring, and launce so closely that identification is a matter for the expert. In any case, capelin are encountered so seldom in our Gulf that their larvae are not apt to be seen there.[5]

Along the coasts of Newfoundland, capelin spawn chiefly in June and July, and we have found them doing so in multitudes along the outer Labrador coast in July. Probably any spawning that may take place within the limits of our Gulf would fall in May at latest, to judge from water temperatures.

The capelin so seldom appears in the Gulf of Maine that we need only add that it is a fish of the high seas frequently encountered far out from land, coming inshore only to spawn and then as a rule moving out again; that it travels in vast schools at spawning time (when it often strands on the beach in countless multitudes). It is the chief bait fish of Arctic seas, preyed upon by whales and by every predaceous fish, particularly by cod, which are often seen pursuing the capelin at the surface in northern waters. Capelin themselves feed chiefly on small crustaceans, particularly on copepods, on euphausiid shrimps, and on amphipods. It is also known to devour its own eggs. We can bear witness that the capelin is a delicious little fish on the table.

General range.—Boreal-Arctic seas, south to the coast of Maine[6] on the Atlantic coast of America.

Occurence in the Gulf of Maine.—The capelin is a sub-Arctic fish that visits the Gulf of Maine occasionally; chiefly the eastern side as might be expected since it comes from the north.

Dr. Hunstman writes:[7]

> In the Gulf of St. Lawrence it occurs abundantly in limited areas, which shift somewhat from year to year. It occurs periodically in similar limited areas farther south. The southeastern corner of Cape Breton is the center of such an area, where large quantities were taken in 1917. Halifax is the center of another area, where, however, it is more rare. In 1916 it was abundant at Sambro, near Halifax. The next area is in the Bay of Fundy, where they have, exceptionally, been taken in large quantities at long intervals.

[5] Templeman (Bull. Newfoundland Government Lab., 17, Res., 1948, figs. 18-20) gives a series of excellent illustrations of capelin larvae at different stages of growth.

[6] According to Jordan and Evermann the capelin finds its southern limit at Cape Cod, but we find no actual records of its occurrence farther south than is mentioned.

[7] Quoted from a letter.

Apparently a period of this sort occurred about the middle of the past century, for Perley, writing in 1852, reported it from a number of points in the neighborhood of St. John, New Brunswick. It seems then to have disappeared from the Gulf of Maine, not to reappear until 1903 when it was common in the Bay of Fundy in May. A few were again taken off Passamaquoddy Bay in that same month of 1915.[8] And this was the prelude to a period of local abundance, for capelin were noticed among the herring in the weirs of the Passamaquoddy Bay region in October 1916, becoming so plentiful by the end of November that one catch of 3,000 pounds of fish consisted of 2,000 pounds of capelin and only 1,000 of herring. They were also reported at various localities along the New Brunswick coast at that time. Probably they persisted locally in the Bay of Fundy throughout the winter of 1916–1917, for large numbers of capelin appeared in Minas Basin in the following May and June. We find no record of capelin within the limits of the bay in 1918, but they were taken again in 1919 in 50 fathoms of water off Passamaquoddy Bay in January, February, and March, and they appeared with smelts a month later as far west as the Penobscot River, penetrating far inland. None, however, have been seen in the Gulf of Maine since then, so far as we have been able to learn.

Smelt *Osmerus mordax* (Mitchill) 1815

SALT-WATER SMELT

Jordan and Evermann, 1896–1900, p. 523.

Description.—The smelt is distinguishable from all other fish common in our waters by its slender form, combined with a long pointed head, large mouth, a small but evident adipose fin standing above the rear part of the anal, and a deeply forked tail. The location of its dorsal fin above the ventrals instead of in front of them, and its much larger mouth and small eye separate it from the argentine. The large, fang-like teeth on the smelt's tongue, its larger scales (of which there are about 75 along each row on the sides, all alike in the two sexes), its shorter adipose fin, its narrower pectoral fins, that its lower jaw projects only slightly beyond the upper and its scales slip off very easily, obviate any danger of confusing

[8] Huntsman (Contrib. Canadian Biol., (1921) 1922, p. 50) and Kendall (Copeia, No. 42, 1917, pp. 28-30; and Copeia, No. 73, 1919, pp. 70-71) give details.

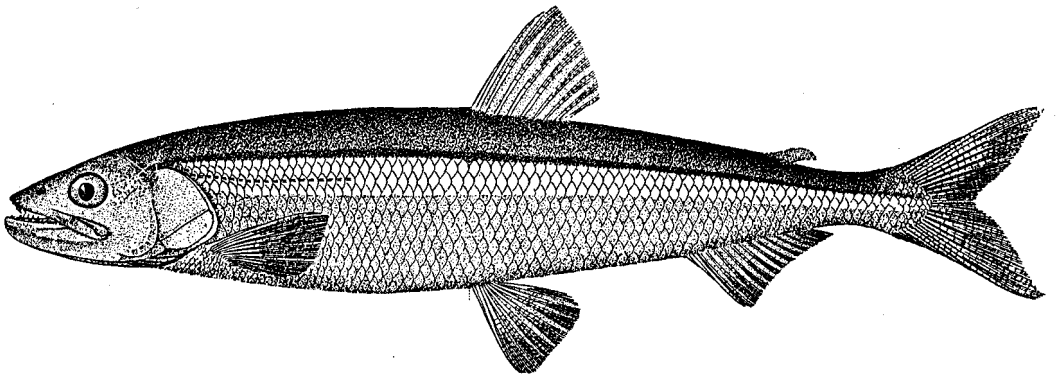

FIGURE 57.—Smelt (*Osmerus mordax*), adult, Woods Hole. From Jordan and Evermann. Drawing by H. L. Todd.

it with the capelin. The body of the smelt is only about one-fifth as deep as long (exclusive of caudal fin), with broadly rounded back but flattened enough sidewise to be egg-shaped in cross section. It is deepest about its mid-length, tapering thence toward the head and toward the tail (at least in fat fish), whereas the capelin is of nearly uniform depth from gill opening to anal fin (p. 134). Its mouth gapes back of the eye.

Printed accounts of the smelt usually credit it with a peculiar "cucumber" odor, and smelt fishermen often speak of a trace of this, but it is so faint that we have never noticed it though we have caught and handled many.[9]

Color.—Transparent olive to bottle green above, the sides are of paler cast of the same hue but each with a broad longitudinal silvery band. The belly is silvery, while the fins and body are more or less flecked with tiny dusky dots. This color pattern is shared by another slender little fish, the silverside (p. 302), but the latter has two large dorsal fins, so there is no danger of confusing the smelt with it.

Size.—Smelt grow to a maximum length of about 13 or 14 inches. Few, however, are more than a foot long, and adults run only about 7 to 9 inches. Smelt weigh from 1 to 6 ounces according to size and fatness.

Habits.[10]— The smelt is an inshore fish, confined to so narrow a zone along the coast that none has ever been reported more than a mile or so out from the land, or more than two or three fathoms in depth, while many spend the whole year in estuarine situations.

Young smelts certainly, and old ones probably, travel in schools, which are mostly composed of fish of a size, hence probably are the product of one year's hatching, and they live pelagic, not on the bottom, though confined to shoal water.

Most authorities describe the smelt as feeding on small crustaceans, which is correct as far as it goes, for shrimp (both decapods and mysids) and gammarids are probably its favorite food, and shrimp were long considered the best smelt bait. But it has been found that pieces of "sea worms" (*Nereis*) are more attractive to the larger smelt (at least in Massachusetts Bay). Small fish also form an important item in the diet. We have, for example, found smelts taken in the Sheepscot River in May packed full of young herring, and have caught many with small mummichogs (*Fundulus*) as bait; while cunners, anchovies, launce, sticklebacks, silversides, and alewives have been identified from smelt stomachs at Woods Hole. The Woods Hole diet list also includes shellfish, squid, annelid worms (*Nereis*), and crabs, but even as greedy a fish as the smelt ceases to feed during its spawning visits to fresh water. Young smelt depend chiefly on copepods and on other minute pelagic crustaceans. Smelt fishermen are familiar with the fact that a smelt approaches a bait slowly, then stops, and appears to suck it in.[11] If the smelt take their living prey in this same way, it is somewhat of a mystery how they succeed in capturing animals as active as shrimps and small fish.

Smelt, like alewives, shad, and salmon, make their growth in salt water, but run up into fresh water to spawn.

The summer habitat of the smelt varies off

[9] The European smelt (*O. eperlanus*) smells so strong that it is not held in very high esteem as a food-fish.

[10] Kendall (Bull. U. S. Bur. Fish., vol. 42, 1927, p. 244) has given a detailed account of the habits, distribution, and catches of the smelt of the New England coast, also of the landlocked populations.

[11] This method of feeding seems first to have been described in print by "Grif" (Forest and Stream, vol. 54, No. 8, Feb. 24, 1900, p. 151).

different parts of the coast of the Gulf, depending on the summer temperature of the water and perhaps on the food supply. Most of them desert the harbors and estuaries of the Massachusetts Bay region and along the southern coast of Maine during the warmest season. But it is probable that they move out only far enough to find cooler water at a slightly greater depth, and a few may be found in harbors through the summer. Smelt, for instance, are caught then in Cohasset Harbor in some years, but not in others; and east of Penobscot Bay, where the surface temperature does not rise so high as off Massachusetts, smelt are to be found in the harbors, bays, and river mouths all summer, and are sometimes taken in numbers then in the weirs.[12]

Adult smelt gather in harbors and brackish estuaries early in autumn, where smelt fishing with hook and line is in full swing by October. The schools then tend to move into the smaller harbors on the flood tide, and out again on the ebb, especially if the tidal current is strong, as it is in Cohasset, a locality with which we are familiar. But some smelt remain over the ebb in the deeper basins. And some of them have run as far as the head of tide by the time the first ice forms in December. Most of them winter between the harbor mouths and the brackish water farther up; the maturing fish commence their spawning migration into fresh water as early in the spring as the ice goes out of the streams and the water warms to the required degree.

Temperature observations by the Massachusetts Commission show that the first smelt appear on the spawning beds in Weir River, a stream emptying into Boston Harbor, when the temperature of the water rises to about 40–42°.[13] This may take place as early as the first week in March or as late as the last, about Massachusetts Bay, depending on the forwardness of the season and on the particular stream. The chief production of eggs takes place in temperatures of 50–57°, and spawning is completed in Massachusetts waters by about the 10th or 15th of May, year in and year out. East of Portland, smelt seldom commence to run before April, and continue through May. In the colder streams on the southern shores of the Gulf of St. Lawrence they do not spawn until June. On the other hand, they may commence spawning as early as February along the southern New England coast west of Cape Cod.

As a rule smelt do not journey far upstream; many, indeed, go only a few hundred yards above tidewater, whether the stream be small or large. Thus Dr. Huntsman informs us that the smelt that enter the estuary of the Stewiacke River, Nova Scotia (a tributary of the lower Shubenacadie, near the head of the Bay of Fundy) spawn only in the tidal part. And some spawn in slightly brackish water in certain ponds back of barrier beaches (e. g., Straits Pond, Cohasset, Mass.). But flooding with salt water, which sometimes happens, kills the eggs.

The adult smelts return to salt water immediately after spawning to spend the summer either in the estuary into which the stream in which they spawn empties or in the sea close by. On the Massachusetts coast north of Cape Cod all the spent fish have left fresh water by the middle of May, earlier in some years. On the Maine coast, too, a good proportion of the spent fish are in salt water by the first weeks in May; thus we have seen a bushel of large smelt taken in a weir at Cutler (near the mouth of the Grand Manan Channel) as early as May 4.

The eggs average about 1.2 mm. (0.05-inch) in diameter and they sink to the bottom, where they stick in clusters to pebbles, to each other, or to any stick, root, grass, or water weed they chance to touch. According to the Manual of Fish Culture a female weighing as little as 2 ounces will produce between 40,000 and 50,000 eggs;[14] The eggs of the closely allied European smelt (*Osmerus eperlanus*) hatch in 8 to 27 days, according to temperature, and the incubation period of the American fish is the same, probably, for smelt eggs are reported as hatching in 13 days at the Palmer (Mass.) hatchery.

FIGURE 58.—Smelt larva, 26 mm.

The smelt has proved a favorable fish for artificial hatching and large numbers of fry are so produced yearly in Massachusetts, the eggs being

[12] Atkins (Fish. Ind. U. S., sect. 5, vol. 1, 1887, pp. 690-693) gives much information on the smelt in Maine.

[13] Kendall (Bull. U. S. Bur. Fish., vol. 42, 1927, pp. 231-233) summarizes these observations and gives additional information for streams on the coast of Maine.

[14] Rept. U. S. Fish Comm., 1897, p. 188.

taken in Weir River, just mentioned, and it has proved possible to re-establish smelt by introducing the eggs or fry into streams from which it has been extirpated. For example, good smelt fishing was reported in "Poorhouse Brook," Saugus, a tributary of Boston Harbor, three years after the stream was stocked with eggs, and attempts have been similarly successful on Long Island, N. Y. Maintenance of the stock is a question either of providing accessible spawning grounds of sufficient extent, or of making up for lack of such by artificial propagation.

The precise season when young smelt go down to the sea in the Gulf of Maine streams is yet to be learned; probably early in summer. We seined several hundred fry, 1¼ to 1⅝ inches long, October 1, 1924, on a beach of Mount Desert Island, evidence that the rate of growth is about the same for our smelt during its first summer and autumn as for the European, i. e., to a length of 1¾ to 2¾ inches.

Most of the smelt evidently do not spawn until they have passed an autumn, a winter, a summer, and a second winter in salt water.

General range.—East coast of North America from eastern Labrador, Strait of Belle Isle, and the Gulf of St. Lawrence southward regularly to New Jersey, and reported to Virginia; running up streams and rivers to spawn. Smelt, also, are landlocked naturally in many lakes and ponds in New Hampshire and in Maine, also in Lake Champlain, and in various Canadian lakes.[15]

Occurrence in the Gulf of Maine.—The smelt is a familiar little fish around the entire coast of the Gulf of Maine, but varies greatly in abundance from place to place according to the accessibility of streams suitable for spawning, from which it seldom wanders far alongshore. Smelt are plentiful, still, all around the inner parts of Massachusetts Bay and its tributary harbors, though many of the local streams are barred to them now; thence northward and eastward all along the coast of Maine; tolerably so in the region of Passamaquoddy Bay (catch for Charlotte County, New Brunswick, 7,400 pounds in 1945), and more so along the western shore of Nova Scotia (60,100 pounds for Yarmouth County in 1945). But they are less plentiful passing inward along the Nova Scotia shore of the Bay of Fundy, as illustrated by catches in 1945 of 20,100 pounds for Digby County, but only 7,600 pounds for Kings County, 2,000 pounds for Hants, and 1,800 for Colchester (covering the Minas Basin region). So few smelt exist along the New Brunswick side of the Bay, inward from the Passamaquoddy region, that none at all were reported for that stretch of coast in any year during the period 1939–1945. Doubtless this scarcity up the Bay is "due to absence of streams suitable for spawning, and the general turbidity of the water," as Jeffers has remarked.[16]

Abundance.—Smelt once were so plentiful in the Back Bay at Boston (now mostly filled in) that "distinguished merchants of lower Beacon Street might be seen, at early hours, eagerly catching their breakfast from their back doors."[17] Those happy days, however, are long since past, and smelt certainly are not so numerous as they were even 50 years ago,[18] around the Massachusetts shoreline of our Gulf, where various streams either have been closed to them, or have been rendered uninhabitable by pollution. But enough still remain to provide sport for thousands of anglers,[19] and we still hear of an occasional catch there of many dozens by some one lucky enough to hit a run of fish at the right time and tide.

In 1938, when a special effort seems to have been made to gather smelt statistics, the reported catch for the inner part of Massachusetts Bay and northward to the New Hampshire line was 25,900 pounds, or some 300,000 fish, if they ran about a dozen to the pound. The yearly catch reported for the coast of Maine, added to that of the Passamaquoddy area (which form one faunal unit so far as the smelt is concerned) averaged about 644,000 pounds during the period 1937 to 1946,[20] or perhaps some 8,000,000 fish; about 61,000 pounds for Digby and Yarmouth Counties, Nova Scotia, combined, which covers most of the catch for the Gulf, north and east of New Hampshire.

The catches of smelt that are made along the coasts of Maine, New Brunswick, and Nova Scotia may seem impressive if taken by them-

[15] The European smelt is landlocked in many lakes in northern Europe.

[16] Ann. Rept. Biol. Board Canada, (1931) 1932, p. 27.

[17] Mass. Rept. for 1870, p. 23.

[18] Kendall (Bull., U. S. Bur. Fish., vol. 42, 1927, pp. 244–249) gives many interesting details as to catches in Massachusetts.

[19] Smelt fishing has long been restricted to hook and line along this part of the coast.

[20] Maximum 675,700 pounds in 1945, minimum 316,400 pounds in 1939. No data are available for Maine for the years 1941 or 1942.

selves. But Miramichi Bay, alone, on the southern shore of the Gulf of St. Lawrence yields yearly between three and four times as much smelt as does the entire coastline of the Gulf of Maine.[21]

Catch records do not suggest any striking alteration in the abundance of smelts during the past 10 years or so for Maine or for the Canadian shores of the Gulf. But they seem to have been somewhat more plentiful along the Maine coast previous to the early 1900's, for catches of 1,125,268 to 1,279,550 pounds there in 1887, 1888, and 1902 have not been equaled since then, the nearest approach being 968,300 pounds in 1945.

We are often asked what effect the disappearance of the eel grass (*Zostera*) from our coasts has had on the abundance of the smelt. Unfortunately, the statistics of the yearly catch do not yield any clear answer. Neither can we offer any convincing explanation for the violent fluctuations that take place from year to year in the abundance (or availability?) of smelts at one point or another. Fishermen report, for example, that they were far less plentiful in Massachusetts Bay and in the Great Bay region, N. H., in 1950 than they were in either of the two previous years.

The smelt also has a great recreational value, smelt fishing being a favorite pastime for home consumption. As many as 2,326 people, for instance, have been counted fishing at one time about Houghs Neck in Boston Harbor, and this same sort of thing is to be seen up and down the Massachusetts coast in harbors and stream mouths in autumn. Many smelt are caught in Great Bay, N. H., in good years, through the ice for the most part. And this applies equally to many localities along the coast of Maine. So plentiful are the fish on occasion and so greedily do they bite, especially on the flood tide, that it is usual to number the catch about Massachusetts Bay by the dozens rather than by the individual fish. Sea worms (*Nereis*) are generally considered the best bait, especially for the larger smelt, shrimp the second best, small minnows or clams a poor third. Smelt have also been taken with a small red artificial fly in the Gulf of St. Lawrence, and perhaps elsewhere.

[21] Average reported catch for Northumberland County, 1937-1946, was 2,258,030 pounds.

THE ARGENTINES

FAMILY ARGENTINIDAE

The argentines resemble the smelts in most of their external characters. But their mouths are much smaller, with the upper jawbone reaching back only about even with the front of the eye, and the entire base of their rayed dorsal fin is in front of the ventral fins.

Argentine *Argentina silus* Ascanius 1763

HERRING SMELT

Jordan and Evermann, 1896-1900, p. 526.

Description.—The argentine has a pointed nose, deeply forked tail, and slender, compressed body, but it has much larger eyes than either smelt or capelin, a character no doubt associated with its deep-water home; its mouth is much smaller, not gaping back even as far as the eye; and its dorsal fin stands wholly in front of the ventrals, instead of above them as it does in both the smelt and the capelin.[22]

The body of the argentine (about one-fifth as deep as long) tapers toward both head and tail, but its sides are so flat, and its back and belly so broad, that it is nearly rectangular in cross section instead of oval. Its scales, too, are larger than those of the smelt, there being only 60 to 70 rows along the lateral line. Its adipose fin is very small and its jaws are toothless, though its palate and tongue are armed with small teeth.

Color.—The color of the adult is variously described by different authors. All agree, however, that the back is brownish or olivaceous, the sides silvery or with iridescent golden or brassy luster, and the belly white. The adipose fin is yellowish.

Size.—The argentine is a larger fish than the smelt or the capelin, growing to a length of about 18 inches.

Habits.—Nothing is known of the life of the herring smelt in our Gulf, and little enough is known of it in Scandinavian waters, where it is sometimes caught on deep set-lines baited with herring or mussels, and where it is occasionally

[22] The anatomy of *Argentina silus* is described, and records along the American coast are given by Kendall and Crawford (Jour. Washington Acad. Sci., vol. 12, No. 1, January 1922, pp. 8-19).

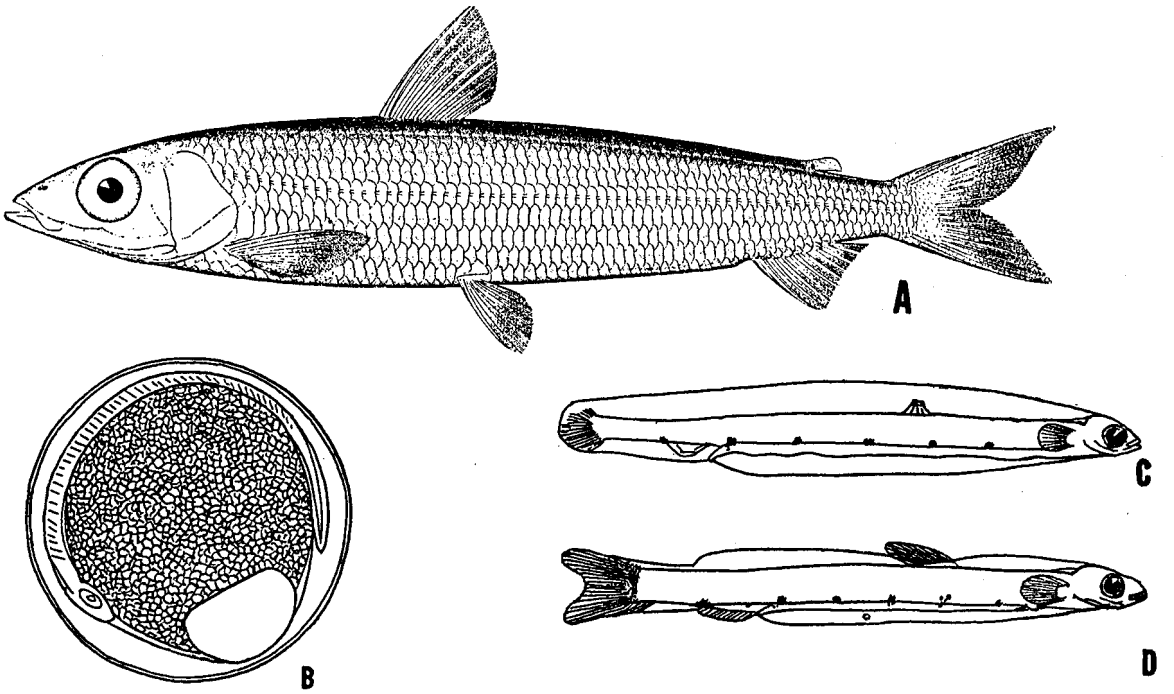

FIGURE 59.—Argentine (*Argentina silus*). A, adult, Biddeford Pool, Maine; from Goode and Bean, drawing by H. L. Todd; B, egg; C, larva, 28 mm.; D, larva, 45 mm. B–D, European, after Schmidt.

swept up to the surface like other deep-sea fishes by some upwelling of the water, to drift there helplessly. Its eggs float chiefly in the deeper water layers, seldom rising to the surface, and they are among the largest of buoyant fish eggs (3 to 3.5 mm. in diameter), with flat oil globule (0.95 to 1.16 mm.) and vacuolated yolk. Newly hatched larvae are about 7.5 mm. long and have a large yolk sac, but this has been absorbed when they have grown to a length of 12 mm. and a line of spots has appeared along the belly. The fin rays are formed by the time the little fish has reached 45 mm., the anus has moved forward, and the forked outline of the tail is apparent, but the ventral fins do not appear until the larva is about 50 mm. long.

General range.—North Atlantic, usually in water as deep as 80 to 300 fathoms; known from northern Norway south to the northern part of the North Sea on the European side, from the Nova Scotia Banks to the offing of southern New England on the American side.[23]

Occurrence in the Gulf of Maine.—The argentine was considered rare in our waters until recently. Some specimens have been brought in from widely scattered localities around the coast, namely, Belfast, Biddeford Pool, and Fletchers Neck, Maine; and from Hampton Beach, N. H. It has proved, with the development of otter trawling, that argentines are fairly common all around the edges of Georges Bank and off Cape Cod in moderately deep water. It is not unusual for one haul of the trawl to bring in from one to a dozen from depths of 30 to 100 fathoms, with much larger numbers taken occasionally; one vessel, for example, trawled 15,000 pounds on the northeastern edge of Georges Bank in about 100 fathoms during a week in mid-September 1929. Evidently there are at least a few argentines in the deep trough of the Gulf also. Firth[24] reports that ten were taken at 90 fathoms on the northwestern slope of Georges Bank on June 18; and the *Albatross II* trawled one at 115 fathoms off Mount Desert Rock. They spawn to some extent in the Gulf, for on April 17, 1920, a townet haul on the *Albatross I* from 109 fathoms in the southeastern part of the Gulf basin yielded 43 eggs, unmistakably of argentine parentage, while we have taken a scattering of argentine fry at localities as widely separated as the offing of Mount Desert Rock and the northwestern edge of Browns Bank.

[23] For recent records of argentines off Nova Scotia, see McKenzie and Homans, Proc. Nova Scotia Inst. Sci., vol. 19, No. 3, 1938, p. 277 and McKenzie, Proc. Nova Scotia Inst. Sci., 20, 1939, p. 15.

[24] Firth, Bull. Boston Soc. Nat. Hist., 61, 1940, p. 10.

LUMINESCENT FISHES

FAMILIES MYCTOPHIDAE, MAUROLICIDAE, CHAULIODONTIDAE, GONOSTOMIDAE, STOMIATIDAE, AND STERNOPTYCHIDAE

These families include a heterogeneous assemblage of small oceanic fishes, that are primitive in some respects, but are highly specialized in others for existence in mid-depths, on the high seas. They all have light-producing organs, which no other Gulf of Maine fish has; this is the only reason why we group them together here.

KEY TO GULF OF MAINE LUMINESCENT FISHES

1. Trunk at least ½ as deep as it is long from tip of snout to base of tail fin; front part of rayed dorsal fin is a hard triangular plate, supported by 7 or 8 spines ..... Hatchet fish, p. 149
   Trunk less than ¼ as deep as it is long from tip of snout to base of tail fin; rayed dorsal fin does not commence with a hard plate or hard spines 2
2. Mouth does not gape back as far as the eye ..... Pearl sides, p. 144
   Mouth gapes back beyond the eye 3
3. No barbel on the chin; the ventral fins are about mid-way of the trunk; origin of rayed dorsal fin either in front of mid-length of trunk or at least not much behind it 4
   There is a long fleshy barbel on the chin; the ventral fins are considerably behind the mid-length of the trunk; the rayed dorsal fin is far back, close to the tail fin 7
4. The rayed dorsal fin is far in advance of the ventrals; the jaws are armed with long and conspicuous fangs ..... Viperfish, p. 145
   The rayed dorsal fin is about over the ventral fins (it may be a little in front of them or a little behind); the teeth are small 5
5. Eyes very small; no adipose fin behind the rayed dorsal fin; anal fin reaches nearly to the base of the caudal ..... Cyclothone, p. 146
   Eyes very large; there is an adipose fin behind the rayed dorsal; there is a considerable interspace between the rear end of the anal fin and the origin of the tail fin 6
6. There are 3 or 4 separate luminescent dots at the base of the caudal fin; the Gulf of Maine species has a large luminescent patch on the snout ..... Headlight fish, p. 142
   There are only 2 separate luminous dots at the base of the caudal fin; the snout does not have a large luminescent patch ..... Lanternfish, p. 143
7. The point of origin of the anal fin is in advance of the origin of the rayed dorsal fin by a distance about as long as the diameter of the eye; the tip of the chin barbel is distinctly swollen as well as bearing several filaments ..... Stomioides, p. 147
   The point of origin of the anal fin is not in advance of the rayed dorsal fin; the tip of the chin barbel is not swollen 8
8. Each side has only about 68 luminescent spots; there is a large luminescent patch crossing the top of the cheek, behind the eye; the point of origin of rayed dorsal fin is in advance of origin of anal fin by a distance about as long as the diameter of the eye; the tip of the lower jaw does not enclose the tip of the upper jaw when the mouth is closed ..... Trigonolampa, p. 148
   Each side has about 85 luminescent spots; the side of the cheek behind the eye does not have a large luminescent patch; the point of origin of rayed dorsal fin is about over origin of anal fin; the tip of the lower jaw encloses the tip of the upper jaw when the mouth is closed ..... Stomias, p. 147

LANTERN FISHES. FAMILY MYCTOPHIDAE

The most distinctive external characters of the lanternfishes are their large eyes (situated close to the tip of the blunt snout), wide mouths gaping back beyond the eye, one soft-rayed dorsal fin, a deeply forked tail, and the presence of a series of luminous organs as conspicuous pale spots along the sides. Some of them have an adipose fin on the back behind the dorsal fin, but others lack this. When present, this fin is so small and fragile that it is apt to be destroyed by the rough treatment the fish receive in the tow net in which they are taken. They most nearly resemble the anchovy (p. 118), the pearlsides (p. 144), and the cyclothone (p. 146) among Gulf of Maine fishes; but they are readily distinguished from the first of these by the presence of luminous organs and by the fact that the snout does not project beyond the mouth; from the second by their much wider mouths; and from the third by their much larger eyes.

They are among the most numerous fishes on the high seas, where they live at a considerable depth by day but often rise to the surface at night. Only two species of the group, representing as many genera (*Diaphus* and *Myctophum*), have been recorded within the Gulf of Maine. But each of these genera includes a considerable number of species that are common along the continental slope abreast of the Gulf, hence are as likely to stray into the latter as are the two that have actually been found there. And this applies equally to various other genera of lanternfishes.

The species of *Diaphus* and of *Myctophum* all resemble one another in general appearance, in having a short dorsal fin, with an adipose fin behind it; a deeply forked tail; large eyes; wide, oblique mouth; and numerous luminous organs along the sides; all, too, are blackishsilvery in color. The members of each genus are separable only by differences in the arrangement of the luminous organs. Hence, positive identification of a given specimen calls for the services of a specialist in the group. Should a lanternfish be taken in the Gulf in which the arrangement of luminous organs does not agree precisely with the two described here, we suggest that it be submitted to the U. S. Fish and Wildlife Service to be named.[25]

[25] Parr (Bull. Bingham Oceanog. Coll., vol. 3, art. 3, 1928), and Tåning (Vidensk. Meddel., Dansk Naturhist. Forening, vol. 86, p. 49, 1928) have recently published critical synopses of the lanternfishes.

Headlight fish *Diaphus effulgens* (Goode and Bean) 1895

Jordan and Evermann, 1896–1900, p. 566.

Description.—This curious little fish is separable from the lanternfish (p. 143) and from the pearlsides (p. 144) at a glance, by the large and very noticeable luminescent patch that covers the entire tip of its snout (including the anterior margin of the orbit) and that extends down over the edge of the upper jaw, a structure that has no parallel in any other fish regularly inhabiting the Gulf of Maine. It also differs from the pearlsides in its much more deeply cleft mouth, its even larger eyes, in the more convex dorsal profile of its head, and in lacking the regular horizontal row of luminescent spots along each side about at the level of the pectoral fin, that are conspicuous on the pearlsides.[26]

The four separate luminescent spots at the base of the tail (besides the organ on its snout) separate it from its close relatives of the genus *Myctophum* (p. 143). The arrangement of the fins (all of which are soft, the dorsal with about 15 rays, the anal with about 16), is essentially the same as in the latter, and in the pearlsides; the caudal fin is more deeply forked than in the pearlsides, the adipose fin proportionately shorter.

Color.—The color has not been described. Probably it is black, overlaid more or less with

[26] The structures along the lateral line shown here on the illustration of the headlight fish are large scales, not luminescent organs.

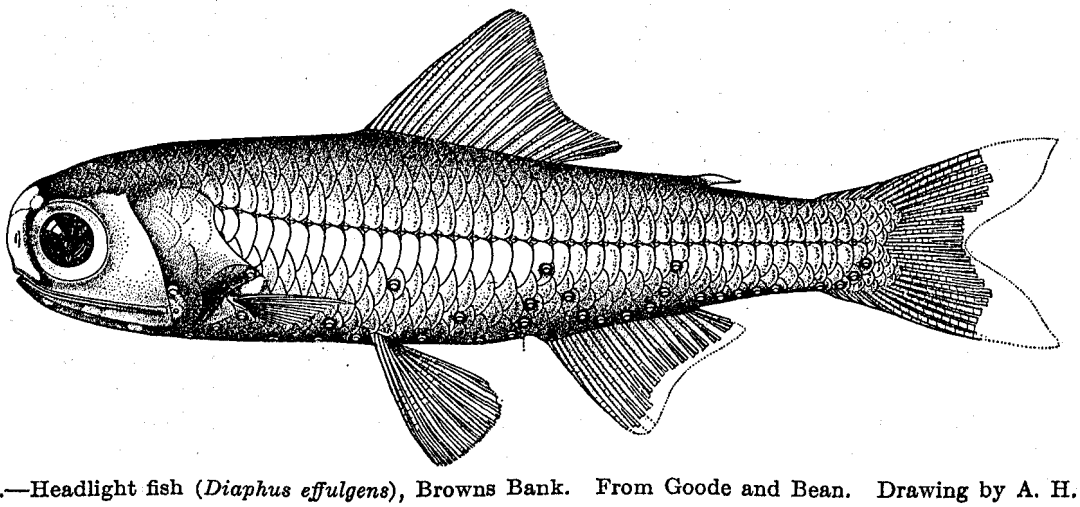

FIGURE 60.—Headlight fish (*Diaphus effulgens*), Browns Bank. From Goode and Bean. Drawing by A. H. Baldwin.

silver, with the luminescent organs pale blue or green.

Size.—The specimens from which this species was originally described seem to have been about 7 inches long.[27]

General range and occurrence in the Gulf of Maine.—This oceanic species is only a stray within the limits of the Gulf. One specimen has been found in the stomach of a cod caught on Browns Bank,[28] and another, also from a cod stomach, has been reported on Western Bank off the outer coast of Nova Scotia.[29]

Lanternfish *Myctophum affine* (Lütken) 1892

Jordan and Evermann, 1896–1900, p. 570.

Description.—The most noticeable features of this little oceanic fish are its silvery black color, the luminous dots along its sides, its enormous eye situated close to the tip of the snout, its very deep oblique mouth, and its deeply forked tail. The anal fin is mostly or wholly behind the short, soft dorsal, and there is an adipose fin behind the latter, as in the headlightfish (p. 142). The longer snout and smaller mouth of *Myctophum*, with the fact that the luminous organs on its snout are in the form of small dots instead of a large patch covering the entire tip of the snout, are the readiest field marks to distinguish it from the latter. The dorsal profile of the head is much arched, the body moderately flattened sidewise, tapering gently backward to the rather deep caudal peduncle. The location of the luminescent spots is shown in the drawing (fig. 61).

Color.—This lanternfish is silvery when alive, the silver underlain on the back with deep brownish black, the sides below the lateral line, and the belly varying (below the silver) from dark brown to dusky gray, or even to white finely dotted with gray. The luminescent organs are pale green or blue.

Size.—All members of the genus *Myctophum* are small; a little more than 3½ inches (89 mm.) is the maximum length recorded for this particular species.

General range.—All the species of this genus are oceanic, occurring only as strays inside the edge of the continent.

Occurrence in the Gulf of Maine.—Goode and Bean[30] report the capture of this lanternfish over the southeast slope of Browns Bank (lat. 42° 21′ N., long. 65° 07′ W.) at 104 fathoms, which still remains the only record for it in the Gulf of Maine,[31] or for any *Myctophum* for that matter.

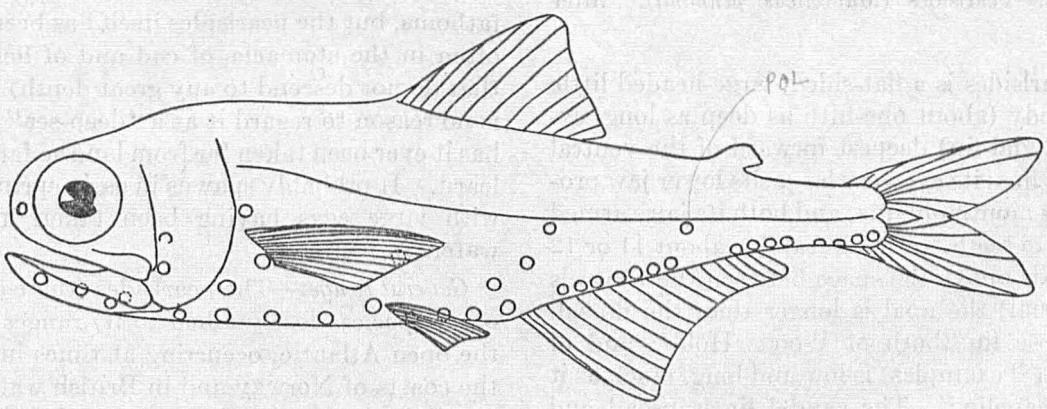

FIGURE 61.—Lanternfish (*Myctophum affine*). After Parr.

PEARLSIDES. FAMILY MAUROLICIDAE

The Pearlsides resembles the lanternfishes (p. 141) in shape of body, but it has a shorter rayed dorsal fin, a longer adipose fin, a longer anal, and a much smaller mouth.

[27] The illustration (Goode and Bean, Smithsonian Contrib. Knowl., vol. 31, 1895, fig. 103), about 6 inches long, is characterized in the legend as "slightly reduced."

[28] Reported by Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895, p. 88) as *Aethoprora effulgens*.

[29] Vladykov, Proc. Nova Scotia Inst. Sci., vol. 19, 1935, p. 2.

[30] Smithsonian Contrib. Knowl. (vol. 30, 1895, p. 72) as *M. opalinum*.

[31] It is likely that *Myctophum glaciale* will be found in the Gulf of Maine sooner or later, judging from its widespread distribution in the boreal belt of the Atlantic and from the fact that it has often been caught at the surface. It resembles *M. affine* very closely in appearance, and in the general arrangement of the luminous organs, but differs from it in that one of the luminescent spots above the base of the ventral fin is elevated above the others.

Pearlsides *Maurolicus pennanti* (Walbaum) 1792

PEARLFISH

Jordan and Everman, 1896-1900, P. 577.

Description.—The presence of an adipose fin between the dorsal and caudal fins, together with luminous organs, distinguishes the pearlsides from all other fishes that occur regularly in the Gulf of Maine. It agrees in both these respects with the lanternfish (p. 143) and with the headlightfish (p. 142), but it has a much smaller mouth and a longer adipose fin than the first of these, and it lacks the large luminous patch on the snout that is so striking a feature of the second. Also, the pearlsides, with its herring-like coloration (p. 88) differs strikingly from the lanternfish, which has a black back overlaid with silver; and probably the headlight fish as well.

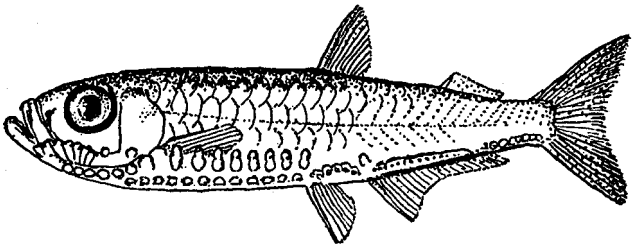

FIGURE 62.—Pearlsides (*Maurolicus pennanti*). After Smitt.

The pearlsides is a flat-sided, large-headed little fish, its body (about one-fifth as deep as long, excluding caudal fin) deepest forward of the ventral and dorsal fins; its eye very large; its lower jaw projecting; its mouth oblique; and both its jaws armed with minute teeth. The dorsal fin (about 11 or 12 rays) stands above the space between the ventrals and the anal; the anal is longer than the dorsal. The adipose fin (both of Woods Hole [32] and of Norwegian [33] examples) is low and long, much as it is in the capelin.[34] The caudal fin is broad and slightly forked.

The pearlsides has been described as without scales, but this is not correct, for both Scandinavian and Woods Hole specimens have been found to be clothed with large but extremely thin transparent scales. There is no definite lateral line.

The most interesting and diagnostic feature of the pearlsides is the presence of a series of luminescent dots situated as follows: [35] First, 12 pairs along the belly between the pectoral and the ventral fins, followed by 5 or 6 from the ventral fins to the anal fin, and, after a gap, by 24 or 25 between the center of the anal fin and the base of the caudal fin; all these together form a practically continuous row on each side of the belly from throat to tail. Second, there is a row of larger spots a little higher up on each side, 6 from chin to pectoral fin, and 9 thence backward to the ventrals. Third, there is a group of 6 low down on each side of the cheek and throat; there is likewise a spot in front of the base of each pectoral fin and 2 on the chin.

Color.—The pearlsides is colored much like a herring, with dark bluish or greenish back and lustrous silvery-white sides and belly. The luminescent spots are described as black rimmed, their centers as pale blue in life but turning yellow in alcohol; and there is a narrow black band along the base of the anal fin and from there to the base of the caudal, the latter being barred with a similar black band.

Size.—Only 1 to 2½ inches long.

Habits.—The relatives of the pearlsides are oceanic, living in the mid-depths mostly below 150 fathoms, but the pearlsides itself has been found so often in the stomachs of cod and of herring (fish that do not descend to any great depth) that there is no reason to regard it as a "deep-sea" stray, nor has it ever been taken far from land so far as we can learn. It probably spawns in early spring, females with large eggs having been taken in Scottish waters in winter.

General range.—The pearlsides (there are several other species closely allied to it) ranges widely in the open Atlantic, occurring at times in shoals on the coasts of Norway and in British waters. It is especially common off the coast of Scotland, but has not been recorded often on the American side of the Atlantic.

Occurrence in the Gulf of Maine.—The known occurrences of the pearlsides in the Gulf have been few. Storer [36] (1867) records one found alive on the beach at Nahant, Mass., in December, 1837; another taken from the stomach of a cod at

[32] Sumner, Osburn, and Cole, Bull. U. S. Bur. Fish., vol. 31, Pt. 2, 1913, p. 743.

[33] Smitt, Scandinavian Fishes, vol. 1, 1892, p. 933, pl. 44, fig. 3.

[34] Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895 p. 96) describe it as "very small," but probably their specimens were damaged.

[35] This account is based chiefly on Smitt's description and plate, the specimens we have seen being in poor condition.

[36] Fishes of Mass., 1867, p. 150, as *Scopelus humboldtii*.

Provincetown; a third picked up alive there in July, 1865 (pictured by Storer on pl. 25, fig. 5); and five others found on the Provincetown beach soon afterward. We have seen one specimen 41 mm. long taken from the stomach of a cod, on Platts Bank, July 27, 1924; one 43 mm. long, also from a cod's stomach, on Cashes Ledge, August 16, 1928; and four, 32 to 39 mm. long, taken from the stomachs of two pollock that we caught in 20 fathoms, 7 miles southeast of Bakers Island, Mount Desert, Maine, July 24, 1930. It has been found twice at Grand Manan,[37] and specimens were picked up on the beach at Campobello Island at the mouth of the Bay of Fundy in July 1914,[38] while others were taken from the stomach of a pollock caught near by. It has also been recorded twice near Woods Hole.

These locality records are distributed widely enough to show that it is to be expected anywhere in our Gulf. And we suspect that the pearlsides is not as scarce there as the paucity of actual records for it might suggest (in fact, Storer tells us that a Nahant fisherman reported finding them repeatedly in the stomachs of haddock many years ago), but that it keeps out of sight, being an inhabitant of the deeper water layers as its luminescent organs would suggest, coming up to the surface chiefly at night.

VIPER FISHES. FAMILY CHAULIODONTIDAE

The viper fishes have slender bodies, bulldog-like faces with long fangs; the first dorsal very far forward, the anal far back; and no barbel on the chin.

Viperfish *Chauliodus sloani* Bloch and Schneider 1801

Jordan and Evermann, 1896–1900, p. 585.

Description.—The viperfish not only has luminescent organs, but it is very different in general appearance from all the fishes that are regular inhabitants of the Gulf of Maine. Most obvious of its characteristics is its bulldog-like mouth. It shares this with its fellow strays, *Stomias* (p. 147), *Stomioides* (p. 147) and *Trigonolampa* (p. 148) and the general form is much alike in the three. But there is no danger of confusing it with any one of these if one looks closely, for the viperfish has an adipose fin and its rayed dorsal fin is far forward, whereas *Stomias*, *Stomioides*, and *Trigonolampa* have no adipose fin and their rayed dorsal fin stands far rearward.

In the viperfish the lower jaw is longer than the upper, the upper is armed with four long fangs on each side, while the lower has a series of pointed teeth set far apart, those in front very elongate and all of them so long that they project when the mouth is closed. Furthermore, the snout is so short that the very wide mouth gapes far back of the eye. The body is about seven times as long as deep, flattened sidewise, deepest close behind the head, and tapering evenly to the tail. The very short dorsal fin (6 or 7 rays) stands far forward and its first ray is separate, very slender, and about half as long as the fish when not broken off, as it usually is. The ventrals are about midway between the snout and the origin of the anal fin, variously pictured as either larger or smaller than the dorsal. The small anal is close to the caudal, with the adipose fin over it. The

[37] Cox (Bull. Nat. Hist. Soc. New Brunswick, 14, 1896, append., p. 55) reported one found dead there, on the shore.

[38] Huntsman (Contrib. Canadian Biol., (1921) 1922, p. 61.)

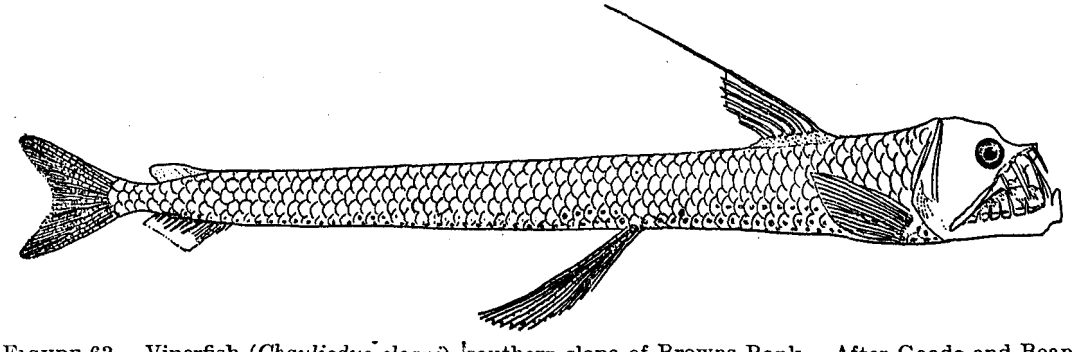

FIGURE 63.—Viperfish (*Chauliodus sloani*), southern slope of Browns Bank. After Goode and Bean.

body is clothed with large but very thin scales. There are several longitudinal rows of small luminescent spots on the ventral surface, running from throat to tail; several more such spots on each side of the head; and many tiny unpigmented dots scattered over the trunk.[39]

Color.—Greenish above, the sides with metallic gloss; blackish below.

Size.—Up to about one foot long.

Habits.—Nothing is known of its habits except that it is an inhabitant of the mid-depths of the Atlantic Basin and that it probably does not rise closer to the surface than 150 or 200 fathoms except, perhaps, during its larval stages. Its teeth suggest a rapacious habit but there is no actual record of its diet.

Occurrence in the Gulf of Maine.—The only definite Gulf of Maine records are of one specimen found in the stomach of a cod caught on Georges Bank in 1874, and of a second found in the stomach of a swordfish that was harpooned in the gully between Browns and Georges Banks in 1931.[40] But the viperfish may be expected on the offshore banks as a stray at any time, for several have been taken off the continental slope abreast of southern New England[41] in deep water.

THE STOMIATIDS. FAMILIES GONOSTOMIDAE AND STOMIATIDAE

The stomiatids include many soft-rayed fishes of the mid-depths, of most diverse appearance, all of them with well developed luminescent organs, with large eyes, large mouths, and teeth in both jaws. Some have and others lack the adipose fin, but the ventrals are inserted more than one-third of the way back on the abdomen in all of them. They differ from the herrings and salmons in the structure of the skull. Four species have been taken in our Gulf, as strays from offshore.

Cyclothone *Cyclothone signata* Garman 1899

Garman, Mem. Mus. Compar. Zoology, vol. 24. 1899, p. 246, pl. J, fig. 3.

Description.—The general aspect of cyclothone is extremely characteristic, the somewhat compressed body being deepest at the gill opening with the upper surface of the head concave in profile, the mouth so large that it gapes back of the eye, the lower jaw projecting, the eye very small, and the gill openings very long. The dorsal fin stands over the anal (the latter is much the longer of the two), both originating close behind the middle of the body. The caudal fin is deeply forked and there is no adipose fin.

The luminescent spots are arranged as follows: One on the head; 1 close below the eye and in front of it; 2 on each gill cover; 9 or 10 between the branchiostegal rays; 2 longitudinal rows along each side of the body, a lower row of 13 from throat to ventral fins, 4 from ventrals to anal fin, and 13 from anal to caudal, and an upper row of 7 reaching about as far back as the ventrals.

Color.—*Cyclothone signata* is colorless or pale gray, except that the blackish, dark silvery lining of the abdominal cavity shows through, that the luminous organs are black rimmed and silver centered, and that there are the following black markings: a Y-shaped mark on the forehead; a series of spots or short transverse stripes on the flank; spots between the bases of the dorsal and anal fin rays; one or two transverse streaks across the bases of the caudal fin rays; and a number of

[39] Brauer, Tiefsee-Fische Wissensch. Ergeb. Deutschen Tiefsee-Exped., (1898-1899) 1906, vol. 15, Pt. I, p. 40.

[40] Reported to us by Walter H. Rich.

[41] Goode and Bean (Smithsonian Contrib. Knowl., 1895, p. 97) list these captures.

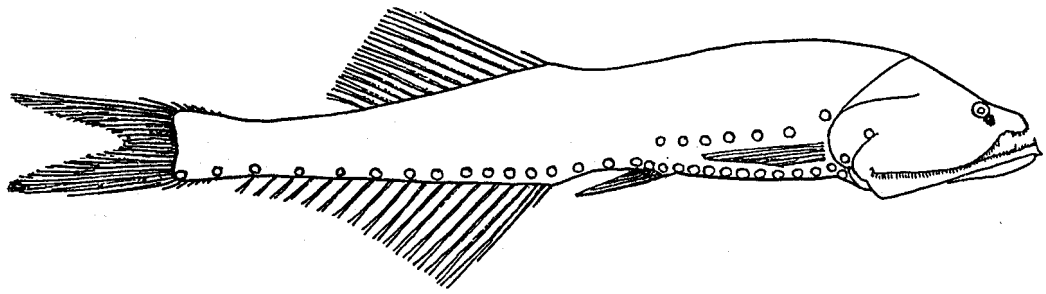

FIGURE 64.—Cyclothone (*Cyclothone signata*). After Brauer.

irregular flecks and dots along the back and on the gill covers.[42]

General range.—This is an oceanic fish, very abundant in temperate latitudes in the Atlantic where it lives pelagic from about 100 fathoms down to 250 fathoms; hundreds have often been taken in a single haul. It is also known from the Pacific.

Occurrence in the Gulf of Maine.—Cyclothone appears within our limits only as a stray from the Atlantic Basin; one 23 mm. long that we took in a haul from 30 fathoms on Browns Bank, June 24, 1915, and a second mutilated specimen probably of this species from the Fundy Deep (haul from 90 fathoms), March 22, 1920, are the only definite records of it within our limits.

Stomias *Stomias ferox* Reinhardt 1842

Jordan and Evermann, 1896–1900, p. 588.

Description.—The members of this genus (there are several), resemble the viperfish in their bulldog-shaped heads, with large mouth and long, fanglike teeth. But they do not have an adipose fin; the dorsal fin and the anal fin both stand far rearward close to the tail fin; the dorsal fin is even with the anal fin; and the first dorsal fin ray is not prolonged as it is in the viperfish. The chin bears a fleshy barbel nearly as long as the head and ending in a group of about three simple filaments. The sides of the body are clothed with about 6 rows of large, thin, somewhat irregular, hexagonal scales, and there is one row of luminescent spots low down along each side and two rows along the belly; also one small, circular light organ below each eye.

The tip of the lower jaw overlaps and encloses the tip of the upper jaw when the mouth is closed in the only member of the genus that has been reported from the Gulf of Maine (or is likely to be found there); the slender body is about 17 times as long as it is high; the ventral fins are only about as long as the head; the dorsal fin is of about the same size and shape as the anal fin, over which it stands; and there are about 85–86 light organs in each of the ventral rows, about 60 light organs in each of the lateral rows.

Color.—Black below as well as above, the sides with metallic iridescence.

General range and occurrence in the Gulf of Maine.—This oceanic fish is so widespread in the northern North Atlantic that it was taken at almost all the stations that the *Michael Sars* occupied there in 1910,[43] mostly between the 75 to 80 fathom level and the 410 fathom (750 meter) level, most plentifully at about 275 fathoms (500 meters). The early cruises of the *Blake* and *Albatross I* took it at many localities also, along the continental slope of North America between the southeastern slope of the Newfoundland Banks and the Bahama Channel.[44] Our only reason for mentioning it is that one specimen about 12 inches long (tip of snout to base of tail fin) was taken by a trawler on the northeastern part of Georges Bank (lat. 42°10′ N., long. 67°05′ W.), at about 100 fathoms, on January 20, 1936.[45]

Stomioides nicholsi Parr 1933

Parr, Copeia, 1933, No. 4, p. 177.

Description.—The chief anatomical character separating *Stomioides* from *Stomias* is the structure of the chin barbel. In *Stomias* this terminates in three simple filaments. But in *Stomioides* it not only has these barbels, but the main trunk is swollen at the tip and has two additional filaments on one side a little inward from its tip. Another difference is that the point of origin of the anal fin is in advance of the origin of the dorsal fin by a distance about as great as the diameter of the eye in *Stomioides*, whereas the point of origin of the anal fin is about even with that of the dorsal in

[42] For detailed accounts and colored illustrations see Garman (Mem. Mus. Comp. Zool., vol. 24, 1899, p. 246, pl. J, fig. 3), Brauer (Wissensch. Ergeb. Deutschen Tiefsee-Exped. (1898–1899), 1906, vol. 15, Pt. 1, p. 77, pl. 6, fig. 6), Murray and Hjort (Depths of the Ocean, 1912, pl. I).

[43] Murray and Hjort, Depths of the Ocean, 1912, pp. 603, 611, 629.

[44] For a list of these stations, see Goode and Bean, Smithsonian Contrib. Knowl., vol. 30, 1895, p. 107.

[45] This specimen is now in the Museum of Comparative Zoology.

FIGURE 65.—Stomias (*Stomias ferox*), Banquereau Bank. From Goode and Bean. Drawing by H. L. Todd.

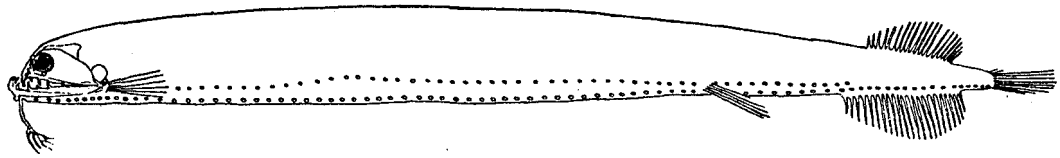

FIGURE 66.—*Stomioides nicholsi*, Browns Bank. Drawing by Myvanwy M. Dick.

Stomias. *Stomioides* resembles *Stomias* in all other respects so closely that should a specimen of either be taken, that is not easily identified, we suggest forwarding it to the U. S. Fish and Wildlife Service for naming.

Color.—Black below as well as above, the luminescent organs showing as whitish dots.

Size.—The only specimen yet seen is about 10½ inches long, from tip of snout to base of tail fin.

Range and occurrence in the Gulf of Maine.—The only known specimen of this species was taken from the stomach of a swordfish harpooned from the schooner *Barbara*, Capt. C. A. Turner, on the southeastern edge of Browns Bank,[46] over the 250 fathom line, August 3, 1932. Presumably it had strayed from the mid-depths offshore.

Trigonolampa miriceps Regan and Trewavas 1930

Regan and Trewavas, Danish *Dana* expeds. 1920–1922, No. 6, 1930, p. 55, pl. 1, fig. 1.

Trigonolampa resembles *Stomias* in general appearance, in the relative sizes and locations of the fins, and in having a long fleshy barbel on its chin. But it not only has a small light organ below the eye (as in *Stomias*), but also has a small luminescent patch close behind it, and likewise a larger triangular patch extending from close behind the eye back across the top of the cheek; these are its most distinctive characters. The one species of the genus yet known differs further both from *Stomias* (p. 147) and from *Stomioides* (p. 147) in a considerably deeper body (cf. fig. 67 with figs. 65, 66); also in that the tip of its lower jaw does not enclose the tip of its upper jaw when the mouth is closed; that the point of origin of its dorsal fin is in advance of its anal fin by a distance about as great as the diameter of the eye; and that it has only about 68 light organs in each of its ventral rows, as against 85 or 86 in *Stomias* (p. 147).

Color.—Not known, but probably black or very dark brown.[47]

Size.—The largest specimen yet seen (in the Museum of Comparative Zoology) is about 9 inches (230 mm.) long to the base of the caudal fin.

Range and occurrence in the Gulf of Maine.—Only three specimens have been seen yet. The first was taken in the eastern Atlantic by the Danish research vessel *Thor* in 1906 at a depth of about 600 fathoms; a second was found by Capt. John Toothaker in the stomach of a swordfish harpooned on the southern edge of Georges Bank in the summer of 1922,[48] and a third, now in the Museum of Comparative Zoology, was recorded simply as taken on Georges Bank about 1913. It reaches the slope of our outer Banks only as a stray from the mid-depths offshore.

[46] This specimen, described by Parr (Copeia, 1933, p. 177), is now in the Museum of Comparative Zoology.

[47] One that we have seen is brown below as well as above wherever the skin is intact, with the light organs showing as darker dots.

[48] Parr (Copeia, 1933, No. 4, p. 178) has given a detailed description of this specimen, which is now in the Museum of Comparative Zoology.

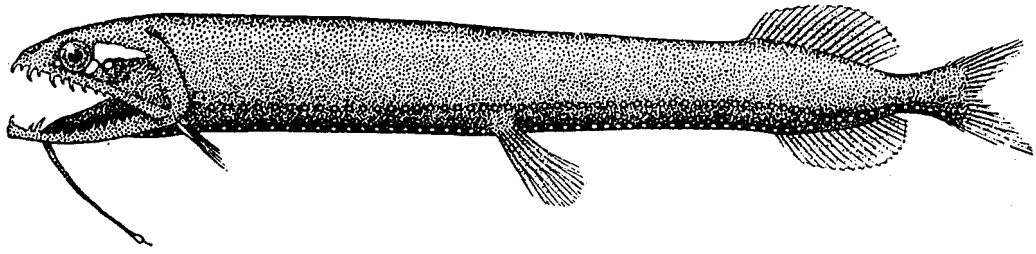

FIGURE 67.—*Trigonolampa miriceps*. After Regan and Trewavas.

HATCHET FISHES. FAMILY STERNOPTYCHIDAE

These are deep, thin, flat-sided little fishes, with various spiny projections, large oblique mouths with small teeth, large eyes which are directed upwards in some of them but sidewise in others, and ventral fins placed far back. Some of them have an adipose fin behind the rayed dorsal, but others do not. All of them are silvery, and all of them have series of large and conspicuous luminescent organs on the lower part of the body. They are to be found in the mid-depths in all oceans, sometimes in great abundance.

Silver hatchetfish *Argyropelecus aculeatus* Cuvier and Valenciennes 1849

Jordan and Evermann, 1896–1900, p. 604, as *A. olfersi* Cuvier, 1829.

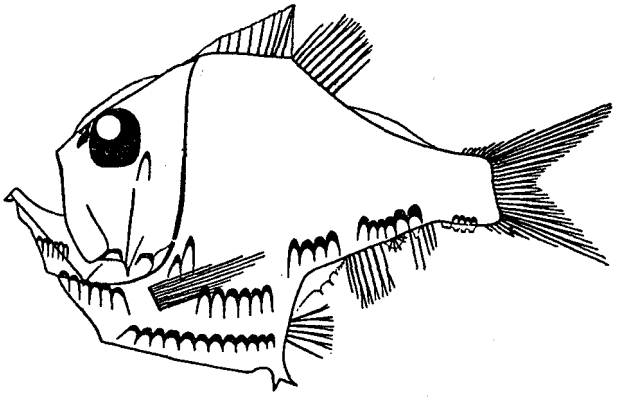

FIGURE 68.—Silver hatchetfish (*Argyropelecus aculeatus*). After Brauer.

Description.—This little fish is of so bizarre an appearance that once seen it could hardly be mistaken for any other species yet known from our Gulf, or for any that is likely to stray thither, unless one of its own tribe.[49] Its body is very thin sidewise, with its forward part a little less than three-fourths (70 percent) as deep as it is long from snout to base of tail fin, but with the ventral contour bending upward abruptly about midway of its length in characteristic contour, so that the rear half is much less deep than the forward half. This break in the ventral contour is marked by two short bony spurs, which are outgrowths from the pubic bones, and there is a short single spur (outgrowth from the pectoral arch) in front of them in the midventral line.

The eyes are large, so high up that the space between them on the top of the head is very narrow, and they are directed more upward than sidewise. The mouth is noticeably large, with wide gape, and it is so strongly oblique that the upper jaw is nearly vertical.[50] The tips of the two jaws are about even one with the other when the mouth is closed, and both jaws are armed with a large number of tiny sharp teeth. The dorsal fin is short, about midway of the fish, and of two parts, separated by a deep but short notch. The forward subdivision is in the form of a hard, triangular plate (apex rearward) supported by 8 or 9 hard spines, the rearmost of which is the stoutest and longest. The rearward subdivision is supported by 9 soft rays, that are bifid toward their tips. The adipose fin is long and low. The pectorals are as long as about two-fifths the greatest height of the body. The ventral fins, each with 6 soft rays, stand close behind the break in the ventral contour of the body, and they are connected with the anal fin by a thin transparent ridge. The anal, commencing about under the rear end of the base of the soft rayed part of the dorsal, is notched midway of its length; its forward part is supported by 7 rays close together, the rear part by 5 shorter rays spaced more widely. The caudal fin is forked. A noticeable feature is that the ventral edge of the deep forward part of the body, from the pectoral spur to the pubic spines, is sharp, with a series of 12 hard, plate-like scales or scutes, that extend for some distance up the sides, each slightly overlapping the next rearward, and the profile is saw-edged between the ventral and anal fins.

The hatchetfishes are provided with a complex system of conspicuous light-producing spots. The species *aculeatus* has one row of 12 very low down along each side of the deep forward part of the body; also, a second row higher up consisting of 6 in front of each pectoral fin, 2 along the base of the pectoral, 6 between pectoral and ventral fins, 4 between the ventral and the anal fins, 6 along the anal, and 4 very small ones between anal and tail fins. There is also one light-organ a little below and behind

[49] The several known species of *Argyropelecus* resemble one another so closely that their identification calls for a specialist. They have been reviewed by Schultz, Proc. U. S. Nat. Mus., vol. 86, 1938, pp. 147–153. The most detailed description of this particular hatchetfish, with the best illustration (copied here as fig. 68) is by Brauer, Wiss. Ergeb. Deutschen *Valdivia* Tiefsee-Exped., vol. 15, Pt. 1, 1908, p. 110, fig. 47.

[50] Most of the published illustrations of *Argyropelecus* fail to show this.

each eye, 2 on the lower part of the gill cover on each side and about 5 on the lower jaw on each side.

Color.—Perhaps the most conspicuous feature of the hatchetfishes, as taken from the water, is that their entire bodies are glistening silvery. On some specimens the silver is underlaid with velvet black over the trunk as a whole; on others the black under pigment is confined to a marginal band, broader or narrower. The luminescent spots are pale yellow or white.

Size.—Maximum length probably not more than 3 inches or so.

Range and occurrence in the Gulf of Maine.—All the members of this genus are oceanic, and inhabit the mid-depths. Localities listed by Schultz [51] for this species include the Grand Banks, between Georges and Browns Banks, and the offing of New Jersey and Virginia in the western Atlantic; the Gulf of Mexico; West Indies; off the South African coast; the Indian Ocean; and the Philippines. Our only reason for mentioning the hatchetfish is that one specimen was taken on August 31, 1883, by the *Albatross* between Georges and Browns Banks where the depth was 144 fathoms.[52]

THE EELS. FAMILIES ANGUILLIDAE, CONGRIDAE, SIMENCHELYIDAE, SYNAPHOBRANCHIDAE, NEMICHTHYIDAE, AND OPHICHTHYIDAE

Eels have no ventral fins; either they have no scales or these are so small as to be hardly visible; their fins are soft, without spines; the gill openings are very small; the vertebrae extend in a straight line to the tip of the tail; and a single fin runs over the back, around the tail and forward on the belly with no separation into dorsal, caudal, and ventral portions. All the species of eels known from the Gulf of Maine have pectoral fins, but most of the morays of warmer seas are without pectorals. There are several other fishes of eel-like form in the Gulf of Maine, viz., the hag and the lampreys the rock eel (*Pholis*); the snake blenny (*Lumpenus*); the wrymouth (*Cryptacanthodes*); the eel pout (*Macrozoarces*); and the sand eel (*Ammodytes*). But the jawless, sucker-like mouth of the first two separates them, at a glance, from the true eels, while there either is a well-marked separation between anal and caudal fins in all the rest; or they have ventral fins (large or small), or the dorsal fin is spiny, not soft.

Only five true eels are known from the Gulf of Maine: the common eel (p. 151), the slime eel (p. 157), the conger (p. 154), the snipe eel (p. 159), and the snake eel (p. 159), which fall into five different families according to American usage. A sixth species, the long-nosed eel (a deep-water form p. 158) is to be expected in the deepest parts of the Gulf though it has not actually been recorded there as yet. The group likewise includes the morays of warm seas and sundry deep-sea forms, some of them exceedingly bizarre in appearance.

Common, conger, slime, and long nosed eels look much alike in general form, but are separated from one another by the size of the mouth and by the relative lengths of the fins. In the snipe eels the two jaws are prolonged into a very long slender beak, recalling that of a silver gar, the tail is whip-like, the neck noticeably slimmer than the head, and the general form extremely slender, while the snake eel is very slender with a hard pointed tail.

[51] Bull. U. S. Nat. Mus., vol. 86, 1938, pp. 146–147 and pp. 151–152.

[52] *Albatross* station 2063, lat. 42° 23′ N., long. 66° 23′ W. This specimen was recorded by Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895, p. 127) as *A. olfersii*. But Schultz (Proc. U. S. Nat. Mus., vol. 86, 1938, p. 151) has found, on reexamination, that it is an *aculeatus*.

KEY TO GULF OF MAINE EELS

1. Both jaws are prolonged into a long slender bill ..... Snipe eel, p. 159
   The jaws are not bill-like 2
2. The anal fin originates well in front of the point of origin of the dorsal fin ..... Long-nosed eel, p. 158
   The anal fin originates well behind the point of origin of the dorsal fin 3
3. The dorsal fin originates far behind the tips of the pectorals ..... Eel, p. 151
   The dorsal fin originates close behind the tips of the pectorals 4
4. Mouth very small, its gape not reaching back as far as the eye; body very soft ..... Slime eel, p. 157
   Mouth large, gaping back as far as the middle of the eye; body firm 5
5. Mouth gaping back only about as far as the middle or rear edge of eye; body moderately stout; tip of tail soft, rounded ..... Conger, p. 154
   Mouth gaping back considerably beyond eye; body very slender, tip of tail hard and pointed ..... Snake eel, p. 159