

## SNIPE FISHES. FAMILY MACRORHAMPHOSIDAE

**Snipe fish** *Macrorhamphosus scolopax* (Linnaeus)  
1758

Jordan and Evermann, 1896-1900, p. 759.

*Description.*—The snipe fish is given so unusual an appearance by a long tubular snout with small toothless mouth at the tip, combined with a very long, stout dorsal fin spine that is saw-toothed along the rear edge that it could hardly be mistaken for any other Gulf of Maine fish.

Its body is about two-fifths as deep as long, measured from front of eye to base of caudal fin, so flattened sidewise that it is only about one-third to three-eighths as thick through as it is deep; the snout, measured from the front of the eye is about  $1\frac{1}{2}$  times as long as the depth of the body. The eye is noticeably large. The two dorsal fins stand far behind the mid-length of the trunk. The first dorsal is of 5 to 7 spines and very short, the second, far the longer, is pointed, with about 11 to 13 soft rays; and the two dorsal fins are separated by an interspace nearly as long as the base of the first dorsal. The anal, with 19 to 20 rays, is much longer than the second dorsal, but lower; the caudal is square-tipped, of moderate size. The very small ventrals are located considerably behind the pectorals. The snout, head, and sides are clothed with small rough scales. And the body is further stiffened with bony plates, of which there are 2 longitudinal rows of 4 each, high up on each side behind the gill opening; also 3 longitudinal series of 6 each along the lower breast and belly in front of the ventral fins, followed by 3 pairs behind the latter

and finally by a single plate close in front of the anal fin, these last forming a sharp keel.

*Color.*—Pinkish or reddish on sides above, fading to silvery white below. Described as sometimes golden above.

*Size.*—Maximum reported size about  $6\frac{1}{4}$  inches (16 cm.);<sup>42</sup> the few we have seen were about 4 inches long.

*General range.*—Widespread in warm seas. Eastern Atlantic, from the coast and Banks of Morocco, where it is sometimes taken in numbers, and the Mediterranean, northward to southern England (Cornwall, Devonshire); so far known in the western Atlantic only from the offing of Nantucket and from Massachusetts Bay.

*Occurrence in the Gulf of Maine.*—Oddly enough, the few records of this eastern Atlantic fish in our side of the Atlantic have all been within the limits of the Gulf of Maine; namely, one reported from Massachusetts Bay;<sup>43</sup> a second trawled south of Nantucket, at the 130-fathom contour line,<sup>44</sup> both many years ago; and eight specimens trawled in that same general vicinity (lat.  $39^{\circ}59'$  N., long.  $69^{\circ}47'$  W.) at 80 fathoms, by the *Albatross III* on May 14, 1950. Evidently it reaches the inner parts of the Gulf only as a stray, and at long intervals although it is taken from time to time by otter trawlers along the southwestern edge of Georges Bank in 75 to 85 fathoms.

<sup>42</sup> One of this size is pictured by Murray and Hjort (*Depths of the Ocean*, 1912, p. 397, fig. 268).

<sup>43</sup> Goode and Bean (*Smithsonian Contrib. Knowl.*, vol. 30, 1895, p. 483), without further details.

<sup>44</sup> Original of Goode and Bean's illustration (*Smithsonian Contrib. Knowl.*, vol. 31, 1895, pl. 127, fig. 396).

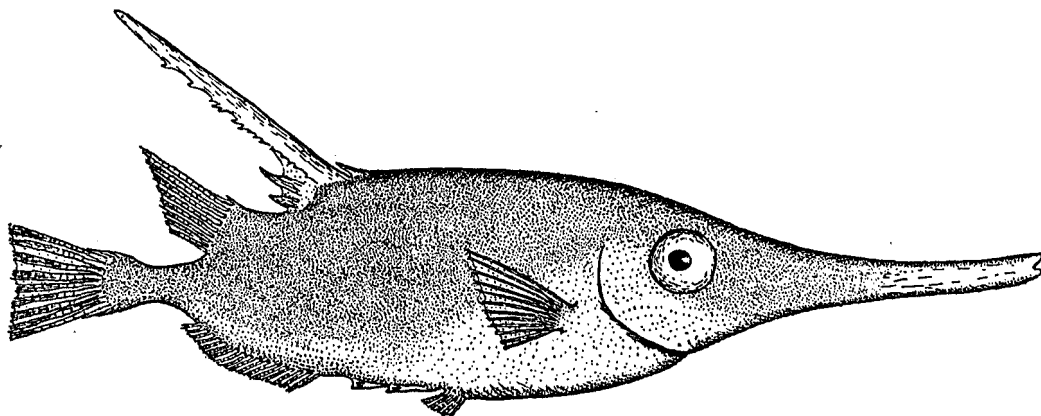


FIGURE 158.—Snipefish (*Macrorhamphosus scolopax*), off Nantucket.

## THE SILVERSIDES. FAMILY ATHERINIDAE

These are small fishes, smelt-like in appearance, except that they have a spiny dorsal fin as well as a soft dorsal fin; do not have the adipose fin, and have much smaller mouths than the smelt. Two species are known from the Gulf of Maine.

## KEY TO GULF OF MAINE SILVERSIDES

1. About 24 rays in the anal fin  
Common silverside, p. 302.  
Only about 15 or 16 rays in the anal fin  
Waxen silverside, p. 304.

Silverside *Menidia menidia* (Linnaeus) 1766

GREEN SMELT; SAND SMELT; WHITE-BAIT;  
CAPELIN; SPERLING; SHINER

Jordan and Evermann, 1896-1900, pp. 800, 2840.

*Description.*—This silvery little fish is often confused with the young smelt, but it does not require very close examination to tell them apart for the adipose fin characteristic of the smelt is lacking in the silverside, while the latter has a spiny dorsal fin as well as a soft dorsal fin instead of the one soft dorsal only, as the smelt does; this last character distinguishes it equally from young herrings; its anal fin too is much longer than that of the smelt.

It is a slender fish, about one-sixth as deep as long, not counting caudal fin; thin-bodied but with rounded (not sharp-edged) belly; with short head; large eye; and small mouth, gaping hardly as far back as the front of the eye, and set very obliquely. Both head and body are clothed with large scales. The first dorsal fin (3 to 7 spines) is smaller than the second and originates about midway between the tip of the snout and the base of the caudal fin; the second dorsal has 7 to 10 soft rays and origi-

nates over the middle of the anal. The anal (of 23 to 26 rays, the first stiff and the others soft) is falcate in outline. The caudal peduncle is slender, the tail moderately forked.<sup>45</sup>

*Color.*—Translucent bottle green above, with top of head, nose, and chin dusky. The upper parts of the sides are thickly speckled with dark brown, and there is a silver band outlined above by a narrow black streak, running along each side from close behind the pectoral fin to the base of the caudal fin. The belly is white.

*Size.*—The silverside grows to a length of about 5½ inches, adults usually running 4 to 4½ inches long.

*Habits.*—Silversides tend to congregate in schools usually made up of even-sized individuals. They frequent sandy or gravelly shores chiefly, and there is no reason to suppose that they ever venture out to sea. At high tide they are often seen among the sedge grass (*Spartina*), where it grows sparsely between tide marks, particularly about the inner bays and in river mouths where they follow the tide up and down the beach within a few yards of the water's edge. They also run up into brackish water; near St. Andrews, in fact, they are chiefly found in brackish situations though more generally distributed on the New Brunswick shore further up the Bay of Fundy and on the Nova Scotian side as a whole. They do not ordinarily descend deeper than a fathom or so in summer. But some of them, at any rate, sink

<sup>45</sup> The common silverside is represented on the coasts of the eastern United States by two races, a southern and a northern, not, however, very distinct and connected by such various intergradations that they hardly deserve two names, subspecies *menidia* for the southern and subspecies *notata* for the northern. The southern form has fewer scales than the northern, only 4 instead of 5 spines in the first dorsal, and is rather a stouter-bodied fish. Kendall has given an account of the genus (Report, U. S. Comm. Fish (1901) 1902, p. 241). For a recent discussion see Bayliffe (Publ. 90, Chesapeake Biol. Lab., Maryland Dept. Nat. Res., 1950, p. 5).

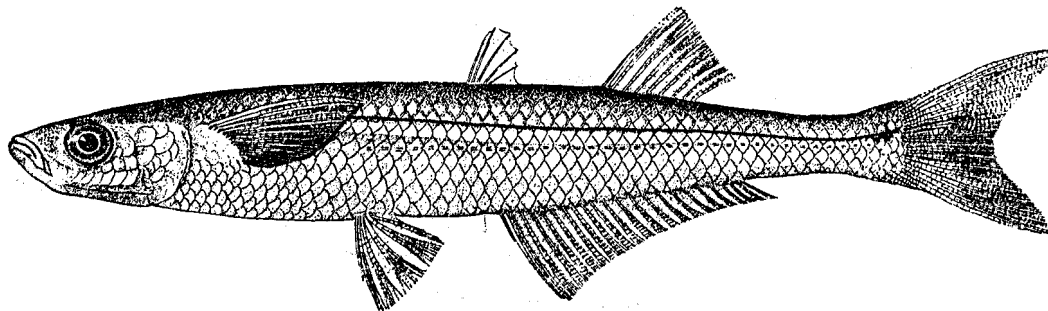


FIGURE 159.—Silverside (*Menidia menidia*), Connecticut. From Goode. Drawing from H. L. Todd.

deeper in winter, probably to avoid low temperature, for Hildebrand and Schroeder<sup>46</sup> found them at depths of 5 to 27 fathoms at that season in Chesapeake Bay. But this is not their universal habit, for they are taken in winter through the ice, as well as in summer, in the southern side of the Gulf of St. Lawrence. And they are resident throughout the year wherever found, generally speaking. Such, at least, is the case along southern New England.

They are omnivorous, feeding chiefly on copepods, mysids, shrimps, small decapod shrimps, amphipods, Cladocera, fish eggs (including their own), young squid, annelid worms, and molluscan larvae. Insects, too, that fall into the water have been found in their stomachs, as have algae and diatoms mixed with sand and mud. On the other hand, they are harried by every predaceous fish that comes close inshore, especially by bluefish and by striped bass. It was interesting in this connection to find that a dolphin (rare in the Gulf), taken at Sandwich, in Cape Cod Bay, in July 1951 (p. 361) was packed full of silversides.

They spawn in May, June, and early July<sup>47</sup> on the southern New England coast. Spawning may begin a little later in the Gulf of Maine, corresponding to more tardy vernal warming, while Leim writes<sup>48</sup> that they do so in June at Prince Edward Island.

The gap in the presence of silversides in abundance that seems to exist along the cool-water stretch from the western side of the Gulf of Maine to the southern side of the Gulf of St. Lawrence (p. 304) suggests that they need summer temperatures as high as 68° or so for successful reproduction. But young fry and adults alike are indifferent to temperatures down to a degree or two above the freezing point of salt water, witness their presence in winter in Cape Cod Bay (p. 304) and below the ice in the bays on the northern side of Prince Edward Island (p. 304).

When the silversides are spawning they gather in schools to deposit their eggs on sandy bottom, often among the sedge grass at high tide, or above low-water mark. Capt. John B. Smith has described them spawning in the sedge at the head

of Buzzards Bay, June 13, 1872, rolling from side to side, some jumping clear of the water, and in such multitudes that the water was "whitened with the milt, and the grass was so full of eggs that they could be taken up by the handfull," while small fishes of various kinds were "helping themselves to the dainty repast."<sup>49</sup>

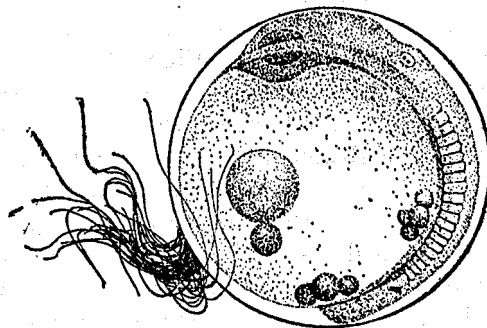


FIGURE 160.—Egg.

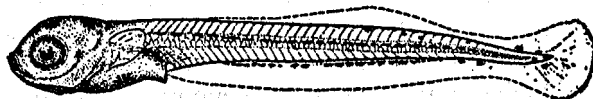


FIGURE 161.—Larva, 8 mm.



FIGURE 162.—Fry, 13 mm.

SILVERSIDE (*Menidia menidia*). After Kuntz and Radcliffe.

The eggs, 1.1 to 1.2 mm. in diameter and each bearing a bunch of sticky filaments, sink and stick fast in ropy clusters or sheets. Incubation occupied 8 or 9 days in the laboratory at Woods Hole. The yolk is absorbed before hatching, at which time the larvae are about 3.85 to 5 mm. long, and the dorsal, anal, and caudal fins are formed in larvae of 12 to 15 mm. in length. The young grew to a length of 9.3 to 11.7 mm. during the first 20 days in the aquaria. Probably they grow more rapidly at liberty, for all sizes from fry of an inch or less to adults are to be found throughout the summer. Probably the silverside attains maturity at 1 year of age.

*General range.*—The northern variety of this silverside is common locally from the southern side of the Gulf of St. Lawrence and the outer

<sup>46</sup> Bull. U. S. Bur. Fish., vol. 43, Pt. 1, 1923, p. 189.

<sup>47</sup> Kuntz and Radcliffe (Bull. U. S. Bur. Fish., vol. 35, 1918, p. 127) describe its development, and Hildebrand (Bull. U. S. Bur. Fish., vol. 38 [1921-22] 1923) that of the southern race. For a recent account of its life history see Bayliffe, Pub. 90, Chesapeake Biol. Lab., Maryland Dept. Nat. Res., 1960.

<sup>48</sup> Proc. Nova Scotian Inst. Sci., vol. 20, Pt. 2, 1940, p. 38.

<sup>49</sup> Goode, Fish. Ind. U. S. Sect. 1, 1884, p. 457.

Nova Scotian coast to Massachusetts Bay, and very abundant thence southward to Chesapeake Bay, south of which it gives place to the southern form or intergrades with it; the southern form has been detected as far north as Woods Hole, but never east of Cape Cod.

*Occurrence in the Gulf of Maine.*—The silverside is to be found all around the shores of the Gulf from Nova Scotia to Cape Cod, always, however, closely confined to the coastline. They are exceedingly plentiful around the sandy shores of Cape Cod Bay. And while we have seen them from Chelsea Beach in Boston Harbor, from Beverly and from Gloucester, many summers spent on the coast leave us with the impression that the silverside is neither as omnipresent nor as abundant from Massachusetts Bay northward, although large schools of them are often to be seen here and there along the sandy beaches on the Maine coast. Bushels, in fact, have been caught in a single haul of the seine in Casco Bay and very likely could be elsewhere.

Silversides are seldom seen along the stretches of rocky coast exposed to the open sea, which make up a large part of the northern shore line of the Gulf of Maine. In Passamaquoddy Bay Huntsman tells us<sup>60</sup> "they are largely restricted to brackish water and hence not very common," but they must be rather generally present in suitable situations around the shore line of the Bay of Fundy, being reported from St. John and Kennebecasis Bay, from Annapolis basin and from St. Mary Bay. Nothing is known as to their status along the Nova Scotian coast of the open Gulf of Maine, or even whether there are any silversides there at all. Halifax is the most northerly locality where they are recorded on the

outer coast of Nova Scotia.<sup>61</sup> But Leim<sup>62</sup> reports them so plentiful in the shallows of the southern side of the Gulf of St. Lawrence that "hardly a seine haul has been made without catching several, and as many as 3,500 have been taken at once" in Malpeque Bay on the north shore of Prince Edward Island, where they are taken in winter through the ice, as well as in summer. Enough of them, in fact, are sometimes caught there to be worth canning.<sup>63</sup> Their abundance there contrasted with their evident scarcity along outer Nova Scotia suggests the presence of an isolated population (or populations) in suitable situations in the southern side of the Gulf of St. Lawrence, able to maintain itself because summer temperatures in the shallows there are high enough for its successful propagation.

*Importance.*—The chief function of the silverside in the economy of the sea is to feed predaceous fishes such as bluefish, mackerel, and striped bass. The silverside is of no commercial value north of Cape Cod, being too small and too soft to answer the never satisfied demand for bait for the offshore fisheries, but they are very generally used to bait eelpots on the Rhode Island coast, and they are excellent on the table, fried, as whitebait.

#### Waxen silverside *Menidia beryllina* (Cope) 1866

Jordan and Evermann 1896-1900, p. 797 (*Menidia gracilis* Günther).

*Description.*—This species resembles the common silverside so closely in general appearance that it would be apt to be overlooked among the schools of the latter were it not paler in color,

<sup>61</sup> Cornish (Contr. Canadian Biol. [1902-1905], 1907, No. 9) does not include it in his list of the fishes of Canso.

<sup>62</sup> Proc. Nova Scotian Inst. Sci., vol. 20, Pt. 2, 1940, p. 38.

<sup>63</sup> Needler, Rept. Fish. Res. Board Canada (1941) 1942, p. 11.

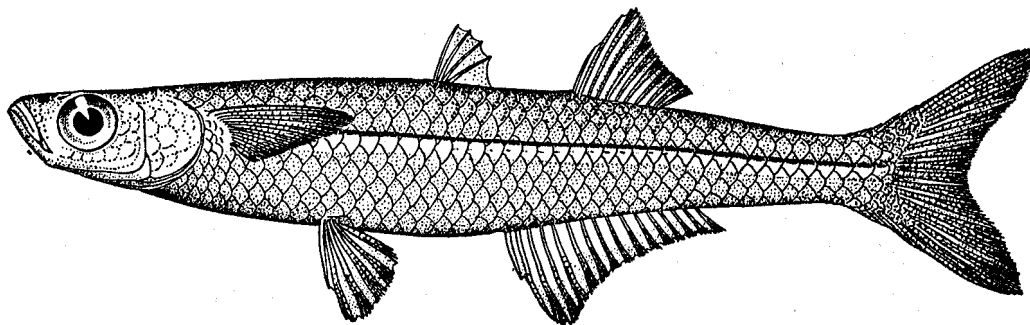


FIGURE 163.—Waxen silverside (*Menidia beryllina*). From Kendall

<sup>60</sup> Contrib. Canadian Biol. (1921) 1922, p. 61.

and stouter bodied as a rule. A more dependable difference, which will always serve to separate the two (for which neither color nor form can be relied upon) is that the anal fin is much shorter (only 15 or 16 rays) in the waxen silverside than in the common silverside.

*Color.*—Pale greenish on the back, silvery below; the sides with a well-defined silvery band bounded above by a dark line; scales on the back with numerous brown dots; fins without markings.

*Size.*—Smaller than its relative *menidia*, the maximum length being about 3 inches.

### THE MULLETS. FAMILY MUGILIDAE

Mullets have two separate dorsal fins, the first spiny and the second soft-rayed. Their ventral fins are on the abdomen behind the point of insertion of the pectorals; their tails are forked and they have large scales. Their closest affinity among Gulf of Maine fishes is with the silversides, which they resemble somewhat in the relative size and locations of the fins; but they differ from the silversides in their short, broad heads, small eyes, and relatively deeper and thicker bodies, while they have only 24 vertebrae instead of 35 or more. Furthermore, they are vegetable and mud eaters instead of carnivorous, their stomachs are thick walled and gizzard-like, the intestines long, corresponding to their food. The lining of the belly of the mullet is black while that of the silverside is pale.

There are many species of mullets. Most of them, however, are tropical, and only one has ever

<sup>44</sup> Occ. Pap. Boston Soc. Nat. Hist., vol. 7, No. 8, 1908, p. 66, as *Menidia beryllina* subspecies *cerea* Kendall (Rept. U. S. Comm. Fish. (1901) 1902, p. 261.)

<sup>45</sup> This specimen is in the Museum of Comparative Zoology.

*General range.*—Cape Cod to South Carolina.

*Occurrence in the Gulf of Maine.*—Specimens reported by Kendall <sup>54</sup> (1902) from Truro, and from Sandwich in Cape Cod Bay, with one taken in Cohasset, on the southern shore of Massachusetts Bay in the autumn of 1939, <sup>55</sup> are the only records for this fish within the Gulf of Maine, where it appears only a stray from warmer waters to the west and south. At Woods Hole, where it is abundant, its habits are the same as those of the common silverside, though it spawns somewhat later (in June and July).

been known to stray within the confines of the Gulf of Maine.<sup>56</sup>

#### Mullet *Mugil cephalus* Linnaeus 1758

COMMON MULLET; STRIPED MULLET; JUMPING MULLET

Jordan and Evermann, 1896-1900, p. 811.

*Description.*—The common mullet, the only one of its numerous tribe (there are more than 100 species of mullets) that has been known to stray north of Cape Cod, has a spiny first dorsal and soft second dorsal fin, the two well separated as in the silverside, and its ventrals are located on the abdomen. It is a much larger fish than the silverside, however, and even very young mullets of the

<sup>56</sup> The so-called red mullet or goat fish (*Mullus auratus*) of more southern waters, which is not a true mullet but belongs to a different family (Mullidae), is taken from time to time near Woods Hole, and it has been reported from Halifax Harbor, Nova Scotia (by Leim, Proc. Nova Scotian Inst. Sci., vol. 17, No. 4, 1930, p. XLVI), hence it may be expected as a stray in our Gulf, though it has not actually been found there as yet. There is no danger of mistaking it for a mullet, for it is bright crimson, with a fleshy barbel on its chin, and with its ventral fins far forward, below its pectorals.

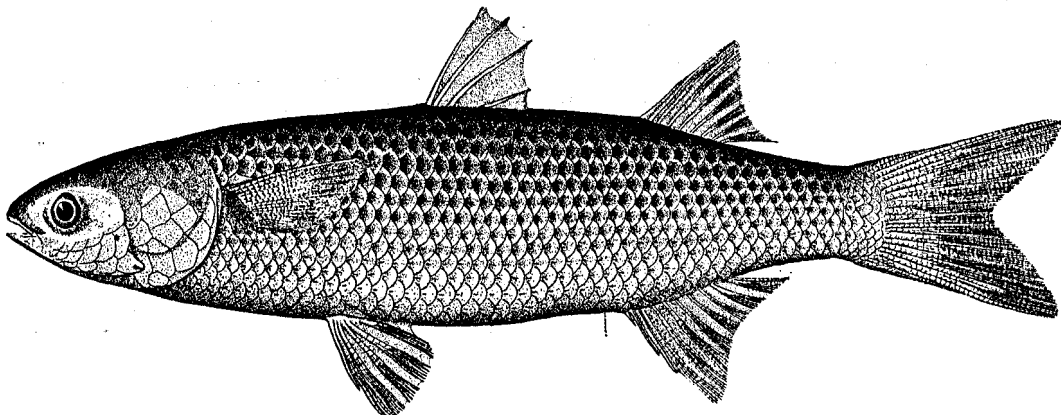


FIGURE 164.—Mullet (*Mugil cephalus*), Woods Hole. From Goode. Drawing by H. L. Todd.

size of the latter (4 to 5 inches long) are easily separable from silversides by the fact that their anal fin is only about half as long in relation to the length of the body, while the second dorsal originates over the origin of the anal instead of well behind it. Furthermore, the head of the mullet is shorter; its nose blunter; its profile quite different (compare fig. 164 with fig. 159); its eye smaller; its body stouter (about one-fourth as deep as long); and it lacks the silvery side stripes so characteristic of the common silverside. There are four spines in its first dorsal fin, 1 spine and 8 soft rays in the second dorsal, 3 spines and (usually) 8 rays in the anal. Young fish, 2 inches long or less, have only 2 spines in the anal, the first soft ray later developing into a spine.<sup>67</sup> The first dorsal stands over the tips of the pectorals or close behind them; and the tail is forked moderately deep. The soft dorsal fin and anal fin are almost naked (they are scaled in most of the other American mullets), but the body and head are clothed with large rounded scales.

*Color.*—Adults are bluish gray or greenish above, silvery on the lower part of the sides and below; the scales on the sides have dark centers which form longitudinal lines; the fins are sometimes partly dusky. Young fry are bright silvery.

#### THE BARRACUDAS. FAMILY SPHYRAENIDAE

The slim bodied barracudas, with their long, pointed heads, somewhat resemble the pikes in general appearance. But they are distinguishable from the latter at a glance by having two dorsal fins. The lower jaw projects beyond the upper, and both jaws are studded with large pointed teeth of unequal sizes. The gill covers are scaly, and there is a well-developed lateral line. The first dorsal is spiny, the second soft-rayed. The anal is roughly opposite the second dorsal, the

<sup>67</sup> See Jacot (Trans. Amer. Microscopical Soc., vol. 39, 1920, pp. 204-214) or a study of the growth of the mullet.

*Size.*—The common mullet grows to a length of 2½ feet in warmer waters, but small specimens alone have been found along our northern coasts.

*General range.*—Both sides of the temperate Atlantic; from Brazil to Cape Cod on the American coast, and as a stray to outer Nova Scotia; also along the west coast of America from Monterey (Calif.) to Chile, and in other parts of the Pacific.

*Occurrence in the Gulf of Maine.*—Mulletts are common as far north as New York, less so to Woods Hole, but so rarely do they stray past Cape Cod that there are only a half dozen records of them in the Gulf of Maine, viz, at Provincetown, at Essex<sup>68</sup> in northern Massachusetts, at Freeport, Harraseeket River, Clapboard Island, and Casco Bay in Maine, each based on an odd fish. And one has also been taken in Bedford Basin near Halifax, Nova Scotia.<sup>69</sup> Mullet are more likely to visit the cool waters of the Gulf in late summer or early autumn than at any other season. They have been known to winter as far north as New York, in the mud, but it is not likely that the few strays that round Cape Cod survive the cold season, nor is there any reason to suppose they ever breed in the Gulf, for immature fish alone are found at Woods Hole.

ventrals opposite the first dorsal, the pectorals short, the caudal forked.

#### Northern barracuda *Sphyraena borealis* DeKay 1842

Jordan and Evermann, 1896-1900, p. 825.

*Description.*—The combination of slender shape with long head, projecting lower jaw, a first dorsal

<sup>68</sup> There is (or was) a specimen so labeled in the collection of the Boston Society of Natural History.

<sup>69</sup> Reported by Vladykov, Proc. Nova Scotian Inst. Sci., vol. 19, 1935, p. 6.

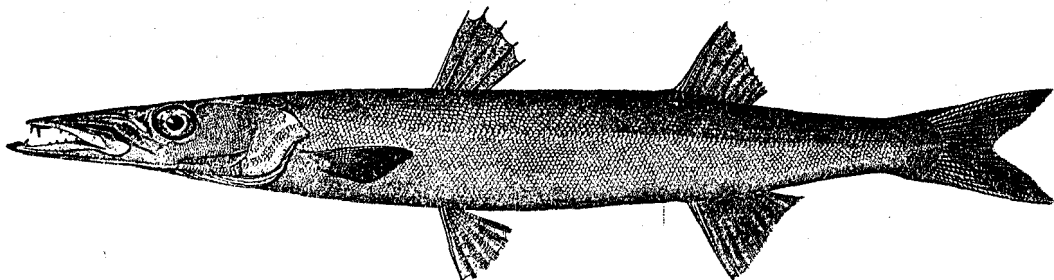


FIGURE 165.—Northern barracuda (*Sphyraena borealis*), Woods Hole. From Goode. Drawing by H. L. Todd.

situated opposite the ventrals, a second dorsal opposite the anal, and a forked tail, separates the barracuda from any other Gulf of Maine fish.

*Color.*—The adult is olivaceous above, silvery below. The young have dusky blotches along the back and along the lateral line.

*Size.*—This is the smallest of the barracudas, few growing longer than one foot.

*General range.*—Atlantic and Gulf coasts of America from Cape Cod to Panama.

*Occurrence in the Gulf of Maine.*—A specimen, about 2 inches long, found alive in the surf at Nauset Beach, Cape Cod, September 26, 1930, by the late Dr. Edward P. Richardson, is the only record for the Gulf of Maine. Young fry, a few inches long, have been taken from time to time in Vineyard Sound, however, and in Buzzards Bay on the southern coast of Massachusetts between July and December.

### THE STICKLEBACKS. FAMILY GASTEROSTEIDAE

Sticklebacks are small fish, made easily recognizable by the presence of two, three or more stout free spines on the back in front of the dorsal fin (spines that they can erect or depress at will) and by the fact that each ventral fin is represented by an even larger spine with only one or two rudimentary rays. Some of them have bony plates in the scaleless skin, but others do not.

#### KEY TO GULF OF MAINE STICKLEBACKS

1. Seven dorsal spines or more  
     Nine-spined stickleback, p. 307  
     Not more than five large dorsal spines..... 2
2. No bony plates on the upper part of the sides, but there is a bony ridge on either side of the abdomen  
     Four-spined stickleback, p. 311  
     The upper part of the sides are armed with bony plates, and there is a plate in the midline of the belly, but there are no ridges on the sides of the abdomen..... 3
3. Many (28 or more) plates on each side  
     Three-spined stickleback, p. 308  
     Only 5 or 6 plates on a side  
     Two-spined stickleback, p. 310

#### Nine-spined stickleback *Pungitius pungitius* (Linnaeus) 1758

Jordan and Evermann, 1896-1900, p. 745.

*Description.*—The nine-spined stickleback is a slender little fish five to 6 times as long (not

counting the caudal fin) as it is deep, with a very slim caudal peduncle. The latter usually has a well-developed longitudinal keel on either side; but this keel may be very low or even wanting. There are no bony plates along the sides of the body, but only along the bases of the anal and dorsal fins and on the caudal keels. There are no true scales. The most distinctive character is that there usually are 9 spines on the midline of the back (from 7 to 12 have been counted) in a continuous row from close in front of the pectorals to the dorsal fin, set in a slightly zigzag line and leaning alternately to one side and to the other. The spines are weakly curved rearward; wider at the base than at the tip; fairly uniform in size; about one-half to one-third as long as the height of the dorsal fin; each has a small triangular fin membrane at its base; and there is a shallow groove along the back, into which the spines can be depressed. Each ventral fin is represented by a stout curved spine thicker and longer than the dorsal spines. The dorsal and anal fins (the former stands above the latter) are alike in form, tapering from front to rear, the anal preceded by a single stout recurved spine. The tail fin is weakly rounded.

*Size.*—Large adults are seldom more than 3 inches long, more commonly 2 to 2½.

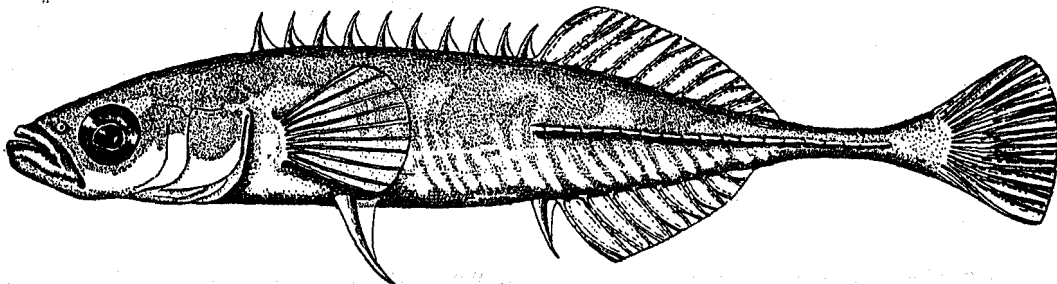


FIGURE 166.—Nine-spined stickleback (*Pungitius pungitius*). From Bigelow and Welsh.

*Color.*—Usually dull olive brown above, the upper part of the sides faintly barred or blotched darker; the belly silvery; the pubic and thoracic regions often black. The color varies, however, with the season of the year, with the state of sexual maturity, and with the color of the bottom on which the fish is living, those on dark mud being darker and those on bright sand paler. All become more brilliant during the breeding season when reddish tints appear under the head, the belly turns greenish, and black dots develop here and there over the entire body. The male has also been described as assuming a rosy tint beneath.

*Habits.*—Since the range of the nine-spined stickleback hardly touches the open waters of our Gulf, we need only note that its mode of life is much the same as those of its three-spined relative next to be considered (p. 308); that it is similarly destructive to the spawn and young of other fish, and similarly pugnacious. Probably it spawns in summer<sup>60</sup> on the shores of the Gulf, for its breeding season in northern Europe covers June and July. The male often (but not always) builds a nest attached to grass or weeds which the female spawns, and he guards nest and eggs until the latter hatch, which occurs in about 12 days.

*General range.*—This is one of the most widely ranging of northern fishes, occurring both in fresh water and in salt in the northern parts of both hemispheres; from northern Scandinavia to France, the western Mediterranean and the Black Sea on the European coast; from Arctic seas south to New York along the American, and westward to Saskatchewan and Alaska.

*Occurrence in the Gulf of Maine.*—This stickleback is to be found all around the shores of the

<sup>60</sup> At Woods Hole it spawns in April and May.

Gulf of Maine from Nova Scotia and the Bay of Fundy to Cape Cod, but it is chiefly restricted there to harbors and the creeks in salt marshes, where large numbers may often be taken in company with the mummichogs that swarm in such locations, and where it is to be found throughout the year. It is also found in fresh water. In fact, the most exposed situations around the Gulf, where we have heard of it, are Biddeford Pool, Maine,<sup>61</sup> Passamaquoddy Bay,<sup>62</sup> and St. Mary's Bay on the west coast of Nova Scotia.

*Commercial importance.*—This stickleback is of no commercial importance in America, but it is sometimes tried out for oil in northern Europe when enough can be caught.

**Three-spined stickleback** *Gasterosteus aculeatus* Linnaeus 1758

TWO-SPINED STICKLEBACK; STICKLEBACK; THORN-FISH; THORNBAC

Jordan and Evermann, 1896-1900, p. 747.

*Description.*—The three-spined stickleback has a very slender caudal peduncle, and squarish tail fin, like its nine-spined relative, but it is a stouter fish, being about one-fourth as deep as long, and it is more flattened sidewise. Its most diagnostic characters are the number of dorsal spines, of which there are three (occasionally four and rarely five), with the first two usually much the larger, and each with a small triangular fin membrane; the small size of the anal spine (this is free in the three-spined stickleback but attached to the fin by the fin membrane in the four-spined); and especially the presence of a series of 28 to 33 bony plates on each side, besides a single ventral plate

<sup>61</sup> MacCoy, Bull. 74, Boston Soc. Nat. Hist. 1935, p. 16.

<sup>62</sup> Huntsman, Contr. Canadian Biol., (1921) 1922, p. 61.

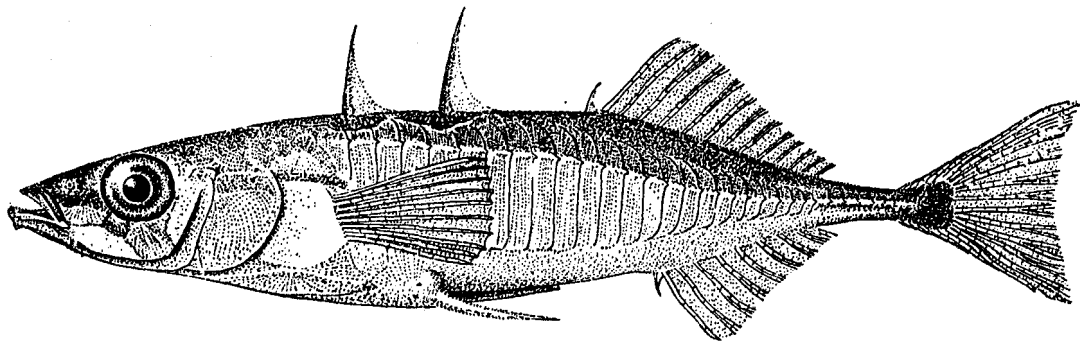


FIGURE 167.—Three-spined stickleback (*Gasterosteus aculeatus*), Woods Hole. From Jordan and Evermann. Drawing by H. L. Todd.



on the lower surface between and behind the ventral fins. The fact that the dorsal fin (1 spine, 10 to 14 rays) originates some distance in front of the anal (1 spine, 8 to 10 rays) is diagnostic also, while its ventral spines are longer and stouter than those of the nine-spined stickleback.

This is one of the most variable of fishes; Smitt,<sup>63</sup> lists no less than 32 named species or races based on its varieties. Thus its dorsal spines may be long or short, and they vary in number as noted above; its bony plates range from none at all to very well developed; and its caudal peduncle may be keeled or it may not. Most American authors have recognized an American species, at the least as contrasted with a European, the former supposedly with longer dorsal spines; the latter with shorter. But the long-spined, as well as the short-spined form is known to occur on the other side of the Atlantic with every possible gradation between the two. Seeing that we have found both in the Gulf of Maine among fish indistinguishable otherwise, we believe that the various forms are environmental races of the one species. And this is well established for the relative strength of the dermal armature, which is weak in fresh water, but strong in salt.

*Color.*—This stickleback is extremely variable in color, a fact hardly mentioned in most American accounts. They are deep grayish, or olive, or greenish-brown above, or sometimes blue; paler and often with silvery reflections on the sides; silvery on the belly. The fins are pale, except that the fin membranes often are red. In breeding season the males are described as turning reddish below from nose to vent and often up the sides. In females, the whole body except the top of the back may then be reddish; at the same time the back turns brownish with transverse bands, and the sides develop brassy reflections.

*Size.*—Maximum length about 4 inches, but few of them are more than 3 inches long. It matures sexually at a length of about 2 inches.

*Habits.*—This is distinctively a shore fish like all the sticklebacks, the great majority of them living their whole lives in estuarine situations. But it is equally at home in sea water of full salinity as in fresh water. And enough stray

out to sea for it to be rather a common experience to pick up a few here and there in the tow net, far from land. On such occasions they usually hide in clumps of floating eelgrass (*Zostera*) or of rockweed (*Fucus*, *Ascophyllum*); indeed we have learned to expect a stickleback or two whenever we dip up bunches of weed of any size. These wanderers keep to the surface except, perhaps, in very rough weather.

It is a permanent all-the-year resident wherever it is found alongshore, entering creeks and the mouths of streams in the spring to spawn, and dropping down into slightly deeper water for the winter. In such situations it probably lies in schools in a more or less sluggish condition while the temperature is lowest.<sup>64</sup> It is a proverbially pugnacious fish, using its spines with good effect as weapons of offense and defense, even on other fishes much larger than itself. It feeds indiscriminately on the smaller invertebrates, on small fish fry, and on fish eggs, to which it is exceedingly destructive in fresh water. The diet list of specimens examined by Vinal Edwards at Woods Hole included copepods, of which they are often full, isopods, schizapod shrimps, and young squid, while some had fed on diatoms only. And it is not only omnivorous but very voracious.

This stickleback affords the classic instance of nest building and of the care of eggs among fishes, and its nesting has been described so often in popular natural histories that a bare outline will suffice here.<sup>65</sup> Recent studies in Europe make it likely that this stickleback spawns chiefly in brackish or fresh water, if not exclusively there, for which purpose it enters the estuaries and the mouths of streams. The spawning time is probably the same in the Gulf of Maine (May to June) as in north European waters,<sup>66</sup> when the fish assume the nuptial dress described above, and the males fight fiercely. It is the male that builds the nest, selecting some sheltered spot in shoal water for his purpose, or some rock pool. Here he makes a barrel-shaped mass of bits of grass, weed, and other vegetation an inch or so in diameter, cementing it together with mucous threads, which he spins from his kidneys, and

<sup>63</sup> Large numbers are sometimes seined in winter in Scandinavian waters.

<sup>64</sup> Smitt (Scandinavian Fishes, vol. 2, 1895, pp. 653-656) and Regan (The fresh-water fishes of the British Isles, 1911, pp. 247-249) give accounts of the nest building on which the following is based.

<sup>65</sup> About Woods Hole it spawns from May until the last week. In July.

<sup>66</sup> Scandinavian fishes, vol. 2, 1895, p. 648.

weighting it down with pebbles. He then escorts one or a succession of females to this nest, and each of them deposits about 100 to 150 eggs in the central cavity. The male then enters the nest to fertilize the eggs, which stick in clumps to each other and to the nest. Incubation occupies 6 to 10 days, during which period the male guards the nest, driving away intruders large or small. He tears down the nest when hatching-time approaches, but he continues to guard the fry until these can shift for themselves. Many males die after spawning. Those that survive go back to sea in summer; the females, too.

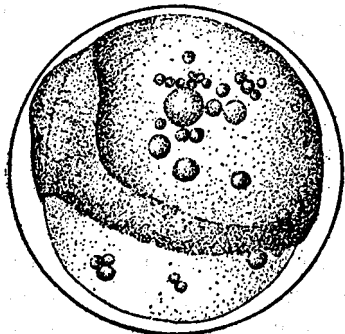


FIGURE 168.—Egg.

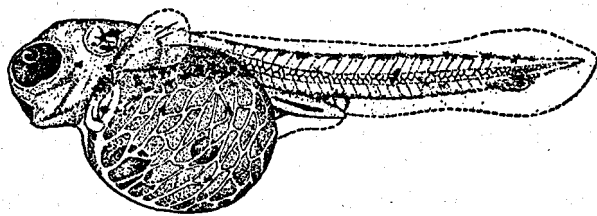


FIGURE 169.—Larva, newly hatched, 4.3 mm.

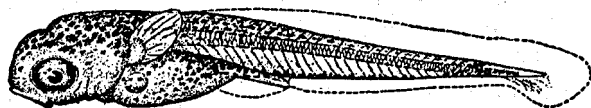


FIGURE 170.—Larva, 6.3 mm.

Three-spined stickleback (*Gasterosteus aculeatus*).  
After Kuntz and Radcliffe.

The young fish are 4.25 to 4.5 mm. long when hatched. The yolk sac is absorbed in three or four days; when a week old they are almost 8 mm. long; and the fry are of adult form with fins and spines fully formed when 6 weeks old, and 14 to 16 mm. long.<sup>67</sup> They are 1¼ to 2 inches (40-50

<sup>67</sup> Figures of stages in development of this fish are given by Kuntz and Radcliffe (Bull. U. S. Bur. Fish., vol. 35, 1918, p. 131); A. Agassiz (Proc. Amer. Acad. Arts Sci., vol. 17, 1882, p. 288, plate 9), and by Ehrenbaum (Nordisches Plankton, vol. I, 1905-1909, p. 319).

mm.) long when 2 years old, 2 to 2½ (50-55 mm.) at 3 years, according to European studies.

*General range.*—Coasts and fresh waters of the northern hemisphere; from Labrador, the Strait of Belle Isle and northern Newfoundland to lower Chesapeake Bay on the eastern coast of America and represented on the northwestern coast by a form (*Gasterosteus cataphractus* Pallas 1811) that probably is identical with the Atlantic species. Its European range is from northern Norway and Iceland to Spain, the Mediterranean, and the Black Sea.

*Occurrence in the Gulf of Maine.*—This stickleback is very plentiful all around the shores of the Gulf from Nova Scotia to Cape Cod, living indifferently in brackish water and in salt. The ditches and creeks of the tidal marshes, brackish ponds and lagoons, rock pools, and weedy shores in shallow water are its favorite habitats. It may be found practically anywhere in such places, often in great numbers and in company with other sticklebacks, for it is the commonest of its tribe in the Gulf, as it is about Woods Hole. And so many of them drift out to sea around the shores of the open Gulf that we have taken them on the eastern part of Georges Bank; over German Bank; in the western basin off Cape Cod; near the Isles of Shoals; off Seguin Island; and off Matinicus Island. In the Bay of Fundy, however, they are known only close to land and in the mouths of estuaries.

*Importance.*—This little fish is of no commercial value in America. In Scandinavia, however, it is sometimes seined in such quantities that it is worth boiling down for oil.

#### Two-spined stickleback *Gasterosteus wheatlandi* Putnam 1867<sup>68</sup>

Jordan and Evermann, 1896-1900, as *Gasterosteus gladiunculus* Kendall, p. 2836.

*Description.*—This stickleback is said to differ from the three-spined stickleback in having a deeper body, fewer fin rays (9 or 10 dorsal and 7 or 8 anal); fewer dermal plates (5 or 6 as against 28 to 33); a caudal peduncle without keels; and a strong cusp both above and below at the base of

<sup>68</sup> This is the *Gasterosteus blaculeatus* of Mitchill 1815 and Storer 1867; *biopinosis* of Walbaum 1792; *gladiunculus* of Kendall 1896, but not the *G. biopinosis* of Jordan and Evermann 1896, which is a variety of *G. aculeatus*. For the reason for using the specific name *wheatlandi*, see Hubbs, Occasional Papers, Museum of Zoology, University of Michigan, No. 200, 1925.

the ventral spine. Dr. Kendall writes<sup>69</sup> that careful examination of large series has convinced him that this is actually a distinct species, not a race of the extremely variable three-spined stickleback, although he saw one specimen apparently intermediate between the two.

*Color.*—Grass-green above in life, mottled and finely speckled with black on the top of the head and back; sides of head and body golden with dark blotches; breast silvery; ventral fins scarlet.

*Habits.*—Its mode of life is the same as that of the three-spined species so far as known, and sticklebacks of this type have been described as building nests with bits of straw on sandy bottom in New York waters,<sup>70</sup> but the two species or races have been confused so often that nothing more definite can be said of its habits.

*General range.*—Newfoundland to New York.

*Occurrence in the Gulf of Maine.*—Sticklebacks of this type are common in company with the three-spined sticklebacks in Passamaquoddy and St. Mary Bays<sup>71</sup> and in the Bay of Fundy. They may be expected anywhere on the Maine coast, being recorded at Winter Harbor; off Monhegan Island; off Seguin Island; from Casco Bay and its tributaries in both salt and brackish water; and from Kittery. They have also been taken at Swampscott, in Massachusetts Bay, and they are fairly common in summer at Woods Hole. We have taken them in our tow-nets, also, off Cape Porpoise; on Platts Bank; in the Western Basin of the Gulf of Maine; and on German Bank.

**Four-spined stickleback *Apeltes quadracus*  
(Mitchill) 1815**

**BLOODY STICKLEBACK**

Jordan and Evermann, 1896-1900, p. 752.

*Description.*—The four-spined stickleback has no bony plates in its scaleless skin, but it does have a bony ridge on each side of the abdomen, making it triangular in cross section, with flat belly and sharp back; this gives it an aspect very different from the other sticklebacks. It is fusiform in side view, tapering to the rather pointed nose and to the slim caudal peduncle. There are two to four free dorsal spines standing close one behind the other, inclining alternately to one side or the other, and another spine is attached to the dorsal fin by the fin membrane. The anal fin is similarly preceded by an attached spine, and each ventral fin is represented by a stouter curved spine, strongly saw-edged, followed by about two slender rays. The dorsal fin stands over the anal as in the nine-spined species, but both these fins are more rounded in outline, while the caudal fin is relatively longer and narrower than in any of our other sticklebacks.

*Color.*—Brownish olive or greenish brown above, with dark mottlings that alternate below the lateral line with the silvery white of the belly. The fin membrane of the ventrals is red. Males are much darker than females.

*Size.*—One and one-half to two and one-half inches long.

*Habits.*—This is a common little fish in the salt marshes, where it consorts with other sticklebacks and with mummichogs. Like the three-

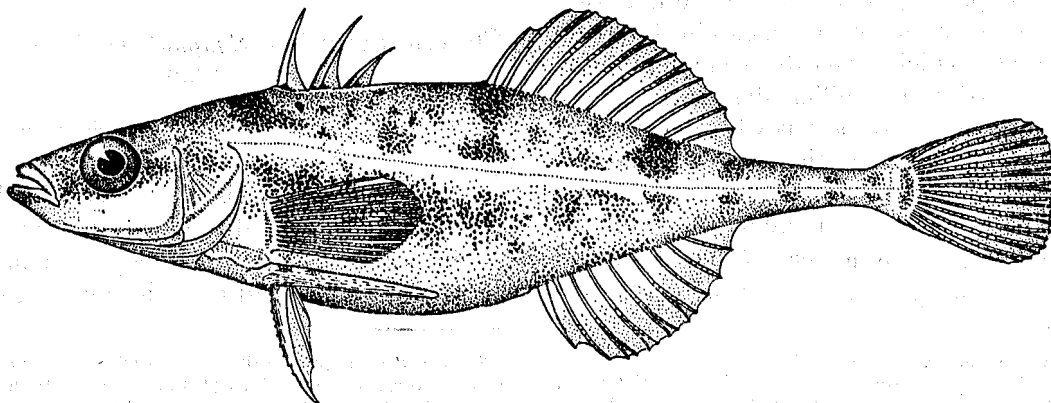


FIGURE 171.—Four-spined stickleback (*Apeltes quadracus*), Woods Hole. From Jordan and Evermann. Drawing by A. H. Baldwin.

<sup>69</sup> Proc. U. S. Nat. Mus., vol. 18, 1893, p. 624.

<sup>70</sup> Bean, Bull. 60, New York State Mus., Zool. 9, 1903, p. 341.

<sup>71</sup> Huntsman, Contrib. Canadian Biol. (1921) 1922, p. 61.

spined stickleback it often runs up into fresh-water, though it is primarily a salt and brackish water fish. And it is never found far in from the coast or out at sea.

In the Woods Hole region this stickleback spawns as early as May and as late as the last week of July, after which spent females are found; but the onset of spawning may be somewhat later in the cooler waters of the Gulf. The male builds a nest of plant fragments which it brings in its mouth, cemented with mucous threads that he spins out of a pore near his vent; a small rudimentary affair, however, compared with that of the three-spined stickleback, described by Ryder<sup>72</sup> as less than 1 inch in diameter, conical, with an opening at the top. Finally, the male stickleback picks up the eggs that have been laid by the female and deposits them in the hollow at the top of the nest, guarding them, presumably, during incubation. The eggs are yellow, approximately 1.66 mm. in diameter; they sink like those of the other sticklebacks and stick together in clumps. Incubation occupies six days or thereabouts at laboratory temperature (about 70°). Newly hatched larvae are about 4.5 mm. long and similar in appearance to those of the three-spined species but more densely pigmented.<sup>73</sup>

## THE PIPEFISHES. FAMILY SYNGNATHIDAE

The forward portion of the head has the form of a long tubular snout in the pipefishes, with the small mouth situated at its tip; the skin is armed with rings of bony plates; there is only one dorsal fin (soft-rayed), the body is very slender, and there are no ventrals. The snout recalls that of the trumpetfishes (p. 316), but pipefishes differ from them and from most other bony fishes in the structure of their gills, which form tufts of small rounded lobes, instead of the familiar filaments. Their general affinity in this respect is with the group of which the sticklebacks are the most familiar exponents. There are many species of pipefishes in warm seas, but only one inhabits the Gulf of Maine regularly, while a second has been recorded there—a stray from the south.

<sup>72</sup> Bull. U. S. Fish. Comm., vol. I, 1882, p. 24.

<sup>73</sup> The early development is described by Ryder (Bull. U. S. Fish Comm., vol. I, 1882, p. 24) and by Kuntz and Radcliffe (Bull. U. S. Bur. Fish., vol. 35, 1918, p. 132).

<sup>74</sup> Contrib. Canadian Biol. (1921) 1922, p. 61.

*General range.*—This is an American fish, known along the coast from the southern side of the Gulf of St. Lawrence and Nova Scotia to Virginia; at home both in salt water and in brackish, and running up into fresh water.

*Occurrence in the Gulf of Maine.*—This stickleback is common all around the shores of the Gulf on the Nova Scotian side as well as the New England side. We have taken it at Yarmouth; Huntsman<sup>74</sup> records it from St. Mary Bay and along the New Brunswick shore well within the Bay of Fundy (Maine has usually been given as its northern limit), and there are many locality records for the coasts of Maine and Massachusetts. But it is so much more closely restricted to estuarine situations than is its three-spined relative (p. 310) that we have never taken it in our tow nets nor do we find a single record of it in the open sea. On the south shore of New England it is a year-round resident. Probably this is equally true in the Gulf, where it may be expected to gather in the bottoms of the deeper creeks in winter, as it is known to do in Chesapeake Bay. It resembles the three-spined stickleback in its feeding habits so far as known (copepods and other small crustaceans being its chief diet) and in its general mode of life.

### KEY TO GULF OF MAINE PIPEFISHES

1. Dorsal fin with 35 to 41 rays; 18 to 20 bony plates in front of the vent and 36 to 42 behind it  
Common pipefish, p. 312
- Dorsal fin with 29 to 31 rays; 16 or 17 bony plates in front of the vent and 31 to 35 behind it  
Pelagic pipefish, p. 314

### Common pipefish *Syngnathus fuscus* Storer<sup>75</sup> 1839

Jordan and Evermann, 1896–1900, p. 770 as *Siphostoma fuscum* (Storer).

*Description.*—This is a very slender little fish, particularly so behind the vent, males being about 35 times as long as they are deep and females about 30 times. The head occupies one-eighth to one-

<sup>75</sup> This is the only pipefish that occurs regularly on our northern coasts. Jordan, Evermann, and Clark (Rept. U. S. Comm. Fish. [1928], 1930, Pt. 2, p. 242) refer it to the genus *Syrristes* Jordan and Evermann, 1927. For a synopsis of the various other species of the genus see Jordan and Evermann, Bull. 47, U. S. Nat. Mus., Pt. 1, 1896, p. 961.

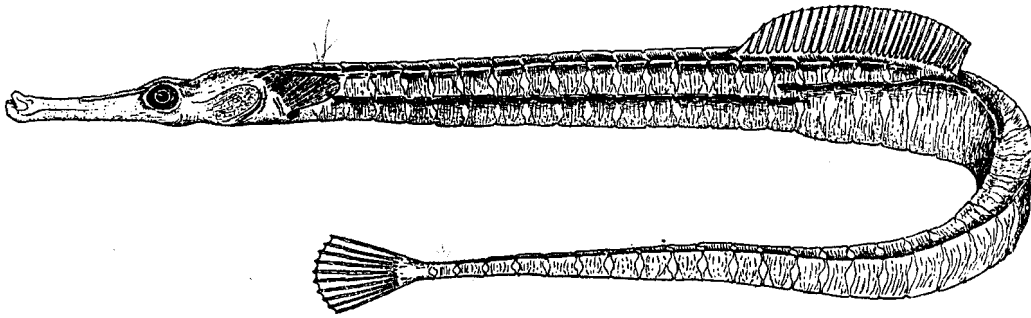


FIGURE 172.—Pipefish (*Syngnathus fuscus*). After Bigelow and Welsh.

ninth of the total length (in the trumpetfish it is nearly one-third); the snout is tubelike, blunt ended, with the small toothless mouth at its tip. The gill openings are very small. The body is hexagonal in cross section in front of the vent but is four-sided behind the dorsal fin and it is clothed in an armor of bony plates connected in rings, of which there are 18 to 20 in front of the vent and 36 to 42 behind the latter. The abdomen of the male is wider just back of the vent than elsewhere, with two lateral flaps that meet along the midline to form the so-called "marsupial" or brood pouch. The female lacks these. The dorsal fin (35 to 41 rays and 5 or 6 times as long as it is high) covers 4 or 5 of the bony rings in front of the vent and as many behind it. The caudal fin is rounded, its middle rays the longest. The anal is very small, close behind the vent; the pectorals are of moderate size; there are no ventral fins.

*Color*.—Greenish, brownish, or olive above, cross-banded and mottled with darker. The lower parts of the gill covers are silvery. The lower parts of the sides are sprinkled with many tiny white dots, and the longitudinal angles separating sides from abdomen are marked by longitudinal brown bars. The lower surface is colorless on the snout, but pale to golden yellow thence back to the vent, with the marsupial flaps flesh-colored. The dorsal and pectoral fins are pale, but the caudal is brown.<sup>76</sup> Pipefishes change color according to the color of their surroundings. We have seen them of various shades of olive and brown; and red ones have been described.

*Size*.—Usually 4 to 8 inches long; occasionally up to 12 inches.

*Habits*.—The chief home of this pipefish is among eelgrass or seaweeds, both in salt marshes,

harbors, and river mouths, where it often goes up into brackish water, and on more open shores as well. In such locations it is caught as often today by boys dipping up mummichogs for bait as it was when Storer wrote of it, nearly a century ago. The pipefish, like the three-spined stickleback, sometimes strays out to sea on the surface, and while we have never taken it in our tow nets, Kendall<sup>77</sup> has often found it under floating rockweed along the Maine coast. But they are so seldom taken at any distance out from the land that the capture of four specimens at a depth of 19 fathoms south of No Mans Land, February 5, 1930, is of present interest, though outside the limits of our Gulf. There is no reason to suppose pipefish are at all migratory, for they are resident in the eelgrass (*Zostera*) at Woods Hole throughout the year.

They usually propel themselves by the dorsal fin, but they can travel swiftly when alarmed, with eel-like strokes of the tail from side to side. And they are able to roll their eyeballs separately, an interesting habit described many years ago by Lyman.<sup>78</sup>

They feed chiefly on minute Crustacea (copepods especially and amphipods), also to some extent on fish eggs, on very small fish fry, and no doubt indiscriminately for that matter on any small marine animals. And their snouts are so distensible that they can swallow larger prey than one might expect. In capturing its prey, the pipefish has been described as expelling the water from the snout and pharynx by muscular action, depending on the return rush to sweep in its victims. Pipefishes have few enemies so far as known.

<sup>76</sup> Colors based on Storer's (*Fishes of Massachusetts*, 1867, p. 412) account and on the specimens we have examined.

<sup>77</sup> Bull. U. S. Fish Comm., vol. 18, 1896, p. 623.

<sup>78</sup> Proc. Boston Soc. Nat. Hist., vol. 7, 1861, pp. 75-76.

*Breeding.*<sup>79</sup>—On the southern shores of New England pipefish breed from March to August; probably through this same period on the shores of the Gulf of Maine. Male pipefishes nurse the eggs in the brood pouch (p. 313), the flaps of which ordinarily lie flat but are swollen and have their edges cemented together during the breeding season. The protruding oviduct of the female is inserted into the opening of the pouch of the male and a dozen or more eggs are passed over. This occurs several times in succession, with intervals of rest, until the pouch is filled, the male working the eggs down toward the rear end of his pouch by body contortions. Fertilization is supposed to take place during the transference of the eggs from one parent to the other. The eggs become embedded in the lining of the brood pouch, and it has been established for the European pipefish (probably this applies equally to our North American species) that the embryos within the eggs are nourished by the epithelial lining layer of the pouch, so that the latter functions as a placenta.<sup>80</sup>

Incubation occupies about 10 days, according to Gudger, and the young are retained in the brood pouch until they are 8 or 9 mm. long, when the yolk sac has been absorbed. The young pipefish are then ready for independent existence, and once they leave the pouch they never return to it, as young sea horses (*Hippocampus*) are said to do (p. 315). Several observers agree on this, among them Miss Marie Poland (now Mrs. C. J. Fish), who kept pipefish under observation at the laboratory of the United States Bureau of Fisheries at Woods Hole during the summer of 1922.

Pipefish fry kept in aquaria have been found to grow from about  $\frac{3}{8}$ -inch (10 mm.) to about  $2\frac{1}{4}$ -inches (70 mm.) in length within about 2 months after hatching.<sup>81</sup> It is probable that they mature when about 1 year old.

*General range.*—Coast of eastern North America, in salt and brackish water, from the southern side

of the Gulf of St. Lawrence<sup>82</sup> and outer Nova Scotia at Halifax, to South Carolina.<sup>83</sup>

*Occurrence in the Gulf of Maine.*—The pipefish has been recorded from so many localities along Maine and Massachusetts that it is evidently to be expected anywhere there, in suitable situations; it is not uncommon in the Bay of Fundy; it has been reported from outer Nova Scotian waters and is common locally in the southern side of the Gulf of St. Lawrence, as noted in the preceding paragraph. It is probable also that they breed in every favorable locality all around the shores of the Gulf, but there are local differences in this respect, for while St. Mary Bay, Annapolis Basin, and Cobequid Bay, on the Nova Scotian shore of the Bay of Fundy, are breeding centers according to Huntsman, large specimens alone are known about Passamaquoddy Bay on the New Brunswick side. No doubt the estuarine waters from the Massachusetts Bay region to Penobscot Bay are favorable nurseries.

*Importance.*—The pipefish is of no commercial importance.

#### **Pelagic pipefish *Syngnathus pelagicus* Linnaeus 1758**

Jordan and Evermann, *Siphostoma pelagicum* (Osbeck), 1896-1900, p. 767.

*Description.*—Most of the species of pipefishes resemble one another so closely that they can be named only by critical examination. The pelagic pipefish differs from its common shore relative of New England (*S. fuscus*) by having fewer dorsal rays (29 to 31) and fewer rings of bony plates, of which only 16 or 17 are in front of the vent, and 31 to 35 behind the vent.

*General range.*—Tropical Atlantic, northward with the Gulf Stream; also the Mediterranean, and the Southern Pacific and Tropical Indian Oceans.

*Occurrence in the Gulf of Maine.*—A single specimen,  $3\frac{1}{2}$  inches (89 mm.) long, taken on Georges Bank (Lat.  $42^{\circ} 09' N.$ ; Long.  $66^{\circ} 41' W.$ ), September 20, 1927, by the *Albatross II* is the only Gulf of Maine record. This specimen was dipped up with a mass of gulf weed (*Sargassum*), and was the only one found in a large amount of weed that was examined.

<sup>79</sup> For a historical survey and a general account of the breeding of the closely allied *Siphostoma floridae* see Gudger (Proc. U. S. Nat. Mus., vol. 29, 1906, pp. 447-500, pls. 5-11).

<sup>80</sup> For detailed (if somewhat divergent) accounts of this interesting phenomenon see Huot (Annales des Sciences Naturelles, Ser. 8, Zoologie, vol. 14, 1902, pp. 197-288) and Cohn (Anatomischer Anzeiger, Centralblatt für die gesamte wissenschaftliche Anatomie, vol. 24, 1904, pp. 192-199).

<sup>81</sup> Tracy, 40th Rept., Rhode Island Comm. Inland Fish., 1910, p. 93.

<sup>82</sup> Leim (Proc. Nova Scotian Inst. Sci., vol. 20, 1940, p. 38) found them common at Prince Edward Island.

<sup>83</sup> There is a specimen from Charleston, S. C., in the Museum of Comparative Zoology.

## THE SEA HORSES. FAMILY HIPPOCAMPIDAE

Sea horse *Hippocampus hudsonius* DeKay 1842

Jordan and Evermann, 1896-1900, p. 777.

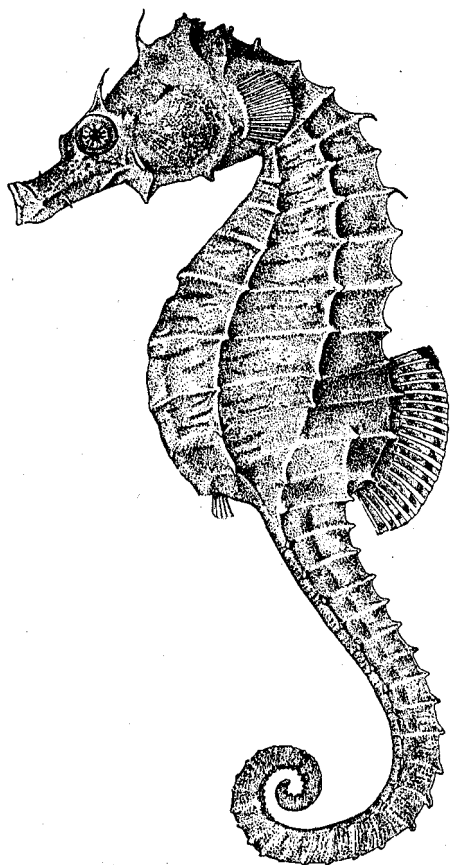


FIGURE 173.—Sea-horse (*Hippocampus hudsonius*), Virginia.  
From Goode. Drawing by H. L. Todd.

*Description.*—The sea horse grotesquely resembles the “knight” in an ordinary set of wooden chessmen in its sidewise flattened body, in its deep convex belly, in its curved neck and in its curious horse-like head carried at right angles to the general axis of the body. The head is surmounted by a pentagonal star-shaped “coronet,” and the snout is tubular with the small oblique mouth at its tip, like that of its relative the pipefish. It has a sharp spine on each side above the eye and one behind it, a third over the gill cover, and a fourth on the side of the throat, which sometimes terminate in short fleshy filaments; also a blunt horn between the nostrils. Its neck, body, and tail are covered with rings of bony plates, 12 rings on the trunk, 32 to 35 on the tail, and each body ring is armed with four

blunt spines. The body tapers suddenly behind the anal fin to a long tail, which is four-cornered in cross section, curled inward, and strongly prehensile. In the male the lower surface of the fore part of the tail bears the brood pouch, opening by a slit in front. The dorsal fin (about 19 rays) originates about midway of the length of the fish, opposite the vent, and runs backward over three and one-half rings to within half a ring of the commencement of the tail sector of the trunk. The very small anal fin stands opposite the rear part of the dorsal fin. The pectorals are of moderate size, broad based and round tipped; it has no ventral fins and no caudal fin.

*Color.*—Light brown or dusky to ashen gray or yellow, variously mottled and blotched with paler and darker, sometimes spangled with silver dots, sometimes plain colored. European sea horses change color according to their surroundings, tints of red, yellow, brown, and white all being within their capabilities, and it is probable that the American species is equally adaptable.

*Size.*—Adults usually are 3 to 6 inches long; one of 7¼ inches is the largest on record.<sup>84</sup>

*Habits.*—Sea horses dwell chiefly among eel-grass and seaweed,<sup>85</sup> where they cling with their prehensile tails, monkeylike, to some stalk. They usually swim in a vertical position by undulations of the dorsal fin, not with the tail, the trunk being too stiff for much sidewise motion.

Sea horses feed on minute Crustacea and on various larvae, in fact on any animal small enough, sucking in their prey as the pipefish does (p. 313.)

They breed in summer<sup>86</sup> and the breeding habits resemble those of the pipefish, the male nursing the eggs in his brood pouch where they are deposited a few at a time by the female in repeated pairings. The young, of which there may be as many as 150, are about 10 to 12 mm. long at hatching. When the yolk sac is absorbed the father squeezes them out of the brood sac, and they already resemble the adult in general appearance within a few days after they are set free. According to some students they swim out and in at will, but this calls for verification.

<sup>84</sup> Bull. New York Zool. Soc., vol. 16, 1913, p. 972.

<sup>85</sup> Gill (Proc. U. S. Nat. Mus., vol. 28, 1905, pp. 805-814) has given an excellent account of the habits and life history of the sea horse.

<sup>86</sup> Ryder (Bull. U. S. Fish Comm., vol. 1, 1882, pp. 191-199) describes its development.

*General range.*—Atlantic Coast of North America, occurring regularly from South Carolina to Cape Cod, and to Nova Scotia as a stray.

*Occurrence in the Gulf of Maine.*—The sea horse is not common much beyond New York. Only a few are found each year about Woods Hole, chiefly in July, August, and September, and they so rarely stray past the elbow of Cape Cod that we have found only one definite (Provincetown) and one dubious (Massachusetts Bay) record of its capture

in the inner parts of the Gulf of Maine, dead or alive; and one record for Georges Bank. Three specimens of the sea horse were also reported from Nova Scotia more than  $\frac{3}{4}$  of a century ago;<sup>87</sup> and Vladykov and McKenzie have reported one, picked up in Terrance Bay, on the outer Nova Scotian coast, Sept. 18, 1934, by V. Slaunwhite.<sup>88</sup>

*Commercial importance.*—The sea horse is of no commercial value, but it is an object of constant interest to visitors to marine aquaria.

### THE TRUMPETFISHES. FAMILY FISTULARIIDAE

The trumpetfishes are characterized by their slender bodies and tremendously long heads, as well as by the fact that the anterior bones of the skull are prolonged in a very long tube with the small mouth at its tip. The only other Gulf of Maine species with which they could possibly be confused is the pipefish (p. 312). In the latter, however, the tubular snout occupies only about one-eighteenth of the length of the fish whereas in trumpetfishes it is nearly one-fourth. Furthermore, the pipefishes lack ventral fins which the trumpetfishes have, while the caudal fin of the trumpetfishes is forked, but that of the pipefishes is rounded.

#### Trumpetfish *Fistularia tabacaria* Linnaeus 1758

##### CORNETFISH

Jordan and Evermann, 1896-1900, p. 757.

*Description.*—The slender body and very long tubular snout of this fish are mentioned above. The body (to base of caudal fin) is about 30 to 35 times as long as it is deep and only about two-thirds as deep as it is thick. The head occupies almost one-third and the snout about one-fourth of the body length. The bones of the snout are so loosely united that the snout is very distensible.

The mouth is small, situated somewhat obliquely at the tip of the snout, and the lower jaw projects a little beyond the upper. The caudal fin is deeply forked and its middle rays are prolonged in a filament about as long as the snout, but which is likely to be broken off. Both the dorsal and the anal fins are triangular, higher than long, the former standing exactly above the latter, about three-fourths of the distance back from eye toward base of caudal fin. The ventrals are very small, and are considerably nearer to the eye than to the rear end of the body (about one-third of the way from eye toward the base of caudal fin). The skin is without scales but with a row of embedded bony plates or shields along either side, conspicuous rearward.

*Color.*—Greenish brown above, the back and sides marked with many large, oblong, pale blue spots and with about 10 dark cross bars; the lower surface is pale and silvery; the caudal filament deep blue.

*Size.*—Said to reach a length of 6 feet, but the few specimens that stray northward are much smaller.

*General range.*—Tropical, southward to middle Brazil, and common among the West Indies; rarely

<sup>87</sup> By Knight (Catal. Fishes Nova Scotia, 1866, p. 9), as *H. bresirostris* Storer (1839); later by Jones, (Proc. Nova Scotian Inst. Sci., vol. 5, Part 1, 1882, p. 95) as *H. antiquorum* Leach 1814.

<sup>88</sup> Proc. Nova Scotian Inst. Sci., vol. 19, 1935, p. 5.

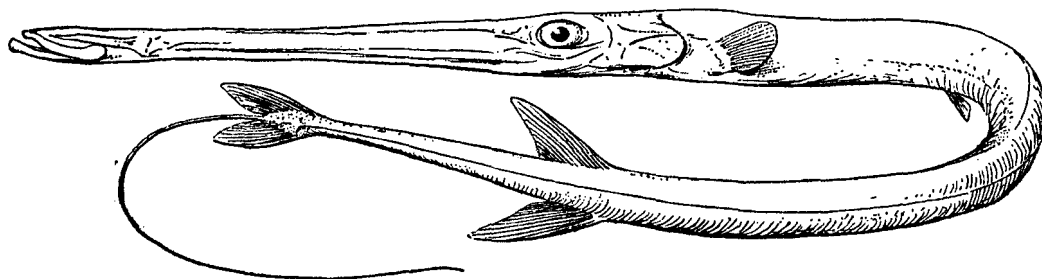


FIGURE 174.—Trumpetfish (*Fistularia tabacaria*), from near Woods Hole. After Storer.



wandering northward as far as the Massachusetts Bay region, and straying to Nova Scotia.<sup>89</sup>

*Occurrence in the Gulf of Maine.*—There are only two records of the trumpetfish from the Gulf of Maine: a specimen taken at Rockport, Mass. (north side of Cape Ann) in September 1865, preserved in the collection of the Essex Institute,

where it was examined and identified by Goode and Bean<sup>90</sup> and a second taken on the northern edge of Georges Bank by the trawler *Flying Cloud* on October 6, 1947, in a haul at 70 fathoms.<sup>91</sup> Like other tropical fishes, however, it is not so rare west of Cape Cod, and a few small ones are taken at Woods Hole almost every year.

### THE MACKERELS. FAMILY SCOMBRIDAE

The mackerels are a very homogeneous group, all of them agreeing in having a spiny dorsal as well as a soft dorsal fin, several small finlets behind the latter and behind the anal, a very slender caudal peduncle, a deeply forked or lunate caudal fin, a very shapely form tapering both to snout and to tail, and velvety skin with very small scales. All, too, are predaceous, swift

swimmers, and powerfully muscled, while all are fish of the open sea and more or less migratory.

In the following key we mention all species so far actually recorded from within the limits of the Gulf of Maine, but it would not be astonishing if still others were to stray in from the open Atlantic from time to time.<sup>92</sup>

### KEY TO GULF OF MAINE MACKERELS<sup>93</sup>

1. The two dorsal fins are separated by a space at least as long as the length of the first dorsal..... 2  
The two dorsal fins adjoin each other or are separated by a space much shorter than the length of the first dorsal... 3
2. The sides below the mid line are silvery, not spotted..... Mackerel, p. 188, 317  
The sides below the mid line are mottled with dusky blotches..... Chub Mackerel, p. 209, 333
3. Body scaleless, except along the lateral line and in the region of the shoulders (the so-called "corselet")..... 4  
Entire body covered with scales..... 5
4. The lower part of the sides, below the lateral line, is marked with dark longitudinal bands, but there are no definite dark markings on the back..... Striped Bonito, p. 335  
There are no dark markings on the lower side below the lateral line, but the back has dark markings  
False Albacore, p. 336
5. The anal fin is about twice as high as long; the corselet of large scales is obvious..... Tuna, p. 338  
The anal fin only is about as high as long; there is no corselet of large scales..... 6
6. Second dorsal fin noticeably lower than the first dorsal..... Common Bonito, p. 337  
Second dorsal fin at least as high as first dorsal..... 7
7. Lateral line with an abrupt downward curve under second dorsal fin..... Cavalla p. 349  
Lateral line descending gradually..... 8
8. Sides with a few rows of oval bronze or yellowish spots and with one or two longitudinal dark streaks  
King Mackerel p. 348  
Sides with bronze spots but without longitudinal dark streaks..... Spanish Mackerel p. 347

### Mackerel *Scomber scombrus* Linnaeus 1758

Jordan and Evermann, 1896-1900, p. 866

*Description.*—The mackerel is fusiform in outline, tapering rearward to a very slim caudal peduncle and forward to a pointed nose. Its body is about four and one-half to five and one-half times as long as it is deep, oval in section, thick and firm-muscled as are all its tribe. Its head is long (one-fourth of length to caudal) and its mouth large, gaping back to the middle of the eye (the premaxillaries are not protractile), while the jaws,

which are of equal length, are armed with small, sharp, slender teeth. The eye is large, and the hollows in front of and behind it are filled with the so-called "adipose eyelid," a transparent,

<sup>89</sup> Bull. Essex Inst., vol. XI, 1879, p. 4.

<sup>90</sup> This specimen is in the Museum of Comparative Zoology.

<sup>91</sup> Fraser-Brunner, Ann. Mag. Nat. Hist. Ser. 12, vol. 3, No. 26, 1950, pp. 131-163, has recently given a synopsis of the mackerels, with useful keys and excellent illustrations for all known species. We follow him in uniting them all in the old and inclusive family Scombridae rather than Jordan, Evermann and Clark (Rept. U. S. Comm. Fish. (1928) Pt. 2, 1930) who have distributed them among four families, Cybiidae, Katsuwonidae, Scombridae, and Thunnidae.

<sup>92</sup> The long finned Albacore (*Thunnus alalunga* Bonnaterre, 1788) has been taken at Woods Hole, also on Banquereau Bank, off eastern Nova Scotia (Goode and Bean, Bull. Essex Inst., vol. XI, 1879, p. 15), so is likely to show up in the Gulf of Maine sooner or later. It is made easily recognizable among North Atlantic mackerel fishes by its very long pectoral fins which reach back past its second dorsal fin.

<sup>93</sup> Dr. A. H. Leim reports the capture of a specimen at Port Mouton, Nova Scotia, on September 10, 1931; the specimen was recorded later by Vladykov (Proc. Nova Scotian Inst. Sci., vol. 10, 1935, p. 5) as *Fistularia serrata*.

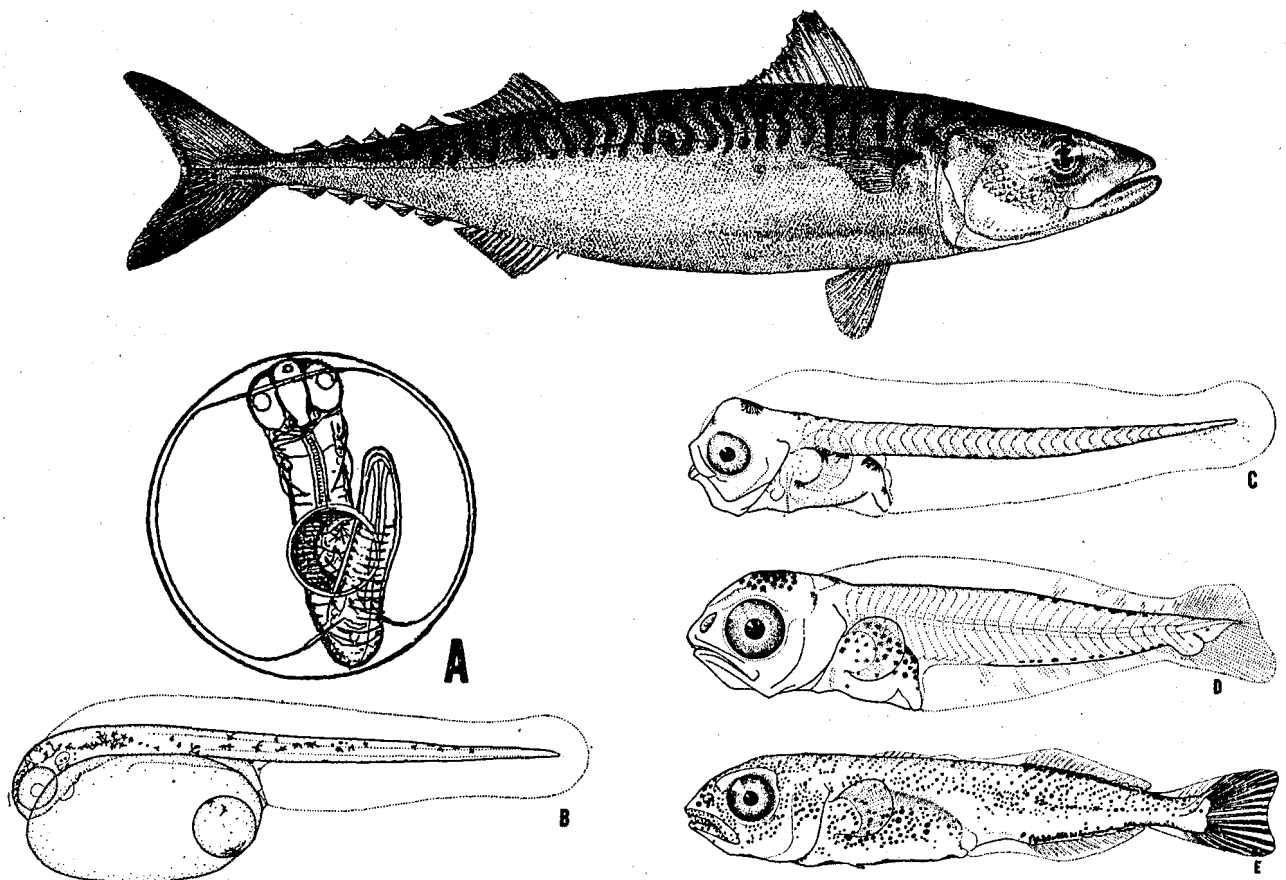


FIGURE 175.—Mackerel (*Scomber scombrus*). A, egg (European), after Holt; B, larva, 3.5 mm.; C, larva, 4.6 mm.; D, larva, 7.8 mm.; E, larva, 15 mm.; B-E, drawings by Luella E. Cable.

gelatinous mass in the form of two scales, a forward and a hinder, which cover the eye except for a perpendicular slit over the pupil.

There are two large dorsal fins: the first originating over the middle of the pectoral fins when the latter are laid back is triangular, of 10 to 14 (usually 11, 12, or 13) rather weak spines that can be laid down along the midline of the back in a deep groove; the second dorsal, separated from the first by an interspace longer than the length of the latter, is smaller (9 to 15 rays, usually 12) and is followed by several small finlets, of which there are usually 5, but sometimes 4 or 6. The anal fin is similar to the second dorsal in shape and size, originates slightly behind it, and is similarly succeeded by 5 small finlets that correspond to the dorsal finlets in size and shape. The caudal fin is broad, but short and deeply forked. The caudal peduncle bears two small longitudinal keels on either side but no median lateral keel, the absence of the latter being a distinctive character. The

ventral fins stand below the origin of the first dorsal and are small, as are the pectorals. The scales of the mackerel are so small that its skin feels velvety to the touch; indeed they are hardly to be seen on the belly with the naked eye, but those about the pectoral fins and on the shoulders are somewhat larger.

*Color*.—The upper surface is dark steely to greenish blue, often almost blue-black on the head. The body is barred with 23 to 33 (usually 27 to 30) dark transverse bands<sup>94</sup> that run down in an irregular wavy course nearly to the mid-level of the body, below which there is a narrow dark streak running along each side from pectoral to tail fin. The pectorals are black or dusky at the base, the dorsals and caudal are gray or dusky. The jaws and gill covers are silvery. The lower parts of the sides are white with silvery, coppery, or brassy reflections and iridescence; the belly silvery white.

<sup>94</sup> Hunt (Copela, No. 117, pp. 53-59, April, 1923) describes the variations in these stripes among young mackerel.

But the iridescent colors fade so rapidly after death that a dead fish gives little idea of the brilliance of a living one.

*Size.*—Most of the grown fish are between 14 and 18 inches long; a few reach a length close to 22 inches. Fourteen-inch fish weigh about 1 pound in the spring and about 1½ pounds in the fall when they are fat; 18-inch fish weigh about 2 to 2½ pounds; a 22-inch mackerel will likely weigh 4 pounds. An unusually large mackerel is taken occasionally; in 1925, for example, the schooner *Henrietta* brought in one weighing 7½ pounds.

*Habits.*—Mackerel are a swift-moving fish, swimming with very short sidewise movements of the rear part of the body and of the powerful caudal fin. When caught they beat a rapid tattoo with their tails on the bottom of the boat until exhausted. And they require so much oxygen for their vital processes that when the water is warm (hence its oxygen content low) they must keep swimming constantly, to bring sufficient flow of water to their gill filaments, or else they die.<sup>95</sup>

Despite their great activity, they do not leap above the surface, as various others of their tribe do, unless perhaps to escape some larger fish.

The mackerel, like the herring, has the habit of gathering in dense schools of many thousands. It is not known how long these schools hold together; it would be especially interesting to know whether they do so through the winter when our mackerel are in deep water, but the general opinion of fishermen is that they do so throughout the migrations at least. Although the mackerel may scatter and the schools mix more or less, especially when they are feeding on the larger and more active members of the free-floating fauna as is said to happen in British waters, the members of any given school usually are all of about the same size, i. e., of the same age. Fish of the year almost always school separately from the others as Sette<sup>96</sup> has pointed out; he has also pointed out that this tendency of the fish to separate according to size is probably due to the fact that the larger ones swim faster than the smaller ones.

Mackerel school by themselves, as a rule. But sometimes they are found mingled with herring, alewives, or shad, as Kendall<sup>97</sup> described. We

have yet to learn how mackerel schools hold together, whether by sight or by some other sense. And various explanations have been proposed to account for the schooling habit, such as that it is advantageous for feeding, that it is a concomitant of spawning (this would not explain its persistence out of the spawning season, however, or the fact that any given school is apt to contain green, and spent as well as ripe fish even at spawning time), or that it affords protection from enemies. But when all is said, the instinct prompting it remains a mystery. At any rate, schooling is not a necessity, though usual. When mackerel are at all plentiful, and even when they are not, numbers of single wandering fish are often hooked by persons trolling for them, and by flounder and cunner fishermen.

Schools of mackerel are often seen at the surface. In the daytime they can be recognized by the appearance of the ripple they make, for this is less compact than that made either by herring or by menhaden. Neither do mackerel ordinarily "fin" or raise their noses above the surface, as is the common habit of the menhaden (p. 114). An observer at masthead height can perhaps see a school of mackerel as deep as 8 to 10 fathoms by day, if the water is calm, and the sun behind him. On dark nights the schools are likely to be betrayed by the "firing" of the water, caused by the luminescence of the tiny organisms that they disturb in their progress. Sette<sup>98</sup> reports one case of a school recognized by its firing as deep as 25 fathoms; but the water is seldom (if ever) clear enough in the Gulf of Maine for a submerged light to be visible from above, more than 15 fathoms down.<sup>99</sup> The trail of bluish light left behind by individual fish as they dart to one side or the other, while one rows or sails through a school on a moonless, overcast night when the water is firing, is the most beautiful spectacle that our coastal waters afford, and one with which every mackerel fisherman is familiar.

No one knows how greatly the movements of the mackerel, from day to day, result from involuntary drifting with the circulatory movements of the water, which are different at different depths, and how greatly they depend on the directive swimming of the mackerel themselves. Our only

<sup>95</sup> This interesting fact seems first to have been reported by Hall (Amer. Jour. Physiol., vol. 93, 1930, pp. 417-421), and we have observed the same thing in the aquaria at the Woods Hole Oceanographic Institution.

<sup>96</sup> Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 264.

<sup>97</sup> Bull. U. S. Bur. Fish., vol. 28, 1910, Pt. I, p. 287.

<sup>98</sup> Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 267.

<sup>99</sup> For observations on the visual transparency of the water of our Gulf, see Bigelow, Bull. U. S. Bur. Fish., vol. 40, Pt. 2, 1927, p. 822.

contribution in this regard is that we once were able to follow on foot beside a school that was advancing along the Scituate shore at a rate of about 3 to 4 miles an hour, against a tidal current of about one-half knot, until the fish swung offshore and out of our sight.

The speed at which a school travels when it is not disturbed depends, it seems, on the size of the fish of which it is composed. It has been observed by Sette that mackerel less than one year old swim at about 6 sea miles per hour (10 ft. a second) while circling inside a live car; yearlings at a rate of about  $11\frac{1}{2}$  sea miles per hour (19 ft. a second), or nearly twice as fast. We find no definite observations on the normal speed of the larger fish, and no one knows how rapidly a mackerel may swim for a short distance, if it is disturbed. Mackerel seen during the warmer months of the year are always swimming, but this rule may not apply in winter, when the water holds more dissolved oxygen because colder, and when it is probable that their demand upon it is lower.

The mackerel is a fish of the open sea; while numbers of them, small ones especially, often enter estuaries and harbors in search of food, they never run up into fresh water. Neither are they directly dependent either on the coastline or on the bottom in any way at any stage in their lives. They are often encountered far out over the outer part of the shelf of the continent. But they are most numerous within the inner half of the continental shelf during the fishing season, and their normal range seems not to extend oceanward beyond the upper part of the continental slope, in which they contrast with their relatives the tunas, the bonitos, and the albacores.

The depth-range of the mackerel is from the surface down to perhaps 100 fathoms at one season or another. (We recur to this in discussing the occurrence of mackerel in the Gulf of Maine, page 325.) From spring through summer and well into the autumn, the mackerel are in the upper water layers; shoaler, mostly, than some 25 to 30 fathoms, and schools of all sizes come to the surface more or less frequently then. But they frequently disappear from the surface, often for considerable periods. And it seems, from fishermen's reports, that the larger sizes tend to swim deeper than the smaller ones, on the whole, especially in mid and

late summer.<sup>1</sup> It is probable, also, that their vertical movements during the warmer part of the year, when they are feeding actively, are governed chiefly by the level at which food is most abundant, which for the most part is shoaler than about 50 fathoms, at least on our side of the Atlantic.

The highest temperature in which mackerel are commonly seen is about 68° F. (20° C.). At the opposite extreme they are sometimes found in abundance in water of 46°–47° (8° C.); and commercial catches are sometimes made in water as cold as 44°–45° (7° C.), but odd mackerel only have been taken in temperatures lower than that<sup>2</sup> in American waters. Large catches of mackerel are made, however, by trawlers in the North Sea in winter in water as cold as 43°–45° (6°–7° C.). But as Sette has emphasized, the European mackerel differs racially from the American, and may differ in its temperature relations as well.

*Food.*—We may assume that the diet of the young mackerel is at first much the same in the Gulf of Maine as it is in the English Channel,<sup>3</sup> namely, copepod larvae and eggs, the smaller adult copepods, various other minute pelagic Crustacea, and small fish larvae. But the young fish depend more and more upon larger prey as they grow. Our Gulf of Maine mackerel have repeatedly been seen packed full of *Calanus*, the "red feed" or "cayenne" of fishermen, as well as with other copepods (we have examined many in this condition). They also feed greedily, as do herring, on euphausiid shrimps (p. 89), especially in the northeastern part of the Gulf where these crustaceans come to the surface in abundance. Various other planktonic animals also enter regularly into the dietary of the mackerel. Thus, Doctor Kendall writes in his field notes that some of the fish caught on the northern part of Georges Bank in August 1896, were packed with crab larvae, others were full of *Sagittae*, others, again, of *Sagittae* and amphipods (*Euthemisto*), of small copepods (*Temora*), or of red feed (*Calanus*), so that even fish from the same school had selected the various members of the drifting community in varying proportion.

<sup>1</sup> See Sette, Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 267, for further discussion of this point.

<sup>2</sup> Sette (Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 257) mentions one winter record from about 40° (4.5° C.) on Georges Bank.

<sup>3</sup> Lebour (Jour. Mar. Biol. Assoc. United Kingdom, vol. 12, N. Ser., No. 2, 1920, p. 305) gives diet lists for 90 larval mackerel ranging from 5 mm. to 13.5 mm. in length, taken in the English Channel.

Similarly, 1,000 mackerel caught near Woods Hole from June to August contained pelagic amphipods (*Euthemisto*), copepods, squid, and lance;<sup>4</sup> others taken off No Man's Land have been found full of shelled pteropods (*Limacina*). And a series of small fish examined by Vinal upwards contained copepods, shrimps, crustacean and molluscan larvae, annelid worms, appendicularians, squid, fish eggs, and fish fry such as herring, silversides, and lance. In short, practically all the floating animals, not too large or too small, regularly serve for the nourishment of mackerel except the Medusae and ctenophores, and a diet list for any given locality would include all the local pelagic Crustacea and their larvae.

Mackerel have often been seen to bite the tentacles out of large Medusae, but, as Nilsson suggests, they probably do this for the amphipods (*Hyperia*) that live commensal within the cavities of the jellyfish, not for the sake of the latter.

Mackerel also eat all kinds of small fish, to a greater or less extent according to circumstances. In the Gulf of Maine they devour large numbers of small herring, lance, and even smaller mackerel. They likewise feed on pelagic fish eggs when available, oftenest on those of their own species. And they bite greedily on almost any bait, especially if it moves, such as a bit of mackerel belly skin, a piece of clam, a piece of sea worm (*Vereis*), a shining jig, spoon or spinner of appropriate size, or an artificial fly, white, red, or silver-bodied. Side by side with these comparatively large objects mackerel are also known to take various microscopic organisms, chiefly the common peridinians and diatoms, but they never feed extensively on these as menhaden do (p. 114). And copepods are so plentiful in the Gulf of Maine, and the vegetable plankton that swarms in April has so largely disappeared over most of the Gulf before the mackerel appear later in the spring, that we doubt if they are ever reduced to a vegetable diet there or anywhere in American waters.

Mackerel are also known to feed on bottom animals to a small extent. Nilsson, for example, reports various worms and hydroids and even small stones from their stomachs, but our experience in the Gulf of Maine is to the effect that this would be exceptional there, if it happens at all.

Most authors describe the mackerel as feeding by two methods: either by filtering out the smaller pelagic organisms from the water by their gill rakers<sup>5</sup> or by selecting the individual animals by sight. A good deal of discussion has centered about the relative serviceability of these two methods of feeding. Probably the truth is that when forced to subsist on the smaller objects in its dietary it must do so by sifting them out of the water, but that it selects the more desirable whenever opportunity offers to exercise its sight. It is not yet known how small objects the fish is able to pick out. It takes fish individually of course, and such large Crustacea as euphausiid shrimps and amphipods, just as the herring does, which evidently applies to the larger copepods, to judge from the fact that mackerel stomachs are often full of *Calanus* or of one or two other sorts in localities where indiscriminate feeding would yield them a variety. Whether they select the smaller copepods and crustacean larvae is not so clear. Captain Damant,<sup>6</sup> whose experience in deep-sea diving has given him an exceptional opportunity to observe mackerel feeding under natural conditions, describes fish among which he was at work 20 to 40 feet deep in Lough Swilly (Ireland), as "feeding on plankton, not by steadily pumping the water through the gill filters but snatching gulps from different directions and making little jumps here and there."

It has been a commonplace from the earliest days of the mackerel fishery that the fish are fat when last seen in the autumn, but that most of them are thin when they reappear in spring, obviously suggesting that they feed little during the winter. This is corroborated by the fact that the mackerel taken on bottom by British and French trawlers between December and March usually are empty, and that a few mackerel taken by the *Albatross II* along the continental edge off Chesapeake Bay in February 1931 were very emaciated. But mackerel taken in winter sometimes have food in their stomachs; some of them even are fat.<sup>7</sup>

<sup>5</sup> The mackerel has long rakers with spines on the foremost gill arch only, and these are not fine enough to retain the smallest organisms. See Bigelow, Bull. U. S. Bur. Fish, vol. 40, Pt. 2, 1926, fig. 42 C, D for photographs of the gill rakers.

<sup>6</sup> Nature, vol. 108, 1921, pp. 12-13.

<sup>7</sup> Sette (Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, pp. 250, 262) reports some fat mackerel in winter.

<sup>4</sup> Nilsson (Publ. de Circ., Conseil Perm. Internat. Explor. Mer, No. 69, 1914) gives a similar list for Swedish waters

The immature fish feed and fatten from the time they appear in spring. And it also seems that the schools of older fish destined to spawn late in the season feed until the actual ripening of their sexual products commences, for large catches of the maturing fish were regularly made on hook and line in June in the Gulf of St. Lawrence where spawning takes place in July (until the eggs began to run, in fact). But these large mackerel would not bite after that until they had spawned out (last half of July or first part of August). And available evidence, American as well as European, is to the effect that fish destined to spawn soon after their vernal appearance inshore continue their winter fast until they have spawned, when they commence feeding greedily.

*Enemies.*—The mackerel falls easy prey to all the larger predaceous sea animals. Whales, porpoises, mackerel sharks, threshers, dogfish, tuna, bonito, bluefish, and striped bass take heavy toll in particular. Cod often eat small mackerel; squid destroy great numbers of young fish less than 4 or 5 inches long, and sea birds of various kinds follow and prey upon the schools when these are at the surface. A considerable list of parasitic worms, both round and trematode, are known to infest the digestive tract of mackerel. But they seem more immune to danger from sudden unfavorable changes in their environment than the herring are, for they are never known to be killed by cold, and they seldom strand, except when small ones are driven ashore by larger fish.

*Breeding.*—Mackerel spawn off the American coast from the latitude of Cape Hatteras to the southern side of the Gulf of St. Lawrence. The spawning area covers almost the entire breadth of the continental shelf southward from Cape Cod, but it is confined more closely to the vicinity of the coast thence northward. Available data point to the oceanic bight between Chesapeake Bay and southern New England as the most productive area, the Gulf of St. Lawrence as considerably less so, and the Gulf of Maine and coast of outer Nova Scotia as ranking third.<sup>8</sup> Mackerel do not resort to any particular breeding grounds, but shed their eggs wherever their wandering habits have chanced to lead them when the sexual products ripen. It follows from this, and from the

fact that mackerel vary so widely in abundance over periods of years that the precise localities of greatest egg production may be expected to vary from year to year, depending on the local concentrations of the fish.

The mackerel spawns in spring and early summer. As it does not commence to do so until the water has warmed to about 46° F. (8° C.), with the chief production of eggs taking place in temperatures of, say, 48° to 57°, the spawning season is progressively later, following the coast from south to north. Thus the chief production takes place as early as mid-April off Chesapeake Bay; during May off New Jersey; in June off southern Massachusetts and in the region of Massachusetts Bay; through June off outer Nova Scotia; and from late June through early July in the southern side of the Gulf of St. Lawrence, where eggs have been taken from early June to mid-August.<sup>9</sup> Mackerel have never been found spawning in autumn, so far as we can learn, though a considerable number of eggs that we towed in Massachusetts Bay early in November of 1916 resembled mackerel eggs from the hatchery so closely that we would not have hesitated to identify them as such, had they been taken in summer. They may have been the product of a belated fish, but more likely of some other Scombroid.

The mackerel is a moderately prolific fish; females of medium size may produce as many as 400,000 to 500,000 eggs in the aggregate, according to various estimates,<sup>10</sup> with 546,000 reported for one weighing 1½ pounds. But it is seldom that as many as 50,000 are set free at any one time, and often many fewer, for the members of a given school spawn over a considerable period. And recent observations<sup>11</sup> have shown that our earlier statement that they spawn chiefly at night was not correct.

The eggs are 0.97 to 1.38 mm. in diameter, with one large oil globule,<sup>12</sup> and drift suspended in the water, chiefly shoaler than the 5-fathom level. The rate of development is governed by the

<sup>8</sup> See Sette (Fish. Bull. U. S. Fish and Wildlife Service, vol. 50, Bull. 38, 1943, pp. 158-163) for a more detailed statement.

<sup>9</sup> Brice, Manual of Fish Culture, 1898, p. 212; Moore, Rept. U. S. Comm. Fish. (1898) 1899, p. 5; Bigelow and Welsh, Bull. U. S. Bur. Fish., vol. 40, Pt. 1, 1925, p. 208.

<sup>11</sup> Sette, Fish. Bull. U. S. Fish and Wildlife Service, vol. 50, Bull. 38, 1943, p. 165.

<sup>12</sup> A series of Gulf of Maine eggs measured by Welsh were about 1.1-1.2 mm. in diameter, with an oil globule of 0.3 mm.

<sup>8</sup> See Sette (Fish. Bull. U. S. Fish and Wildlife Service, vol. 50, Bull. 38, 1943, pp. 158-164, and especially fig. 3) for discussion of spawning seasons and temperatures, and the relative importance of different spawning areas.

temperature of the water. Recent experiments by Worley<sup>13</sup> (which corroborate early hatchery experience) have shown that incubation takes about 150 hours at 54°; 115–95 hours at 57°–61°; about 70 hours at 64°–65°; and about 50 hours at 70°; with normal development limited to temperatures between about 52° (11° C.) and 70° (21° C.).

Newly hatched living larvae are 3.1 to 3.3 mm. long<sup>14</sup> with large yolk sac, and with numerous black pigment cells scattered over head, trunk, and oil globule which give them a characteristic appearance. The yolk is absorbed and the mouth formed, the teeth are visible, and the first traces of the caudal fin rays have formed by the time the larva is about 6 mm. long. The rays of the second dorsal and anal fins and of the ventrals appear at about 9 mm. (to end of caudal fin); the first dorsal when the total length of the larva is about 14 to 15 mm. The dorsal and anal finlets are distinguishable as such in fry of 22 mm., and the tail fin has begun to assume its lunate shape, but the head and eyes still are much larger than in the adult, the nose blunter, and the teeth longer. At 50 mm. the little mackerel resemble their parents so closely that their identity is evident.

*Rate of growth.*—The sizes of the mackerel fry taken during the mackerel survey carried out by the U. S. Bureau of Fisheries in 1932,<sup>15</sup> added to other available evidence show that our mackerel grow to a length of about 2 inches during the first 1 to 2 months after they are hatched, a rate about the same as in British and Norwegian waters.<sup>16</sup>

This size is reached earlier or later in the season, depending on the date when any particular lot of fry was hatched. Thus mackerel fry of 1¼ to 2½ inches obviously spawned that spring, have been taken at Woods Hole, both in the first half of June<sup>17</sup> and in the last 10 days of July,<sup>18</sup> fry of 2½ to 5 inches in the first half of August, and fish of about 6½ inches at the end of that month. Similarly, Captain Atwood found fry of 2 inches and shorter in July in the Massachusetts Bay

region, i. e., about a month after the local mackerel schools had spawned out.

Fry of 3½ to 4½ inches (obviously of the same season's crop because too small for yearlings) have been taken at Gloucester in August, and Captain Atwood reports them as 6½ to 7 inches long, near Provincetown by October. Many of these little fish, up to 7 or 8 inches long (now large enough to be caught in the fish traps and known as tacks or spikes) are caught along the western shores of the Gulf of Maine and along southern New England during the fall. And measurements of thousands of young mackerel from the Gulf and from southern New England, compiled by the U. S. Bureau of Fisheries, have shown that the fry of the year average 8 to 9 inches, or longer, by the end of their first autumn, before they leave the coast for the winter. But broods produced in different years may grow at different rates, probably depending on feeding conditions, as well as on the dates when they are hatched. Thus fry spawned in the spring of 1927 averaged 8¾ inches in November, but those spawned in 1928 averaged 9¾ inches then.

Our mackerel run about 10 to 11 inches long in spring and early summer of their second year of growth (they are known now as tinkers), which agrees closely with Stevens'<sup>19</sup> estimate for mackerel of the English Channel, based on studies of scales and otoliths. They grow to about 12 to 13 inches by that autumn, or to 14 inches in years of especially rapid growth,<sup>20</sup> and the yearlings usually are a little longer in the Gulf of Maine than at Woods Hole, and longer at Woods Hole than off Long Island, N. Y. It remains to be seen whether these differences are due to temperature, to the varying richness of the food supply, or perhaps to crowding. It is also a question for the future whether the differences persist into later life. The brood of 1923, which may perhaps be taken as typical, averaged almost 14½ inches in their third autumn, about 15½ inches in their fourth, about 15½ inches in their fifth, about 16 inches in their sixth, 16¾ inches in their seventh, and about 16¾ inches in their eighth years. Thus the American mackerel, like the European, grows very slowly after its third

<sup>13</sup> Jour. Gen. Physiol., vol. 16, 1933, pp. 841–857.

<sup>14</sup> They shrink somewhat when preserved.

<sup>15</sup> See Sette (Fish. Bull. U. S. Fish and Wildlife Service, vol. 50, Bull. 38, 1943, pp. 173–178) for detailed statistical analysis of these.

<sup>16</sup> See Ehrenbaum (Rapp. et Procès Verb., Conseil Perm. Internat. Explor. Mer. vol. 30, 1923, pp. 21, 25) for a discussion of the early growth rate of the European mackerel.

<sup>17</sup> Bigelow and Welsh, Bull. U. S. Bur. Fish. vol. 40, 1925, p. 204.

<sup>18</sup> Sette, Bull. U. S. Fish and Wildlife Service, vol. 50, Fish. Bull. 38, 1943, p. 178, fig. 8.

<sup>19</sup> Jour. Marine Biol. Assoc. United Kingdom, vol. 30, No. 3, 1952, pp. 549–568.

<sup>20</sup> Fry spawned in 1927 averaged about 13¾ inches but those spawned in 1928 averaged only about 12¼ inches in their second November according to Sette.



summer, although it is long lived. The two sexes grow about equally fast.

Nilsson's studies<sup>21</sup> point to a slightly slower rate of growth for the North European mackerel. But American mackerel have been found to vary so widely in this respect that the reported difference may have been only an accident of observation.

A few fish of both sexes may mature sexually in their second year; about  $\frac{1}{2}$  of the males and  $\frac{1}{2}$  of the females spawn in the third year; and practically all of them do so in their fourth year, i. e., when three full years old.<sup>22</sup> This coincides with the transition from fast growth to slow, as might be expected, the ripening of the sexual products being so great a strain that the adult fish do little more than recover before winter. Once a mackerel has matured sexually, it no doubt spawns yearly throughout life, as most other sea fishes do.

*Proportions of the sexes.*—In American waters males have been described as predominating largely over females.<sup>23</sup> But more recent observations have shown that there are about as many of the one sex as of the other, as there are in Sweden also.<sup>24</sup>

*General range.*—Both sides of the North Atlantic; Norway to Spain off the European coast<sup>25</sup>; from the northern side of the Gulf of St. Lawrence and Strait of Belle Isle<sup>26</sup> to Cape Lookout, N. C.<sup>27</sup> off the American coast.

*Migrations, and occurrence in the Gulf of Maine.*—The occurrence of the mackerel in the Gulf of Maine is closely bound up with the seasonal movements of the species as a whole, for this is a migratory fish wherever it occurs, appearing at the surface and near our coasts in spring, to vanish thence late in the autumn. The directions and extent of the journeys which it carries out have been the subject of much discussion ever

since the fishery first assumed importance, because of their intrinsic interest, because of their bearing on the prosecution of the fishery, and because this fish has been the subject of much international dispute. The point chiefly at issue has been whether the main bodies of mackerel merely sink when they leave the coast in autumn and move directly out to the nearest deep water, or whether they combine their offshore and onshore journeys with the extensive north and south migrations in which most fishermen have long believed.<sup>28</sup>

The great majority of the mackerel have withdrawn from the coast by the end of December, not only from the Gulf of St. Lawrence, but from the entire inshore belt as a whole, not to be seen there again until the following spring or early summer, and it is not yet known definitely where the bulk of them go, though the subject has been widely discussed. Mackerel, it is true, have been caught, and have been found in the stomachs of cod and pollock in January, February, and early March at various localities on and around the outer Nova Scotian banks westward from Sable Island Bank; on the southern and northwestern parts of Georges Bank; in the deeper water between the latter and Nantucket Shoals; on Nantucket Shoals; and along the middle and outer parts of the continental shelf off southern New England, off New York, off New Jersey, off Delaware Bay, off Virginia, and off northern North Carolina. Most of these winter records have been along the 30–70 fathom contour zone, but sometimes as shoal as 4–5 fathoms off Nova Scotia, and as shoal as about 10–20 fathoms (near Ambrose Lightship) off New York,<sup>29</sup> as deep as 90 fathoms off Chesapeake Bay.<sup>30</sup>

Most of these winter records have been based on odd fish only, i. e., not enough to suggest the presence of any great concentration of mackerel.<sup>31</sup> But there were enough of them off New York in January, February, and March of 1949 for commercial fisheries to bring in what Gordon<sup>32</sup> has

<sup>21</sup> Publ. de Circ., No. 69, Cons. Perm. Internat. Explor. Mer, 1914.

<sup>22</sup> Sette, Fish. Bull. U. S. Fish and Wildlife Service, vol. 50, Bull. 38, 1943, p. 156.

<sup>23</sup> Smith, Report U. S. Comm. Fish (1900) 1901, p. 128.

<sup>24</sup> Nilsson, Pub. de Circ. No. 69, Cons. Perm. Internat. Explor. Mer, 1914.

<sup>25</sup> There is a fairly constant racial difference between American and British mackerel (Garstang, Jour. Mar. Biol. Assoc. United Kingdom, New Ser., vol. 5, No. 3, 1898, pp. 235–295), the latter showing a larger number of transverse bars, being more often spotted between them, and more often having 6 dorsal finlets instead of 5.

<sup>26</sup> Jeffers (Contr. Canad. Biol., N. Ser., vol. 7, No. 16 [ser. A, General No. 13], p. 207) reports that several mackerel were caught in 1929 at Raleigh, on the Newfoundland coast of the Strait of Belle Isle, where none had been seen in recent years.

<sup>27</sup> Coles, Copeia, No. 151, February 1926, pp. 105–106 records a three-quarter pound mackerel taken at Cape Lookout in February 1925.

<sup>28</sup> The literature dealing with this subject is very extensive. See especially Goode, Collins, Earl, and Clark (Rept. U. S. Comm. Fish. [1881] 1884, p. 91); Tracy (37th Annual Report, Rhode Island Commissioners of Inland Fisheries, 1907, p. 43); and Sette (Fishery Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, pp. 268–313) for the American mackerel.

<sup>29</sup> Gordon, Marine Life, Occ. Pap., vol. 1, No. 8, March, 1950, p. 39.

<sup>30</sup> Sette (Fish. Bull. U. S. Fish and Wildlife Service, vol. 50, Bull. 49, 1950, pp. 260–261, table 1) lists several such instances besides those cited previously by Bigelow and Welsh (Bull. U. S. Bur. Fish. vol. 40, Pt. 1, 1925, p. 196).

<sup>31</sup> Three hundred pounds seems to be the largest winter catch definitely reported up to 1951.

<sup>32</sup> Marine Life, vol. 1, No. 8, 1950, p. 39.



characterized as "huge amounts." He also reports "a large body of fish" off Montauk in mid-February of 1950. Schools of "mackerel" have also been reported as sighted at the surface on several occasions in winter, but none of these seem to have been brought in.

Direct evidence carries us only this far. But the indirect evidence of temperature is suggestive. Thus, the Gulf of St. Lawrence (where ice sometimes forms), outer Nova Scotian waters, and the upper 50 fathoms or so within the Gulf of Maine which chill to 35°-39° F. (2°-4° C.) or colder, are all too cold by late winter for mackerel, which are never encountered in commercial quantities in temperatures lower than about 45° F. (7° C.). In most years this applies equally to the inner part of the continental shelf as a whole, southward as far as northern Virginia, for the water usually cools there to 37°-40° F. (3°-4° C.) at the time of the winter minimum. But the mackerel need only move out to the so-called warm zone at the outer edge of the shelf to find a more suitable environment, for the bottom water there is warmer than 44°-46° F. (7°-8° C.) the year round as far north and east as the central part of Georges Bank, and about 41° F. (5° C.) along outer Nova Scotia.

Available evidence thus supports Sette's<sup>33</sup> conclusion that the bulk of the American mackerel winter on the outer edge of the continental shelf from the offing of northern North Carolina to the mid-length of Georges Bank, 30 to 100 miles off shore according to location, in depths of perhaps 50 to 100 fathoms. The few that are caught closer to land and in shoaler water in winter either represent the inshore fringe of the main population, or they are strays. Perhaps some winter off Nova Scotia as far east as Sable Island Bank. And it would not be astonishing should it prove that some winter in the deep eastern trough of the Gulf of Maine, where the temperature of the bottom water, at depths greater than 75 fathoms or so, does not fall below about 41° F. (5° C.). A few mackerel have, in fact, been caught on cod lines in deep water off Grand Manan in winter,<sup>34</sup> while two were found among kelp near Yarmouth, Nova Scotia, on December 28, in 1878.<sup>35</sup>

Sette<sup>36</sup> has pointed out, however, that some other factor besides temperature must have to do with the wintering habits of the mackerel, for they disappear as completely from the surface and from inshore in the southern part of their range as they do in the northern even in very warm years such as 1932, when the water (surface to bottom) was warmer than 45°-46° F. (7°-8° C.), from New Jersey southward, even at the end of the winter. On the other hand, the event (probably abnormally low temperature) that was so destructive to the tilefish in March, 1882 (p. 429), did not affect such of the mackerel as were wintering on the tilefish grounds, for they reappeared that summer in normal numbers, a point to which Sette<sup>37</sup> has called attention already.

Two additional facts which support the view that our mackerel do not travel very far in winter are (a) no mackerel, young or old, have ever been taken outside the edge of the continent, or anywhere on the high seas far from land for that matter; (b) their reappearance in spring takes place so nearly simultaneously along some hundreds of miles of coastline that they can hardly have come from any great distance.

Thus time and increased knowledge have corroborated the view of Captain Atwood and of Perley, of more than half a century ago that mackerel winter offshore in deep water and northward from the latitude of Virginia, not in the far south nor out in the surface waters of the warm parts of the Atlantic.

The winter home of the American mackerel appears to correspond rather closely to that of the mackerel of British seas, some of which winter on the deep northern slope of the North Sea, some in the deeper parts of the English Channel, and many on the outer edge of the continental shelf southwest of Ireland, mostly deeper than 60 fathoms.<sup>38</sup>

The failure of the otter trawlers to take commercial quantities of mackerel off Chesapeake Bay in winter when they fish there intensively, leads Sette<sup>39</sup> to conclude that our mackerel

<sup>33</sup> Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Fish. Bull. 49, 1950, p. 527.

<sup>34</sup> Sette, Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 257, Footnote 3.

<sup>35</sup> Ehrenbaum (Rapp. et Proc.-Verb. Cons. Perm. Internat. Explor. Mer, vol. 18, 1914) summarizes what was known of the life history of the European mackerel up to that time. And Steven (Jour. Marine Biol. Assoc. United Kingdom, vol. 27, 1948, pp. 517-539) has recently outlined the chief wintering grounds.

<sup>36</sup> Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 261.

<sup>33</sup> Fish. Bull. 49, U. S. Fish and Wildlife Service, vol. 51, Fish. Bull. 49, 1950, p. 261.

<sup>34</sup> Collins, Rept. U. S. Comm. Fish (1882) 1883, p. 273.

<sup>35</sup> Goode, Collins, Earll, and Clark, Rept. U. S. Comm. Fish. (1881) 1884, p. 98; cited from the Yarmouth, Nova Scotia, *Herald*, January 2, 1879.

winter in the mid-depths, not concentrated on the bottom. This, however, would imply that the wintering mackerel manage to hold position for two or three months in some way without drifting far with the movements of the water. Another possibility is that they do keep on bottom, or near it, but somewhat deeper down the continental slope than the trawlers ordinarily fish,<sup>40</sup> perhaps concentrated in the many gullies, large and small, with which the upper part of the slope is seamed all along from the offing of Chesapeake Bay to Georges Bank, much as the mackerel of the Celtic Sea and English Channel winter "on the sea floor, densely packed in places where its level is interrupted by banks and gullies."<sup>41</sup>

Whichever of these alternatives is the correct one, the oft repeated assertion that the adipose eyelids of the mackerel become opaque in winter has no foundation. And they certainly do not hibernate in thousands along the coasts of Greenland and Hudson Bay,<sup>42</sup> and of Newfoundland, with heads in the mud and tails protruding as a vice admiral, no less, has described them; a wholly imaginary tale, we need hardly add.<sup>43</sup> They may winter in a more or less sluggish state. But the presence of food in the stomachs of some of the winter-caught fish, added to the fact that some of them are fat though others are thin, shows that they move about more or less even then, and feed more or less.<sup>44</sup>

Most American students have looked on the vernal warming of the surface water to about 45° F. as the stimulus causing the mackerel to quit their winter quarters. European studies, however, have shown that the date of their re-appearance in spring is not closely associated with any particular temperature. And if the mackerel winter on bottom along the edge of the continent, vernal changes in the temperature of the surface water nearer to land would be wholly outside their ken.

The European mackerel usually keep to the bottom on their spring migration until close in to the land before rising to the surface. But this

generalization does not apply to the American fish, for while some may swim deep (so, only can we account for the fact that the first schools often show as early in Massachusetts Bay as on Georges Bank or off Nantucket) mackerel in great numbers are first sighted 30 to 50 miles offshore, and this all the way from the latitude of Cape Hatteras to the mouth of the Gulf of Maine. The first mackerel "show" off the Cape Hatteras region at any time between about March 20 and April 25, usually early in April, and by the middle of April off Delaware Bay. As the water warms they spread northward and shoreward, being joined, it seems, by additional contingents from offshore. They reach the offing of southern New England some time in May, and they are plentiful on Nantucket Shoals by the first week of that month, as a rule.

The date when they are first sighted off Cape Cod in the southwestern part of the Gulf of Maine varies from the last of April or first of May (April 29 in 1901, May 2, in 1898) to the first of June, with May 10 about the average. The earliest dates of commercial catches, for example, made in one particular set of traps near Provincetown have varied between May 14 and June 19. And the fish are plentiful in the western side of the Gulf of Maine as a whole by the end of the first week in June at the latest, if it is fated to be a good mackerel year. Mackerel (usually in smaller numbers) also appear on the Nova Scotian side of the Gulf about as early as they do in its western side; thus they were reported almost simultaneously off Yarmouth, Nova Scotia, and off Chatham on Cape Cod in 1898; in 1922 they were sighted off Yarmouth on May 7th, and off Cape Sable on the 11th. And they may appear even earlier in the season at Cape Breton, and as early well within the Gulf of St. Lawrence and in the eastern side of our Gulf. In 1894, for example, mackerel were first reported off Cape Breton on May 5 and at Gaspé on May 12, but not until May 16<sup>45</sup> at Yarmouth on the Gulf of Maine coast of Nova Scotia. But few of them show along the coast of Maine or in the Bay of Fundy until toward the end of June.

Sette<sup>46</sup> has made the very interesting discovery that two distinct populations are represented among the American mackerel, a southern and a

<sup>40</sup> The southern trawl fishery is mostly shoaler than 70 fathoms.

<sup>41</sup> Steven, Jour. Marine Biol. Assoc. United Kingdom, vol. 27, 1948, p. 537.

<sup>42</sup> Mackerel do not range that far north.

<sup>43</sup> Cited from Lacépède, Hist. Nat. Poissons, vol. 3, in Buffon, Hist. Naturelle, 1802, p. 32.

<sup>44</sup> Ehrenbaum (Rapp. et Procès Verbaux, Cons. Perm. Internat. Explor. Mer, vol. 18, 1914, p. 13), whose studies of the fish entitle his view to great weight, thinks that the mackerel of northern Europe probably are torpid during part of their stay on the bottom.

<sup>45</sup> Huntsman, Canadian Fisherman, vol. 9, no. 5, 1922, pp. 88-89.

<sup>46</sup> Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950.

northern, with rather different migratory habits, and differing also in the relative success of reproduction in different years.<sup>47</sup> The nature of these two contingents is not known, whether genetic or environmental.

It is probable (though not proved) that the southern contingent tend to winter in the southern part of the wintering zone. The main bodies of mackerel that appear in spring along the middle Atlantic coast belong to this contingent, also most of those taken off southern New England. They summer for the most part over Nantucket Shoals; on the western part of Georges Bank; and in the western and northwestern parts of the Gulf of Maine, which they enter in the western side around Cape Cod. And they do not journey farther east than the coast of Maine. On the other hand, it seems the mackerel that appear early in the season along the Nova Scotian shore of the Gulf, to spread later to Maine, belong to the northern contingent, and also a scattering of those that enter the western side of the Gulf. These appear to winter mostly eastward from the Hudson Gorge, and their vernal migration carries most of them past our Gulf, to pass the summer along outer Nova Scotia, and in the southern side of the Gulf of St. Lawrence.<sup>48</sup>

A few mackerel (mostly small) from the southern contingent remain all summer in the coastwise belt from Long Island to Nantucket. Apart from these, however, the whole body of American mackerel have deserted the southern grounds altogether by the early summer, to spend the later summer either in the region of our Gulf, off Nova Scotia, or in the Gulf of St. Lawrence.<sup>49</sup>

If the view now held is correct as to their migratory routes, some of the mackerel that summer in our Gulf may come from as far as the offing of North Carolina; others from as nearby as the offing of New York or of southern New England. The vernal journey of the Gulf of St. Lawrence

<sup>47</sup> This conclusion, seemingly conclusive, is based on analysis of the size (i. e. age) composition of the mackerel population at various times and places, with some evidence from tagging experiments. The data are too extensive for discussion here.

<sup>48</sup> For further information as to migrations of the northern contingent, see Sette, Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, pp. 269, 285.

<sup>49</sup> We have found no positive record of mackerel taken in late summer anywhere south of Delaware Bay, although they are plentiful off this part of the coast in spring. Bell and Nichols, It is true, speak of "mackerel" as found in tiger-shark stomachs off North Carolina (Copela, No. 92, 1921, pp. 18-19), but Dr. Nichols writes us that these were "just *Scombroids* and probably not *Scomber scombrus*."

mackerel may be anywhere between, say 300 to 350 miles, and 700 miles, depending on whether they have wintered off outer Nova Scotia or as far west as the western slope of Georges Bank.

It seems certain that some of the mackerel that are first sighted on Nantucket Shoals and on Georges Bank in May remain on these offshore grounds all summer, both spawning and feeding there, for they provide good fishing there any time from June to September or October, in some years. The farther advance of such of them as continue northward into the Gulf of Maine covers a period of some weeks, with the first-comers followed by other schools later. And it seems certain (as just remarked) that fish resorting to our Gulf, do so summer after summer, never visiting the outer coast of Nova Scotia, much less a region as far afield as the Gulf of St. Lawrence. But it is an interesting question for the future, whether a given school returns to the same part of the Gulf, year after year.

Many of the mackerel that summer in our Gulf have already spawned farther south (p. 322). Others, however, are still hard, but they are soon taken there with eggs or milt running. Spawning in the Gulf of Maine is at its peak in June in most years, with the proportion of spent fish increasing through July, and only an occasional ripe fish as late as the first of August. But a year comes occasionally, such as 1882, when spawning is not at its height in the Gulf until July, with ripe fish continuing plentiful until August. And our towings there have yielded a few mackerel eggs as early as May 6, as late as September 1.<sup>50</sup>

The spawning season is at its height in the Gulf of St. Lawrence during the last half of June and the first half of July, continuing into August, a fact well known by the hook-and-line fishermen of half a century ago, because the ripe fish will not bite at that time, and more recently corroborated by the egg catches of the Canadian Fisheries Expedition.<sup>51</sup>

It seems from the relative numbers of eggs taken from place to place, that Cape Cod Bay is the only subdivision of our Gulf that has rivaled the more southern spawning grounds in egg production during the particular years when intensive studies

<sup>50</sup> See Bigelow and Welsh (Bull. U. S. Bur. Fish., vol. 40, Pt. 1, 1925, p. 206), for details.

<sup>51</sup> Dannevig, Canadian Fish. Exped. (1914-1915); 1919, p. 8.

have been made.<sup>52</sup> Mackerel also spawn to some extent thence northward, as far as Casco Bay, but we believe very few do so farther east than that along the coast of Maine. Neither is it likely that mackerel breed successfully in the northern side of the Bay of Fundy for neither eggs nor larvae have been taken there though some production may take place on the Nova Scotian side for Huntsman reports eggs at the mouth of the Annapolis River. And while a moderate amount of spawning takes place along the outer coast of Nova Scotia,<sup>53</sup> it seems that the eggs do not hatch in the low temperatures prevailing there, for no larvae have been found. But the southern side of the Gulf of St. Lawrence, where the surface waters warm to a high temperature in summer, is an extremely productive spawning ground (p. 322).

Since the large adult mackerel tend to keep farther offshore than the small ones (p. 328), such of them as spawn in our Gulf do so at least a few miles out. Very few eggs, for example, were found in 1897 (a year of plenty) in the inshore parts of Casco Bay,<sup>54</sup> though this was formerly thought to be a productive spawning ground.

Once the mackerel have entered our Gulf, schools are to be expected anywhere around its coastal belt, at any time during the summer; also on Nantucket Shoals, on the western part of Georges Bank, and on Browns Bank, as just noted (p. 327). And while adult fish seldom venture within the outer islands or headlands, good catches of them have been made well up Penobscot Bay, and young ones 6 to 10 inches long often swarm right up to the docks in various harbors in summers of plenty.<sup>55</sup>

Mackerel are proverbially unpredictable in their appearances and disappearances at any particular place, hence the common saying that "mackerel are where and when you find them." This is partly because the schools are constantly on the move, but partly because it is only while they are schooling at the surface or near it that they are seen.

<sup>52</sup> Subsequent information, and especially the result of tow nettings on the southern grounds in 1929, 1930, 1931, and 1932 (Sette, Fish. Bull. U. S. Fish and Wildlife Service, vol. 50, Bull. 38, 1943) have shown that the Gulf of Maine as a whole is much less productive than the more southern spawning grounds, not more so as Bigelow and Welsh (Bull. U. S. Bur. Fish., vol. 4, Pt. 1, 1925, p. 206) believed.

<sup>53</sup> Sparks, Contrib. Canadian Biol. and Fish., N. Ser., vol. 4, No. 28, 1929.

<sup>54</sup> Moore, Rept. U. S. Comm. Fish. (1898) 1899, p. 16.

<sup>55</sup> Sette (Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 297) discusses this point further.

When they sink to lower levels in the water, as they often do, they drop out of sight entirely, unless some of them chance to be picked up by drift netters. Large mackerel are more prone to disappear in this way than small ones, especially in late summer or early autumn. In 1906, for example, the schools of large fish vanished from the Massachusetts Bay region in June, to reappear the 27th of July, on which date 28 seiners made catches ranging from 18 to 250 barrels each. And in 1892, a year of abundance, they disappeared (that is, sank) in August, not to appear again in any abundance anywhere in the Gulf of Maine until October.

The view has grown that when this happens the mackerel have deserted the Gulf for the time being. But it was common knowledge in the days before the introduction of the purse seine, when it was the regular practice to lure the fish to the surface by throwing out ground bait, that large mackerel summer as regularly in the Gulf as small, and that good hook-and-line catches of large fish could be made in one or another part of the Gulf through the season from June to October, even when none showed at the surface.

Their disappearances in summer merely mean that the fish have sought lower levels in the water; that they have wandered to some other part of the Gulf; or perhaps that the schools have dispersed more or less. When they sink in summer in our Gulf, it is not likely that they descend very deep. In the first place the water deeper than about 40 to 50 fathoms is colder than 46°-47° F. (8° C.), i. e., than they seem to prefer; in the second place the planktonic animals on which they feed are more concentrated above the 50-fathom level than deeper. And a year comes, now and then, when mackerel of all sizes school at the surface all summer long.<sup>56</sup>

Sette's<sup>57</sup> painstaking analysis of the relative frequency with which schools are seined in different localities has shown that mackerel are seen far the most often in the southwestern part of the Gulf and out along the western part of Georges Bank, with the chief concentrations in one part or another of Massachusetts Bay and off the outer shore of Cape Cod to Nantucket Shoals, though great numbers are also caught along the Maine coast, close inshore.

<sup>56</sup> 1882 was an example of this.

<sup>57</sup> Fish. Bull. U. S. Fish and Wildlife Service, vol. 51, Bull. 49, 1950, p. 297, fig. 17.

Mackerel contrast in an interesting way with herring in this respect, the latter being caught in by far the greatest numbers in the northeastern corner of the Gulf, i. e., just where there usually are fewest mackerel. But there is much variation from year to year in their relative abundance from place to place as appears from the following table of catches, made in two successive years when the total landings from the Gulf, as a whole, did not differ greatly (landings at Boston, Gloucester, and Portland by the vessel fishery, stated in pounds).

Fishing grounds	1916	1917
Georges Bank.....	3,701,597	624,086
South Channel.....	77,157	13,600
Nantucket Shoals.....	2,516,414	6,277,830
Off Chatham.....	2,017,753	3,938,452
Off Race Point.....	99,250	621,751
Stellwagen Bank.....	1,559,972	519,550

In some years few mackerel are seen at the surface in the Gulf eastward of the Isles of Shoals, 1926, 1927, 1933, 1934, and 1935 were examples. In other years, however (e. g., in 1928, 1929, 1930, 1931, and 1932) many schools are sighted and seined along the coast of Maine as far eastward as the vicinity of Mount Desert Rock (see fig. 176, based on Sette's painstaking analysis). But the experiences of the old time hook-and-line fishermen suggest that the mackerel tend to move northward and eastward in general from the Massachusetts Bay region, for they made their best late-summer and early-fall catches between Cape Elizabeth and Mount Desert Rock in most years, notably about Monhegan Island. And the results of hook-and-line fishing are a far better clue to the presence or absence of mackerel than the seine catches are, since they draw from the fish that are deep down, as well as from those that may chance to be at the surface.

The Nova Scotian side of the Bay of Fundy has been a profitable mackerel ground, occasionally, but only for short periods and at long intervals. Thus good catches were made there for some years previous to 1876, but this fishery was abandoned a few years later for want of mackerel. There were enough fish there again in the early 1900's to yield about 7 million pounds in the 6-year period 1901 to 1906.<sup>58</sup> But we have not heard of any large catches made anywhere in the Bay of Fundy since that time, so events of the sort must be out of the ordinary. And very few mackerel are ever

reported along the New Brunswick side of the Bay.

In most years, mackerel are few over the central deeps of the Gulf (fig. 176), but a year comes now and then when they are plentiful there, as happened in 1882 (a year of great abundance), when great numbers were caught between Georges Bank, Browns Bank, and Cashes Ledge, and thence northward to within 40 miles or so of the Maine coast. Most of the early season catch, in fact, was made in this deep water region that year, and in the weirs along the west coast of Nova Scotia. But the fish disappeared thence later in the season. And large catches have never been reported from the eastern part of Georges Bank to our knowledge.

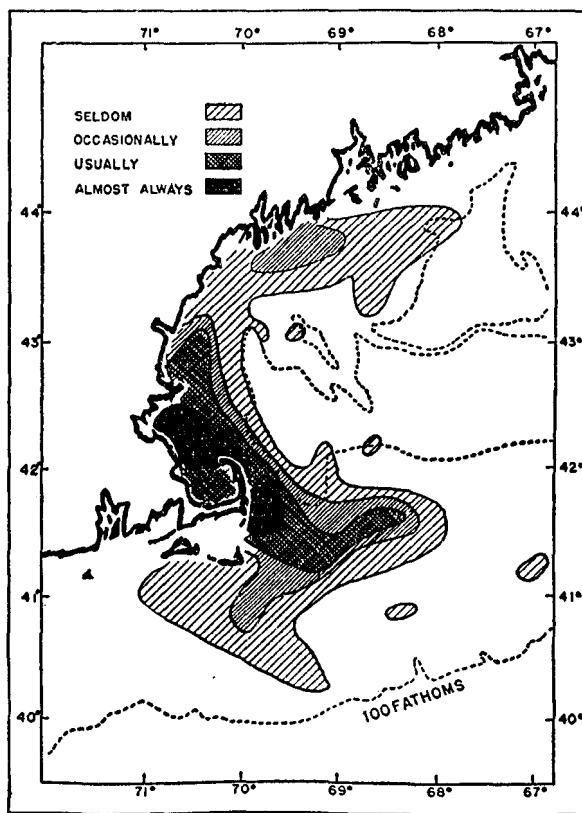


FIGURE 176.—Average distribution of mackerel in the Gulf of Maine, July through September, based on relative frequencies of catches recorded for each 10-mile rectangle, 1926 through 1935. After Sette.

As a rule, the schools tend to stay nearer the coast in years when small (i. e., young) fish dominate the population. The entire Gulf of Maine catch, for example, was taken within 45 miles of

<sup>58</sup> Sette and Needler, Inv. Rept. 19, U. S. Bur. Fish., 1934, pp. 1-48.

land in 1926, when the stock was dominated by fish hatched in 1923, i. e., were in their third year. In years of this sort, anglers fishing in harbors, or going out in charter boats for the day, do well, catching the smaller sizes chiefly. But in 1928, when the same year class dominated as had in 1926 (i. e., fish now in their fifth year), only about two-thirds of the catch was made that close in, with about one-third of the catch taken more than 45 miles out at sea. Nineteen twenty-nine may serve as another example, with more than one-half (57 percent) of the large fish caught more than 45 miles out, but less than 1 percent of the small ones, and a few large ones, taken as far out as 80 miles. But even the fully grown fish do sometimes come close inshore; we have ourselves caught mackerel within a few yards of the beach in the southern side of Massachusetts Bay, as large as any that we have seen taken anywhere.

Fishermen have long realized that mackerel are most likely to be found where there is a good supply of "red feed" (copepods) or other small animal life in the water. A relationship has, in fact, been found to hold in the English Channel between the catches of mackerel and the numbers of copepods present.<sup>59</sup> And while no attempt has been made yet to relate the local abundance of mackerel in our Gulf, or the depths at which they swim with the supply of food on a statistical basis, the mere fact that they do fatten in our waters is evidence enough that they manage in some way to congregate where food is plentiful. But it appears that their vernal journey, from their wintering grounds to the Gulf and to Nova Scotian waters, is directed by some impulse to migration more definite than the mere search for food. Thus while a large proportion of the mackerel did travel along the zone of abundant plankton in the only year (1930) when their advance along the coast has been compared with the quantitative distribution of the animals on which they prey,<sup>60</sup> they deserted the waters south of New England that year while the food still was abundant there, for regions (Gulf of Maine and eastward) where there is no reason to suppose that feeding conditions were any better at the time.<sup>61</sup>

<sup>59</sup> Bullen, *Jour. Marine Biol. Assoc. United Kingdom*, vol. 8, 1908, pp. 269, 302.

<sup>60</sup> Bigelow and Sears, *Mém. Mus. Comp. Zool.*, vol. 64, No. 4, 1939, pp. 250-261.

<sup>61</sup> See Sette (*Fish. Bull. U. S. Fish and Wildlife Service*, vol. 51, Bull. 49, 1950, p. 302) for a further discussion of the influence of feeding conditions on the movements of the American mackerel.

As autumn draws on, the fish that summer along the Maine coast (chiefly belonging to the southern contingent) seem to work back southwestward toward Cape Cod, for catches were made successively off Portland, near Boon Island, and off Cape Ann, in the days when mackerel were caught on hook and line. It is probable, too, that such of the fish from the northern contingent as have entered the Gulf in the eastern side join in this general autumnal movement around the coast to the westward and southward, rather than that they leave by the route along which they enter, for schools have often been reported, and actually followed, swimming southward at the surface across Massachusetts Bay. And while reports of this sort are likely to be based on misconception,<sup>62</sup> they are corroborated in this instance by the fact that the latest catches are always made either in or off Massachusetts Bay, along the outer shore of Cape Cod, or on the neighboring parts of Nantucket Shoals, never either on Georges Bank, which would be on the direct route of any fish swimming westward from Nova Scotia, or in the inner parts of the Gulf of Maine.

Sette's studies indicate that the bulk, at least, of the mackerel of the southern contingent have moved out of the Gulf around Cape Cod and past Nantucket Shoals by late September or October in most years. But many of the fish of the northern contingent coming from Nova Scotia, and perhaps even from the Gulf of St. Lawrence, usually provide good fishing off Cape Ann and southward through October and late into November,<sup>63</sup> with good commercial catches until mid-December in some years. In 1913, for example, 1,200 mackerel were caught off Gloucester on December 10; 3,000 off Chatham, Cape Cod, a day or two earlier; and nearly 1,000 barrels (200,000 pounds) were seined off the Massachusetts coast during the early part of that month in 1922. In mild winters schools of mackerel are sometimes reported and even caught off the outer coast of Nova Scotia as late as Christmas time; i. e., somewhat later than off Cape Cod. But the

<sup>62</sup> The successive approach of one school after another to the coast often suggests a long-shore movement of the fish. Thus Kendall (*Bull. U. S. Bur. Fish.*, vol. 28, Pt. 1, 1910, p. 287) tells of an instance when seiners reported "following" the schools continuously eastward along outer Nova Scotia, although the fish taken off Liverpool proved to be of quite different sizes from the catch made later about Cape Breton.

<sup>63</sup> In 1922, for example (*Gloucester Times* of April 26, 1923), mackerel netters fishing near Cape Ann did well right through November, with a catch of about 1,200,000 pounds (6,000 barrels) for the month.

whole body of Gulf of Maine, Nova Scotian, and Gulf of St. Lawrence mackerel have withdrawn thence by the end of December at the latest, except for odd stragglers. And when they do depart, they must sink at once to lower levels in the water, for schools are never sighted on their journey offshore and southward; they simply drop out of sight.

*Abundance.*—It has been common knowledge since early colonial days that mackerel fluctuate widely in abundance in our Gulf from year to year, perhaps more widely than any of our other important food fishes, with periods of great abundance alternating with terms of scarcity, or of almost total absence. In good years the fish may appear in almost unbelievable numbers; schools or associations of schools, miles in length, are reported; and it is common to see 50 or more separate bodies of fish from the masthead at one time. Mackerel, in short, seem to be everywhere, and a tremendous catch is made. But perhaps only an odd school will be seen here and there the next year, and the fishery will be a flat failure.

The period from 1825 to 1835 was one of abundance. In 1831, for example, more than 380 thousand barrels (76 million pounds) of salt mackerel (in those days most of them were salted) were landed in Massachusetts ports. But mackerel were scarce for the next 8 years (1837–45), only 50,000 barrels being landed in Massachusetts in 1840. The Massachusetts catch then fluctuated violently from 1851, when the landings rose once more to 348,000 barrels, down to 1879. The fleet brought in something like 294 million fish from Nova Scotian and United States waters combined in 1880. And this introduced a period of extraordinary abundance, culminating in 1885 when the catch reached the enormous total of 500,000 barrels (100,000,000 pounds). But this was followed in its turn by a decline so extreme, so widespread, so calamitous to the fishing interests, and so long continued, that the catch was only about 3,400 barrels (equivalent to 582,800 pounds of fresh fish) for the entire coast of the United States in 1910 (when the stock of mackerel fell to its lowest ebb) with almost none reported in Massachusetts Bay or along the Maine coast.

Mackerel then increased again in numbers; slowly at first, then more rapidly, as appears from the fact that the catch for the Gulf of Maine and for the banks at its mouth was about four times as

great in 1911 (about 2½ million pounds) as it had been the year before, rising to about 4½ million pounds in 1912, 5 million in 1913, 7½ million in 1914, to something more than 11 million in 1915, and 16 to 16½ million each for 1916 and 1917. But this period of multiplication fell far short of equaling the banner years of the 1880's. And the catches fell off again so rapidly after 1917 that the Gulf of Maine yield for 1919<sup>64</sup> was only about one-quarter as great as it had been in 1917. Although 1920 saw some slight recovery, 1921 (with a local catch of only about 1 million pounds) proved the worst mackerel season for our Gulf since 1910. The stock then built up enough (following the familiar seesaw pattern) for the Gulf to yield about 25 million pounds of mackerel in 1925. Since that time down to 1946, the Gulf of Maine catch has ranged between a low of about 20 million pounds (1937) and a high of about 59 million (1932). Thus the catch of mackerel in our Gulf may be 50 to 100 times as great in a good year as in a poor. The average Gulf of Maine catch for the period 1933–1946 was about 37 million pounds, yearly.

Various far-fetched explanations have been proposed for these astounding ups and downs in the catches from year to year, such as that the fish have gone across to Europe; have sunk; or have been driven away or killed off by the use of the purse seine. Actually, these changes reflect the ups and downs in the numbers of the fish that are in existence from year to year. Mackerel, in short, were extremely plentiful in 1885, very scarce in 1910, moderately plentiful in 1916 and 1917, very scarce again in 1921, and they have been moderately plentiful since about 1925, but probably not so plentiful as they were in the 1880's.<sup>65</sup>

It has long been known for the herring and for some other species that the prime factor in determining the abundance of the fish is the comparative success of reproduction from year to year, years favorable to the production and survival of larvae presaging several seasons of abundance, or vice-versa. And comparison of the relative proportions of mackerel of different sizes (that is, of different ages) in the total catches from year to year has shown that this is equally true of the

<sup>64</sup> In 1919, 4,091,345 pounds.

<sup>65</sup> See especially, Sette, U. S. Bur. Fish., Fishery Circular No. 4, 1931.



mackerel.<sup>66</sup> When there is an abundant crop of young mackerel, the fishing is good during the next several years, but the catches then fall off, if another good brood does not soon appear upon the scene. The course of events since the low point in 1910 may then be reconstructed about as follows:

In 1910, when the stock of mackerel was at its lowest, most of the fish caught were large, suggesting that few young had survived for several years past. Unfortunately, no information is available as to the composition of the population from the point of view of size for the next three years, when the catch was progressively somewhat larger, but great numbers of small fish, (apparently yearlings), were reported in 1912, pointing to a good breeding season in 1910, in 1911, or in both. In 1914 fish smaller than 1½ pounds again formed nearly 60 percent, by weight, of the catch in and off the Gulf of Maine, and approximately 80 percent in 1915, with an even greater preponderance in actual numbers between small (young) fish and large (old). These little fish, hatched during the period 1910 to 1912 or 1913, were responsible, as they grew, for the fairly good catches made in the Gulf in 1916 and 1917.<sup>67</sup> But the production of fry must have been very poor in 1916 and 1917, for the Gulf of Maine catch was only about one-seventh as great in 1919 as it had been in 1916. And reproduction must have practically failed in 1918 or in 1919, for the mackerel caught in 1920 ran very large, both south of New York that spring, and in our Gulf during that summer and autumn.

The population was now back again in about the same state as it had been in 1910, the cycle having run through a period of 10 years. The parallel goes further, too, for 1921 must have seen a wave of production to account for the swarms of small fish that appeared along the New England coast from Woods Hole to Mount Desert during the summer of 1922. This again presaged a great increase in the catches of mackerel for the next few years to come (more than 11 million pounds were taken in the Gulf of Maine in 1923). And Sette's studies show that 1923 was another productive year, resulting in a catch more than twice as great in 1925 as it had been in 1923, and about 3 times

as great in 1926.<sup>68</sup> The very large catch of about 59 million pounds in the Gulf in 1932 was preceded similarly by the presence of great numbers of yearlings in 1929, evidence of successful reproduction in 1928.

Thus, it seems that the proportion of fish of different ages in the catch in any one year may be used as a basis for predicting the success or failure of the run of mackerel for the next year; such predictions have in fact been attempted by Sette<sup>69</sup> with fair success.

No record has been kept, so far as we know, of the relative numbers of mackerel of different ages, of late years. But a failure of reproduction, followed by a slump in the catch, may come at any time, for history has a way of repeating itself, especially where fishes are concerned.

Nothing definite is known as to what determines the success or failure of reproduction of the mackerel in any given year. Towsings by the U. S. Bureau of Fisheries make it likely that the actual production of eggs is usually sufficient. But the vitality of the eggs spawned in any given year goes back to the physiological condition of the parents. And studies of the composition of the stock of fish in periods of high production and of low suggest that there is some correlation between the number of adult mackerel existing in the sea at any time, and the success with which they breed, for it seems that years when great numbers of fry survive always fall when the parent fish are scarce, average large, and also average very fat (by general report).

One hypothesis is that the mackerel tend to grow fast when there are only a few of them and go into the winter in excellent condition, hence are able to produce eggs of high vitality and in abundance; but they do not fare so well individually when plentiful, hence, do not emerge from their winter quarters in as good physiological condition in spring, so that fertilization and incubation may be less successful, and such larvae as hatch may be less strong. On the other hand, all this may be insignificant as compared with the success or failure of the larvae in surviving the dangers and difficulties of subsistence that confront them. Onslaughts by enemies,

<sup>66</sup> See especially Sette, U. S. Bur. Fish., Fishery Circular No. 4, 1931.

<sup>67</sup> Gulf of Maine catch, 16,391,095 pounds in 1916; 16,021,619 pounds in 1917.

<sup>68</sup> Gulf of Maine catch, 11,007,676 pounds in 1923; 25,475,876 pounds in 1925; 33,152,768 pounds in 1926.

<sup>69</sup> U. S. Bur. Fish., Fish. Circ., No. 4, 1931; No. 10, 1932; No. 14, 1933; No. 17, 1934; Fishing Gazette, vol. 50, No. 5, 1933, pp. 9 and 21.



abundance and ready availability of food, temperature, and salinity of the sea water all act upon the young fish to make their existence precarious; a favorable environment depends on a happy combination of all these.

*Importance.*—The mackerel is a delicious fish, but it does not keep so well as some other fishes that have less oil in their tissues. When mackerel are rather plentiful they are one of the four most valuable fishes of our Gulf commercially, surpassed in dollar value only by the haddock, cod, and rosefish, as appears from the following table of landings in New England for the years 1943–1947.

When the fishery fails, as it does periodically through periods of several years (p. 331), the value of the catch decreases accordingly, and to a point where it is only a negligible fraction of the total yield and value of the Gulf of Maine fishery.

Species	1943	1944
Haddock.....	\$8,650,000 (1.1)	\$7,550,000 (1.2)
Cod.....	4,000,000 (1.2)	3,500,000 (1.5)
Rosefish.....	4,350,000 (1.1)	4,300,000 (1.1)
Mackerel.....	3,180,000 (1.1)	2,400,000 (1.3)

Species	1945	1946	1947
Haddock.....	\$7,000,000 (1.4)	\$8,800,000 (1.2)	\$8,900,000 (1.3)
Cod.....	4,280,000 (2.3)	3,940,000 (1.4)	2,780,000 (1.4)
Rosefish.....	3,840,000 (1.3)	4,750,000 (1.7)	4,200,000 (1.4)
Mackerel.....	3,160,000 (1.3)	2,340,000 (1.1)	2,000,000 (1.2)

NOTE.—The total value of the catch landed in Maine, New Hampshire, and Massachusetts, including fish from grounds outside the Gulf of Maine, as well as from within the Gulf, may be determined by multiplying the values by the figures in parentheses.

Most of the mackerel were caught formerly with hook and line, ground bait being thrown out to lure the fish close enough to the vessel.<sup>70</sup> But this way of fishing was gradually given up about 1870, when the use of the purse seine became general. And practically the entire catch of mackerel of the past 70 years has been made with purse seines, with pound nets, weirs and floating traps coming second, and gill nets a poor third. In 1943, for example, when the total Gulf of Maine catch was between 53 and 54 million pounds, about 80 percent was taken in purse seines; between 12 and 13 percent in pound nets, weirs, and floating traps; and between 3 and 4 percent (between 1 and 2 million pounds) in gill nets (anchored or drifting), but only 1,700 pounds on hand lines. Otter trawlers, too,

<sup>70</sup> See Goode and Collins, *Fish. Ind. U. S.*, Sect. 5, vol. 1, 1887, pp. 275–294, for an excellent account of the hook and line fishery.

bring in scattering mackerel from the offshore banks: 2,400 pounds, for example, in the year in question.

Many anglers, also, troll or bait-fish for mackerel all along the coast from Cape Cod to Penobscot Bay; as far as Mount Desert if mackerel are on the coast that far east. In good years it is not unusual for 3 or 4 anglers fishing from a party boat to bring in one or two hundred fish. And in summers when young tinkers are plentiful inshore many of them are caught from the wharves in various harbors. If one chooses to troll, an ordinary pickerel spinner, No. 3, serves well, especially if tipped with a small piece of pork rind or with mackerel skin; a small metal jig similarly adorned, or any small bright spoon. Mackerel will also take a bright artificial fly, and bite greedily on a white piece of clam, a piece of mackerel belly, or on a sea worm (*Nereis*), especially if attracted by ground bait.

### Chub mackerel *Pneumatophorus colias*

(Gmelin) 1789<sup>71</sup>

#### HARDHEAD; BULLSEYE

Jordan and Evermann, 1896–1900, p. 866, *Scomber colias* Gmelin.

*Description.*—The hardhead (by which name it is commonly known to fishermen) resembles the common mackerel so closely that we need mention only the points of difference. Most important of these, anatomically, is the fact that the hardhead has a well-developed swim bladder connected with the esophagus, which the mackerel lacks. But it is not necessary to open the fish to identify it for there is a characteristic color difference between the two, the mackerel being silvery-sided below the mid line, whereas the lower part of the sides of the hardhead (otherwise colored somewhat like the mackerel) are mottled with small dusky blotches, and the chub has a larger eye than the mackerel. Less obvious differences are that the dorsal fins are closer together in the chub and that there are only 9 or 10 spines in its first dorsal fin instead of 11 or more, which is the usual count in the mackerel.

<sup>71</sup> This genus is separated from *Scomber* by having a well developed swim bladder which the true mackerel lacks (see Starks, *Science*, N. Ser., vol. 54, 1921, p. 223).

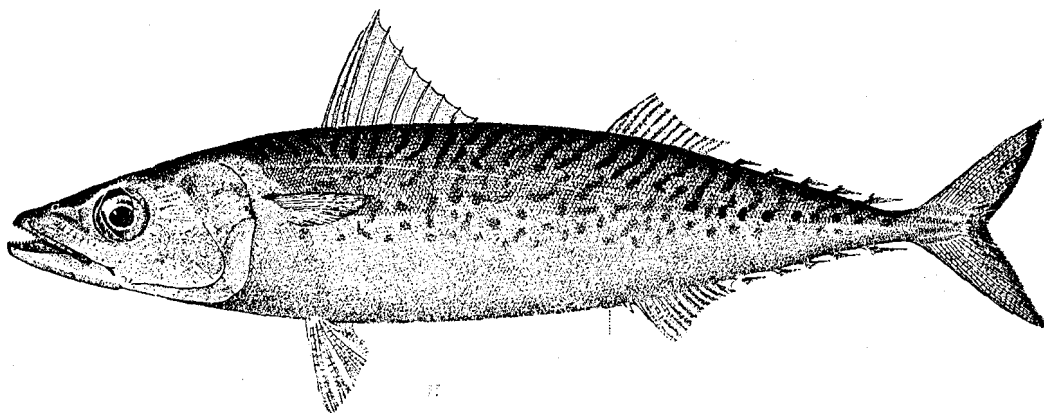


FIGURE 177.—Chub mackerel (*Pneumatophorus colias*), Provincetown, Mass. From Goode. Drawing by H. L. Todd.

*Size*.—This is a smaller fish than its better known relative, growing to a length of about 8 to 14 inches only.

*Habits*.—Hardheads school like mackerel, and their feeding habits are much the same, for Doctor Kendall found fish on Georges Bank in August 1896, full of the same species of pelagic Crustacea and Sagittae that the mackerel had taken at the same time and place, while specimens taken at Woods Hole had dieted chiefly on copepods, to a less extent on amphipods, Salpae, appendicularians, and young herring. They follow thrown bait as readily and bite quite as greedily as mackerel do. Their breeding habits have not been studied.

*General range*.—Temperate Atlantic Ocean, north to outer Nova Scotia and to the Gulf of St. Lawrence in the west,<sup>72</sup> to England in the east. It is represented in the Pacific by a close ally, *Pneumatophorus japonicus*. It is a more southerly fish than the mackerel.

*Occurrence in the Gulf of Maine*.—Goode,<sup>73</sup> long ago summarized the early history of the chub mackerel in our waters, which briefly was as follows:

It was tremendously abundant during the last of the eighteenth century and early years of the nineteenth, down to 1820–1830. Thus Capt. E. E. Merchant, an experienced and observant fisherman, described them as so plentiful off Provincetown from 1812 to 1820 that three men and a boy could catch 3,000 in a day on hook and

line. But it practically disappeared from the United States coast some time between 1840 and 1850. It is interesting to note, as Captain Atwood pointed out, that destructive methods of fishing had nothing to do with the case, for its disappearance antedated the introduction of traps, pounds, or purse seines; it also antedated the re-appearance of the bluefish (p. 386); hence cannot be blamed on these sea pirates. So completely did the hardheads vanish that the Smithsonian Institution tried in vain for 10 years prior to 1879 to obtain a single specimen. But a school was taken in the summer of 1879 in a trap at Provincetown (where representatives of the U. S. Fish Commission were stationed at the time), and though none were seen in 1880 there were some off the coast of New York in 1886.

We find no definite record of the status of the hardhead during the next decade. But Bean<sup>74</sup> describes them as abounding off New York in 1896, swimming up little creeks in such numbers that they could be dipped in boat loads. And hardheads were taken singly and in schools by the mackerel fleet on Georges Bank during that same August,<sup>75</sup> while many were caught on hook and line from the *Grampus* in Block Island Sound during the first week of that September.

Kendall found them at Monomoy, the southerly elbow of Cape Cod in 1898, and they were sufficiently reestablished by then for Smith<sup>76</sup> to describe them as uncommon to abundant at Woods Hole. They then dropped out of the published record again (they are not separated from the

<sup>72</sup> It is reported from St. Margaret Bay and Halifax by Vladykov (*Proc. Nova Scotian Inst. Sci.*, vol. 19, 1935, p. 7), and Schmitt (*Monographie de l'Isle de Anticosti*, 1904, p. 285, Paris) credits it with "apparitions irrégulières" at Anticosti.

<sup>73</sup> *Fish. Ind.*, U. S., Sect. 1, 1884, p. 303.

<sup>74</sup> *Bull.* 60, New York State Mus., Zool. 9, 1903, p. 383.

<sup>75</sup> Field notes supplied by Dr. W. C. Kendall.

<sup>76</sup> *Bull.* U. S. Fish. Comm., vol. 17, 1898, p. 95.

common mackerel in the fishery returns) until 1900, when they were found in the Casco Bay region. There is no reason to suppose that they appeared in any numbers anywhere on our coasts during the period 1900 to 1906, but in the latter year many were taken in the traps near Woods Hole, also in 1908. And the mackerel fleet found great schools of hardheads on Georges Bank in 1909, when vessels brought in fares of 50,000 to 100,000 of them during the first week of July,<sup>77</sup> their small size (500 to 700 to the barrel) suggesting that there had been a great production of hardheads a year or two previous. Fishermen speak of catching a few from time to time since then, but no great numbers. We caught one at Cohasset on the south shore of Massachusetts Bay in September 1942.

In its years of plenty, which fall at long intervals, however, the chub mackerel is likely to appear wherever mackerel do off the Massachusetts coast, especially about Provincetown. Thus 13,420 pounds were taken in traps at North Truro, in 1952, between August 11 and October 5. Other definite Gulf of Maine records are mostly<sup>78</sup> about Casco Bay and one from Johns Bay, Maine. We found no record of it farther east along the coast of Maine; it is unknown in the Bay of Fundy, nor does it seem to reach the west Nova Scotian coast. But in good "hardhead" years, it is to be expected all along Georges Bank and on Browns as well, to judge from its occasional visits to the outer coast of Nova Scotia.

<sup>77</sup> Boston Herald, July 9, 1919.

<sup>78</sup> Scattergood, Trefethen, and Coffin (Copela, 1951, No. 4, p. 208), report one caught in August 1949.

*Importance.*—The chub mackerel is as choice a table fish as the mackerel, and no distinction is made between them in the market, other than the size of the individual fish.

**Striped bonito** *Euthynnus pelamis* (Linnaeus)  
1758

OCEANIC BONITO

Jordan and Evermann, 1896-1900, p. 868, *Gymnosarda pelamis*.

*Description.*—The various fishes commonly called bonitos, albacores, and tuna, are fusiform in shape like all their family, tapering to a pointed nose and to an extremely slender caudal peduncle. But they are much stouter-bodied than mackerel or chub mackerel, and their second dorsal fin originates close to the rear end of the first dorsal, instead of being separated from the latter by a long interspace. The present species is about one-fourth as deep as it is long; its caudal peduncle has one prominent median longitudinal keel on either side, with a smaller keel above it, and another below at the base of the tail. The very deeply concave contour of its first dorsal fin (fig. 178) is enough to separate it at a glance from the common bonito (fig. 180), or from a young tuna (fig. 181), and from the Spanish and king mackerels (figs. 182, 183). The fact that its sides have dark markings below the lateral line, but not above the latter, is the readiest field mark by which to distinguish it from its close relative the false albacore (p. 336), in which the reverse is true. Also, its anal fin originates

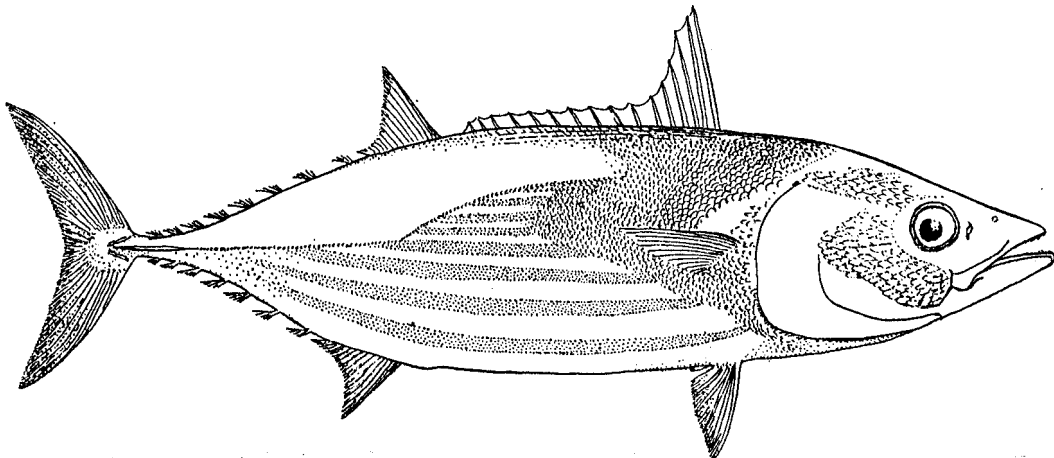


FIGURE 178.—Striped bonito (*Euthynnus pelamis*). After Smitt.

farther forward than in the false albacore; i. e., under the middle of the second dorsal fin, instead of under the first dorsal finlet.

Another distinctive character (shared, however, by the false albacore, p. 335) is that it has no body scales except along the lateral line, and covering a very prominent corselet on the forward and upper part of the trunk, which is outlined in the illustration (fig. 178). Its lateral line curves downward suddenly below the second dorsal which is not the case in its relative *alleteratus* (p. 336).

The first dorsal fin (about 15 spines) is not only much longer, relatively, than that of the mackerel, but its upper edge is abruptly concave behind the second spine, with the last 9 or 10 spines much shorter. The second dorsal is triangular, with concave rear edge; almost the whole of it stands in front of the anal; the anal is as large as the second dorsal and of about the same shape. There are about 8 little finlets behind the second dorsal, and about 7 finlets behind the anal. The pectorals are of moderate size, reaching back only about midway of the first dorsal. The tail fin is very short but broad and lunate in outline.

*Color*.—Deep steel blue above, with the lower part of the sides, the throat and the belly shining white. Each side is barred behind the corselet with 4 to 6 longitudinal blue or brown stripes, the upper ones terminating at their intersection with the lateral line, the lower 3 or 4 fading out as they near the caudal peduncle.<sup>79</sup>

<sup>79</sup> The number of stripes is different in different geographic regions; American fish usually show only 4; 7 have been described for Japanese specimens; there usually are 4, and sometimes 5 or 6, on each side in the European bonito.

*Size*.—This bonito grows to a length of about 30 inches.

*General range*.—Warmer parts of all the great oceans, the Atlantic, Pacific, and Indian.

*Occurrence in the Gulf of Maine*.—A specimen obtained at Provincetown in 1880 by J. Henry Blake is the only record for this oceanic fish in the Gulf, but it sometimes appears in numbers about Woods Hole, where 2,000 to 3,000 were taken in 1878, but where it did not show again until October 1905.

**False albacore** *Euthynnus alleteratus* (Rafinesque)  
1810

LITTLE TUNNY; BONITO

Jordan and Evermann, 1896-1900, p. 258.

This bonito resembles the striped bonito (p. 335) very closely in body form, in size and arrangement of its fins, and in the fact that its body has no scales except on the forward and upper part of the trunk, the corselet, and along the lateral line. But it is distinguishable from the striped bonito by its color pattern, for it is above its lateral line that its sides bear dark markings, not below. And its lateral line does not bend downward appreciably below the second dorsal fin.<sup>80</sup> Also, its anal fin originates relatively farther back than in the striped bonito, i. e., under the first dorsal finlet instead of under the middle of the second dorsal fin.

<sup>80</sup> For further differences between the species of *Euthynnus*, see Fraser Brunner, Ann. Mag. Nat. Hist., Ser. 12, vol. 3, 1950, p. 150.

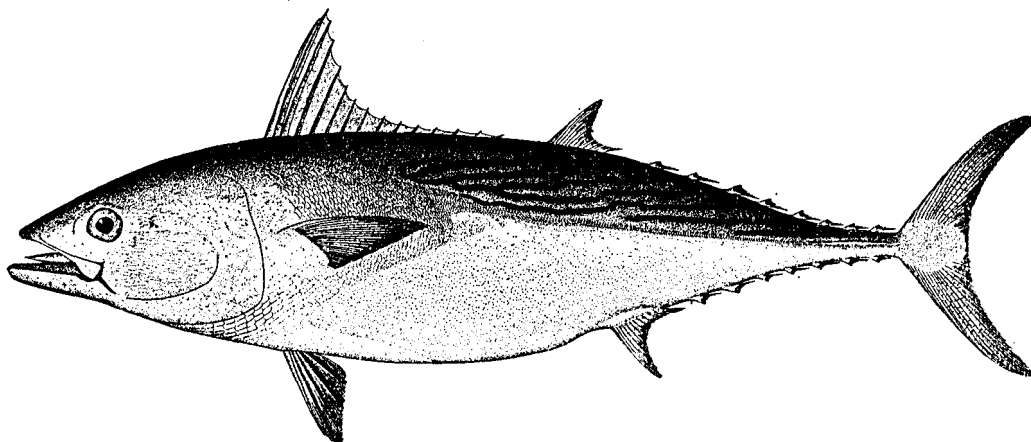


FIGURE 179.—False albacore (*Euthynnus alleteratus*), Woods Hole. From Jordan and Evermann. Drawing by H. L. Todd.

*Color*.—Steel blue above, glistening white lower down on the sides and on the belly. The sides are without markings below the lateral line, except for a few dark spots below the pectoral fin, but are marked above the lateral line with dark wavy bands, in various patterns.

*Size*.—About the same as *E. pelamis*, i. e. growing to about 2½ feet.

*General range*.—This, like its relative *pelamis* is a tropical-oceanic fish, widespread on the high seas, in all the great oceans.

*Occurrence in the Gulf of Maine*.—False albacores are picked up from time to time near Woods Hole, in July or August. But the only records of them within our Gulf are of 200 to 300 taken in a trap at Barnstable, in the autumn of 1948,<sup>81</sup> and of 28 taken in another trap in Cape Cod Bay, near Sandwich, on September 11, 1949.<sup>82</sup> Like various other tropical fishes they come our way only as strays from warmer seas; they are likely to be in schools whenever they reach our Gulf.

### Common bonito *Sarda sarda* (Bloch) 1793

BONITO; SKIPJACK; HORSE MACKEREL

Jordan and Evermann, 1896-1900, p. 872.

*Description*.—This bonito is shaped much like a small tuna, being thick and stout bodied, about one-fourth as deep as it is long (not counting the caudal fin), and similarly tapering to a pointed snout and very slender caudal peduncle. It is tuna-like also, in that its body is scaled all over, that its caudal peduncle has median longitudinal keels, and that its two dorsal fins are so close together that they are practically confluent. But

<sup>81</sup> Reported to us by Frank Mather of the Woods Hole Oceanographic Institution. All of these, weighing 2,498 pounds, were caught on September 16 in the trap of John Vettori.

<sup>82</sup> Schuck, Copeia, 1951, p. 98.

the shape of its fins distinguishes it at a glance from a small tuna, the only regular member of the Gulf of Maine fish fauna, with which it is apt to be confused,<sup>83</sup> its first dorsal being relatively much longer than that of the tuna (about one-third as long as the body, not counting the caudal, and with about 21 spines), and its second dorsal considerably longer than high, whereas the second dorsal is at least as high as it is long in the tuna.

The mouth, too, of the common bonito is relatively larger than that of the tuna, gaping back as far as the hind margin of the eye, and its jaw teeth are larger, with the two to four in the front of the lower jaw noticeably larger than the others. The shape of its first dorsal, with nearly straight upper margin marks it off from the oceanic bonito (p. 335), also from the false albacore (p. 336), in both of which this fin is very deeply concave in outline; the uniform scaliness of its body, also, is diagnostic, as contrasted with them.

We need only note further that its first dorsal fin is triangular, tapering regularly backward, with only slightly concave upper edge; that the margins of the second dorsal and anal fins are deeply concave; that it has 7 or 8 dorsal finlets and 7 anal finlets; that its tail fin is lunate, much broader than long; and that its lateral line is not deeply bowed below the second dorsal, but is only wavy.

*Color*.—The color of this bonito is so distinctive as to be a ready field mark to its identity, for while it is steely blue above with silvery lower part of the sides and abdomen, like most of the mackerel tribe, the upper part of the sides are barred with 7 to 20 narrow dark bluish bands running obliquely downward and forward across the lateral line. While young its back is transversely barred

<sup>83</sup> No one should take a bonito for a large mackerel, its dorsal fins being close together, while those of the mackerel are far apart.

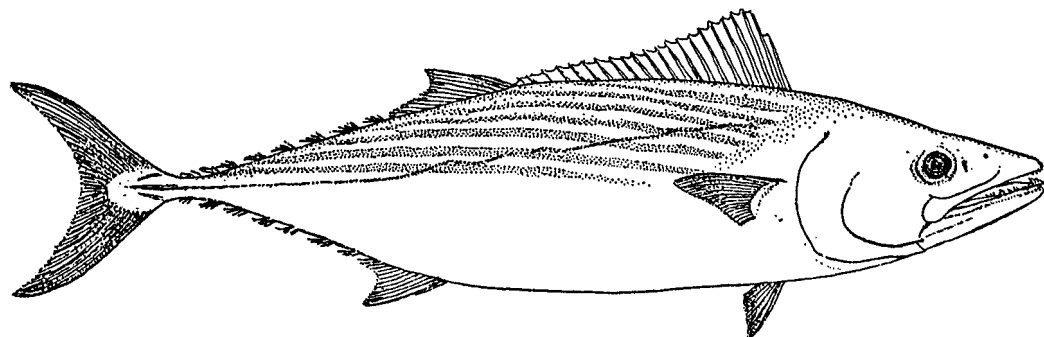


FIGURE 180.—Common bonito (*Sarda sarda*). After Smitt.

with 10 to 12 dark-blue stripes, but these dark cross-bars usually disappear before maturity.

*Size.*—This bonito grows to a length of about 3 feet and to a weight of 10 to 12 pounds.

*Habits.*—The bonito is a strong, swift, predaceous inhabitant of the open sea and like all its tribe travels in schools. When they visit our northern waters they prey upon mackerel, alewives, menhaden, and other smaller fish such as launce and silversides; also upon squid. They are very likely to be noticed, for they jump a great deal when in pursuit of their prey.

Further to the southward the bonito spawns in June; but it is not likely to spawn in the Gulf of Maine, nor does it do so in the northern part of its European range. Presumably its eggs are buoyant like those of other scombroids. Young 5 to 6 inches long have been reported as common off Orient, N. Y., early in September.<sup>85</sup> But nothing is known of its rate of growth.

*General range.*—Warmer parts of the Atlantic, including the Mediterranean; north to outer Nova Scotia,<sup>86</sup> on the American coast and to Scandinavia on the European coast.

*Occurrence in the Gulf of Maine.*—Cape Ann is the northern limit to the usual occurrence of the bonito within our Gulf. It has been taken occasionally in Casco Bay, while one was recorded from the mouth of the Kennebec River in September 1930 and two more in July 1932.<sup>87</sup> But we find no definite record of it east of this on the coast of Maine, or in the Bay of Fundy, although the young have been reported from Halifax on the outer coast of Nova Scotia. Its usual limitation to the southern half of the Gulf appears clearly in the location of the commercial catches.

In 1919<sup>88</sup> for example, pound nets, traps, and other gear, accounted for almost 34,000 pounds in Cape Cod Bay, but only 90 pounds about Cape Ann, while the entire catch landed in the fishing ports of Maine during that year was only half a dozen fish (44 pounds). And there have been so

few of them in Maine waters of late that none at all were mentioned in the fisheries statistics for that State of late years.

Bonito have been known to reach Cape Ann in larger numbers in the past, as happened in 1876, when 73 were taken in one August day in a weir near Gloucester. And probably they are far more plentiful every year out at sea in the southern part of the Gulf than these meager returns would suggest, for fishermen often mention schools of them. Capt. Solomon Jacobs reported them as very plentiful, in August 1896, for instance, in the deep water to the northward of Georges Bank. And we have seen schools of large scombroids, (probably bonito) splashing and jumping off Cape Cod more than once in August.

Apparently bonito visit New England shores only in the summer and fall. Thus the earliest catch made by a certain set of pound nets at Provincetown over a period of about 10 years was in July (1915), the latest on October 4 (1919).

The bonito is more regular in its occurrence west and south of the Cape, being common in some years at Woods Hole and especially off Marthas Vineyard, whence about 57,000 pounds were marketed in 1945. And party-boat captains have described Buzzards Bay and the waters around the Vineyard and Nantucket as full of them in some recent summers.

*Importance.*—The bonito is a good food fish. It readily bites a bait trolled from a moving boat, once one has the lure that it will strike on the particular occasion. A good many are caught in this way off southern New England, and we can assure the reader that a bonito is one of the strongest fish that swims, weight for weight, and one of the swiftest. Bonito are picked up now and then in Cape Cod Bay by anglers trolling for other fish; we heard of two taken in this way off Wellfleet, on August 29, 1950. But they are never abundant enough in the Gulf of Maine to be worth fishing for there with hook and line.

### Tuna *Thunnus thynnus* (Linnaeus) 1758

BLUE FIN TUNA; HORSE MACKEREL; GREAT ALBACORE; TUNNY; ALBACORE<sup>89</sup>

Jordan and Evermann, 1896-1900, p. 870.

*Description.*—The two dorsal fins of the tuna are practically continuous, a character (with the

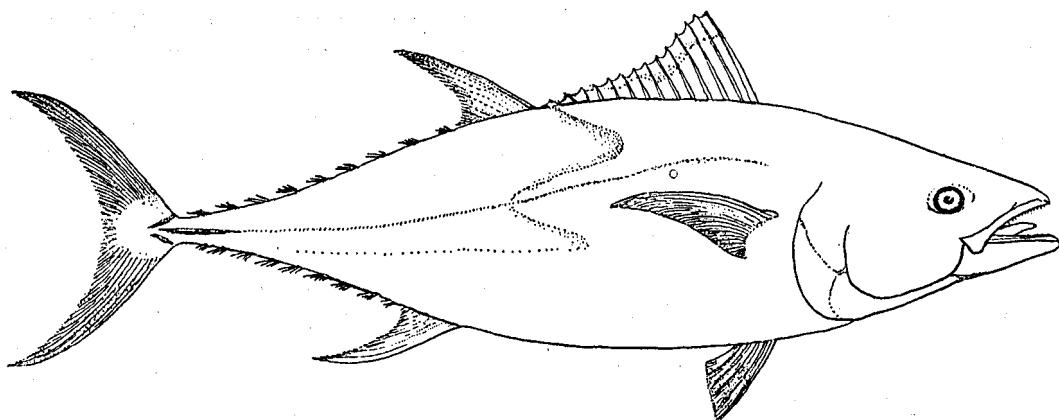
<sup>85</sup> Nichols and Breder (Zoologica, New York Zool. Soc., vol. 9, 1927, p. 123).

<sup>86</sup> "Fair numbers" have been taken in St. Margarets Bay, also some in mackerel traps near Lunenburg, and one was taken at Cape Breton, Nova Scotia, in October 1937 (McKenzie, Proc. Nova Scotian Inst. Sci., vol. 20, 1939, p. 16). It is also reported from the mouth of Halifax harbor (Jones, Proc. and Trans. Nova Scotian Inst. Sci., vol. 5, pt. 1, 1882, p. 88). One specimen, 276 mm. long, was taken off Centre East Pubnico, September 12, 1951 (reported to us by A. H. Selm).

<sup>87</sup> Reported by Walter H. Rich.

<sup>88</sup> Nineteen nineteen is the most recent year, the published statistics for which mention bonito in the regional breakdown of the total Massachusetts catch. And there is nothing in the published fishery statistics to suggest that the status of the bonito has changed since then.

<sup>89</sup> A comprehensive list of publications dealing with the tunas is given by Corwin, Division Fish and Game of California, Fish Bull. No. 22, 1930.

FIGURE 181.—Tuna (*Thunnus thynnus*). After Smitt.

large number of finlets) sufficient in itself to separate a very young one from either of our true mackerels. A small one is readily separable from the striped bonito and from the false albacore by the fact that the entire trunk of the tuna, including the belly, is scaly, the upper outline of its first dorsal fin only very slightly concave; and from the common bonito (p. 337) by a second dorsal that is considerably higher than it is long by the shape of its anal with only weakly concave margin, by the small size of its jaw teeth; and by the midline of the roof of its mouth armed with hairlike teeth. The plain coloration of the tuna, without dark markings, is still another convenient field mark for separating small ones from any of the bonito tribe that have been reported from our Gulf.

The tuna is shaped like a bonito rather than like a mackerel, with robust body, about one-fourth to one-sixth as deep as long, tapering to a pointed nose and to a very slender caudal peduncle which bears a strong median longitudinal keel on either side. The first dorsal fin (13 or 14 spines), originating close behind the axil of the pectoral, is triangular, its upper edge weakly concave, tapering backward from its first spine, and with the last spine very short indeed. And it can be laid down, flush, in a groove along the back. The second dorsal (about 13 rays, not depressible) is almost confluent with the first (a little lower than the latter in young fish and a little higher in old) is at least as high as it is long or higher, deeply concave behind, and with sharp-pointed apex. The anal fin originates under the rear end of the second dorsal to which it is similar in out-

line and size (about 12 rays). Usually there are 9 or 10 dorsal finlets and 8 or 9 anal finlets, behind the second dorsal fin and the anal fin, respectively. The tail fin is much broader than long, its margin evenly lunate, its two lobes sharp pointed, much as it is in the bonitos. The pectoral and ventral fins are of moderate size, the former scimitar-shaped and much longer than broad.<sup>90</sup>

*Color.*—The back is dark lustrous steel blue or nearly black, with gray or green reflections; the cheeks silvery; the sides and belly silvery gray, often with large silvery spots and bands, and iridescent with pink. The first dorsal is dusky to blackish; the second dusky to reddish brown; the dorsal finlets yellow with dark edgings. The anal fin is silvery gray; the anal finlets the same, or yellow; the caudal dusky but more or less silvery; the ventrals and pectorals blackish above and silvery gray below.<sup>91</sup>

*Size.*—This is the largest Gulf of Maine fish, except for some sharks; a length of 14 feet or more, and a weight of 1,600 pounds being rumored, with fish of 1,000 pounds not rare. The heaviest Rhode Island fish on record, taken about 1913, weighed 1,225 pounds, while 4 or 5 fish have been brought into Boston that weighed approximately

<sup>90</sup> The tunas and their allies are discussed by Jordan and Evermann (Occas. Papers, Cal. Acad. Sci. vol. 12, 1926); Fraser-Brunner (Annals and Magazine Nat. Hist., Ser. 12, vol. 3, 1950, pp. 142-146) has recently given a convenient key to all known species of tunas, with excellent illustrations; and Godsil and Holmberg have recently discussed the relationships of the blue-fin tunas of New England, Australia, and California (Fish. Bull. 77, California Dept. Nat. Resources, 1950).

<sup>91</sup> The foregoing description of the color is based on accounts of freshly caught tuna by Storer (Fishes of Massachusetts, 1867, p. 65) and by Nichols (Copeia, No. 111, 1922, pp. 73-74); and on fish we have seen.

1,200 pounds each, and one in 1924 that is said to have reached 1,300 pounds; and Sella<sup>92</sup> mentions a "fairly well authenticated instance" of one caught 60 to 70 years ago off Narragansett Pier, R. I., that weighed in the neighborhood of 1,500 pounds, was divided among the various hotels, and fed 1,000 people. The largest caught so far on rod and reel weighed 977 pounds and was 9 feet 9 inches long.<sup>93</sup> One of 932 pounds, taken at Wedgeport, Nova Scotia, by H. E. Teller, in September 1951, is the largest that has been caught on rod and reel in the Gulf of Maine.<sup>94</sup> Another of 864 pounds<sup>95</sup> was 9 feet 4 inches long and 88 inches in girth.

Large tuna of the same length and caught the same day may vary as much as 100 pounds or more in weight, depending on their condition, as pointed out by Crane.<sup>96</sup> Lengths and weights of tuna, before being dressed, caught in Massachusetts Bay and off Ipswich in July and August 1951 were as follows: 28 inches, 17 pounds; 34 inches, 30 pounds; 42 inches, 56 pounds; 60 inches, 144 pounds; 63 inches, 172 pounds; 66 inches, 188 pounds; 68 inches, 200 pounds; 88 inches, 516 pounds; 93 inches, 587 pounds. Off Bimini, in May and June, 1950, two 88-inch tuna averaged 415 pounds and three 93-inch fish averaged 450 pounds indicating that they are much thinner in the spring in their more southern habitat than they are in summer to the northward.<sup>97</sup>

In the western side of the Mediterranean, where tuna run smaller than in our Gulf, a 500-pound fish is very large and this is equally true off the California coast. But tuna weighing as much as 1,595 pounds (725 kilograms), if the stated weights are reliable, have been reported from the eastern parts of the Mediterranean and from the Bosphorus near Constantinople.<sup>98</sup>

*Habits.*—The tuna is a strong, swift fish and an oceanic wanderer like all its tribe. Probably its chief reason for holding to continental waters along our coasts during the warm seasons is that

its prey are more concentrated there and hence more easily caught than over the ocean basin.

The small, medium, and fairly large-sized fish, up to 350–500 pounds or so, commonly travel in small schools of half a dozen to 30 or 40 fish, but sometimes in much larger schools, and each school is usually composed of fish of about the same size: we have never heard of large and small tuna schooling together. And it seems that the very large fish usually are solitary.<sup>99</sup>

When tuna are at the surface, as they often are, they are proverbial for their habit of jumping, either singly or in schools; they may do this when swimming about, or harrying smaller fishes, or less often, when traveling in a definite direction, in which case all that are jumping do so in the same direction.

Frank Mather, for instance, reports seeing a school of 200-pounders, jumping in unison, 2 or 3 feet clear of the water. When large tuna jump, they sometimes fall flat, making a great splash, but they reenter the water a little head-first as a rule, though they do not make as complete and graceful an arc in the air as the various oceanic kinds of porpoises usually do. When schools, at the surface, are not jumping, they often splash a good deal and they are conspicuous then. We remember, for instance, sighting a large school so employed, off the Cohasset shore at a distance of about 3 miles, on one occasion. Even if they are neither jumping nor splashing, as is more commonly the case, the wakes that large ones leave behind them betray their presence, if the sea is smooth.

They sometimes cut the surface with the sickle-shaped second dorsal fin and with the tip of the caudal fin, on calm days, and they have been photographed while so doing.<sup>1</sup> But we have not seen this and experienced tuna fishermen have told us that tuna are not often seen finning. In any case, it seems that the first dorsal fin is laid back, when they do fin; at least we have never heard of a tuna as showing both of its dorsals above the surface, except after it had been hooked.<sup>2</sup>

<sup>92</sup> Internat. Rev. Gesamten Hydrobiol. Hydrogr., vol. 25, Pt. 1-2, 1931, p. 60.

<sup>93</sup> Caught by Comm. D. W. Hodson at Cape Breton, Nova Scotia, September 4, 1950.

<sup>94</sup> Reported in Salt Water Sportsman, for Oct. 1, 1951.

<sup>95</sup> Caught near Jordan Ferry, Nova Scotia, by Alfred Kenny in 1950.

<sup>96</sup> Zoologica, New York Zool. Soc., vol. 21, No. 10, 1936, p. 207.

<sup>97</sup> These records are from unpublished data furnished by Frank Mather of the Woods Hole Oceanographic Institution and Howard Schuuck of the U. S. Fish and Wildlife Service, who have given us much first-hand information on the habits of the tuna.

<sup>98</sup> Heldt, 10 Rapp. Comm. Internat. Explor. Medit., vol. 11, 1938, p. 343

<sup>99</sup> Crane (Zoologica, New York Zool. Soc., vol. 21, 1936, pp. 207-211) has given a readable account of the tuna off Casco Bay, which we cannot better, and with which our own sightings of tuna agree.

<sup>1</sup> See Farrington (Fishing the Atlantic, 1950 [approximate date], upper photo facing p. 421), for an excellent photograph of a tuna finning.

<sup>2</sup> See Farrington (Fishing the Atlantic, 1950 [approximate date], lower photo facing p. 421), for an excellent photograph of a hooked tuna showing the first dorsal fin as well as the second dorsal.



Tuna often break the surface when striking a bait, or they may even leap clear then. But for some reason they do not jump ordinarily after they are hooked, but first make one or more swift shallow runs and then tend to bore deep unless in very shallow water.

Tuna prey on smaller fishes, especially those of the schooling kinds, the particular species depending on the local supply. In the Gulf of Maine they destroy great numbers of herring, large and small; also mackerel of which they are often full. They have been reported as pursuing silver hake; 26 tuna contained these, out of 30, that were examined by Crane at Portland, Maine, in July 1936. She also reports a rosefish (*Sebastes*) in one. No doubt they take whatever small fishes are available locally, and a tuna has been known to swallow a whole dogfish as large as 8 pounds. Southward from Cape Cod they prey on menhaden, as predaceous fishes do in general. They also eat squid: Crane found squid, in two, at Portland, and quantities of euphausiid shrimps (*Meganyctiphanes*) in two others. It is not unusual for tuna to strand in pursuit of prey. But this is a timid fish and easily frightened though so voracious.

Tuna have no serious enemies in the Gulf of Maine, but killer whales take toll of them in Newfoundland waters where, writes Wulff<sup>3</sup> "one or more times annually, usually in September, orcas will ravage the tuna schools in the bays they frequent most."

The tuna is a fish of at least moderately warm seas. The smaller sizes seem rather closely restricted to regions where the surface layer is warmer than 60°-62°, and while large ones are regular visitors in summer to the eastern side of our Gulf where the water warms only to about 50°-54°, this, seemingly, is about the lower limit to the thermal range they favor.<sup>4</sup> Few tuna, for example, whether large or small, are seen in the Passamaquoddy region in most summers (p. 343) though the multitudes of small herring there would seem to offer ideal feeding conditions, but where the temperature rises only to about 52°-54° even by August, when it is highest. And seasonal chilling is generally accepted as the factor that

drives them from our northern coasts in the autumn.

Tuna tolerate a wide range of salinity, and they run well up into bays, and even into harbors in pursuit of herring; the bays on the outer Nova Scotian coast for example; Bras D'or "lake," Cape Breton; Bonne Bay on the west coast of Newfoundland; and Trinity and Conception Bays on the southeastern coast of Newfoundland. But we have never heard of one entering brackish water.

Tuna are as definitely migratory as the mackerel is, those that visit our coasts working northward in spring, to drop out of sight again late in the autumn.<sup>5</sup> They are said to be around Jamaica throughout the year, but most plentiful there in March and April.<sup>6</sup> Ordinarily they appear earliest on the Bahaman side of the Straits of Florida in the first or second week in May; next off New Jersey, off Long Island, off southern New England, and in Cape Cod Bay in June. But they have been reported well within the Gulf of Maine by the last week of May (p. 342), or nearly as early as in Bahaman waters. This, with the added fact that they are not known to approach the American coast anywhere between the Bahama Channel and North Carolina or Virginia<sup>7</sup> suggests that we may have two separate populations, a southern and a northern.

They usually arrive in Bonne Bay, on the Gulf of St. Lawrence coast of Newfoundland in late June or in early July, and a week or two later in Trinity and Conception Bays, on the southeastern part of the Newfoundland coast.<sup>8</sup>

Finally, we should point out that it is not known yet whether the tuna populations of the two sides of the Atlantic are entirely separate, one from the other, or whether more or less interchange takes place between them.

The vertical range of the tuna is from the surface down to an indeterminate depth; the only barriers likely to limit their descent are the

<sup>3</sup> See Heldt (Bull. No. 5, Station Oceanographique de Salambo, 1926), and Sella (Int. Rev. Hydrobiol., Hydrogr., vol. 24, 1930, p. 446) for accounts of the migration and food of tuna in the Mediterranean and eastern Atlantic.

<sup>4</sup> Information contributed by Capt. Eddie Wall and Walter Whiteman, for which we are indebted to Frank Mather of the Woods Hole Oceanographic Institution.

<sup>5</sup> Frank Mather of the Woods Hole Oceanographic Institution informs us that a 600-pound tuna has been taken in a trap 200 miles south of Chincoteague, Md., and that small ones are taken off Chincoteague. "Tuna" are reported from time to time off North Carolina, also. But it is not yet certain whether these actually are "bluofins."

<sup>6</sup> Wulff, Internat. Game Fish Assoc. Yearbook, 1943, p. 65.

<sup>1</sup> Internat. Game Fish Assoc. Yearbook, 1945, p. 65.

<sup>2</sup> The tuna that visit the west coast of Newfoundland find summer temperatures as high as 59°-60° along the south coast of Newfoundland, and 55°-57° in Trinity and Conception Bays on the southeastern part of the Newfoundland coast.

low temperatures they would encounter in regions where there is a strong thermal gradient (the Gulf of Maine is an example, p. 344), the increasing scarcity of prey, and, perhaps, darkness.

The breeding habits of the tuna remained a mystery until recently. And while it is now known that those that visit the Mediterranean spawn in June and July, both the spawning grounds of our American tuna and their spawning season are yet to be learned.

The eggs (Mediterranean) are buoyant, small for so large a fish (1.05–1.12 mm. in diameter) with one oil globule of about 0.27 mm.

The larval stages have also been recorded in the Mediterranean in abundance; and the characters determined by which they may be distinguished from allied species.<sup>9</sup> Tuna fry of 3¼ inches (81 mm.) and about 6 inches (152 mm.) have also been pictured and are described from the Gulf of Mexico by Fowler.<sup>10</sup>

*Rate of growth.*—The rate of growth of so large a fish is naturally a matter of much interest. Young fry grow so rapidly that fish hatched in June in the Mediterranean reach a weight of a little less than ¼ pound to a little more than 1 pound (300–500 grams) by September. According to studies by Sella, based on the number of concentric rings in the vertebrae<sup>11</sup> for 1,500 individuals, Mediterranean tuna average about 10 pounds at 1 year of age, about 21 pounds at 2 years, about 35 to 36 pounds at 3 years, about 56 pounds at 4 years, about 88 pounds at 5 years, about 128 pounds at 6 years, about 170 pounds at 7 years, about 214 pounds at 8 years, about 265 pounds at 9 years, about 320 pounds at 10 years, about 375 pounds at 11 years, about 440 pounds at 12 years, about 517 pounds at 13 years, and 616 to 660 pounds at 14 years of age.

Average lengths of 20 to 24 inches in their second summer of growth, 27 to 34 inches in the third, 35 to 40 inches in the fourth, and 42 to 46 inches in the fifth, reported by Westman and Gilbert<sup>12</sup> suggest about the same growth rate for

the American tuna. Thus the giants of 800 pounds and heavier have reached a very respectable age. According to Sella<sup>13</sup> Mediterranean tuna weighing only 35 pounds may already be sexually mature. But nothing definite is known about the American fish in this regard.

*General range.*—Warmer parts of the Atlantic (including the Mediterranean), Pacific and Indian Oceans;<sup>14</sup> north regularly to the western, southern and southeast coasts of Newfoundland,<sup>15</sup> on the western side of the Atlantic; to Iceland and northern Norway (Lofoten Islands) on the European side.

*Occurrence in the Gulf of Maine.*—The tuna is a yearly visitor to our Gulf. Every fisherman knows the tuna or horse mackerel, as it used to be called, and this great fish visits all parts of the Gulf of Maine, but we do not understand its comings and goings much better now than when Storer called attention to its abundance about Provincetown nearly a century ago. Scarcity is not to blame for this (it is common enough) but the fact that little attention was paid to it until recently for want of market value. And while a demand for tuna has developed of late, as is reflected in the catches (p. 346), and while many anglers now fish for them (p. 347), most of the resulting information is confined to the few inshore localities where they either seem to be the most plentiful, or where they are caught most easily from small craft, or incidentally in the fish traps.

It is now known that tuna are to be found all around the shores of the Gulf from Cape Cod to eastern Maine; in the Bay of Fundy; also along the west coast of Nova Scotia. And fishermen often report them on Nantucket Shoals, Georges Bank, and Browns. In ordinary years the first of them are likely to be seen as early in the season between Cape Ann and the Maine State line as they are off Cape Cod. In 1950, for example, the earliest report of them was off Hampton, N. H., May 26; the next off Plum Island, Mass., on June 9; and it was not until about June 16 that word came of one hooked in Cape Cod Bay, and of the first fish (one of 462 pounds) harpooned off Plum

<sup>9</sup> See Sella (Atti Reale accad. Lincei, Roma, Ser. 5, vol. 33, Fasc. 7–8, semestr. 1, 1924, p. 300) and Sanzo (R. Comit. Talass. Ital. Mem., No. 189, 1932) for description of the larvae; Heldt (Bull. 5 and 18, Station Oceanographique Salambo, 1926 and 1930) for summaries of all previous observations on the breeding habits and larval stages.

<sup>10</sup> Monogr. 6, Acad. Nat. Sci. Philadelphia, 1944, pp. 261, 373.

<sup>11</sup> Memoria No. 166, R. Comitato Thalassografico Italiano, 1929, p. 10.

<sup>12</sup> Copeia, 1941, pp. 70–72, based on length frequencies for those up to 3 years of age and on scale studies for the older ones.

<sup>13</sup> Memoria No. 156, R. Comitato Thalassografico Italiano, 1929, p. 6.

<sup>14</sup> Sella's recent studies (Internat. Rev. Ges. Hydrobiol., Hydrogr., vol. 25, 1931, pp. 48–50) showed no characteristic differences between the bluefin tuna of the two sides of the Atlantic, and those of different oceans appear, at most, to represent races of a single wide-ranging species.

<sup>15</sup> Vesey-Fitzgerald and Lamonte (Game Fishes of the World, 1949, p. 183) report tuna from Hamilton Inlet.

Island. This may have been an early year. But tuna are to be expected throughout the western side of the Gulf generally by the middle or end of June, which is about as early as they ordinarily appear in any numbers off southern New England; and they appear on the Nova Scotian side of the Gulf by the first of July if not earlier. In 1950, for example, upwards of 450 had been landed from Ipswich Bay by July 31, the largest weighing 734 pounds.<sup>16</sup> The peak season usually is from about the middle or end of July to the middle of September off Massachusetts; July and August off Casco Bay; through August and September along western Nova Scotia.

The vicinity of Provincetown, with Cape Cod Bay, has long been known as a center of abundance for tuna. Other well known centers are from Cape Ann north to Boon Island and from the Ipswich Bay-Plum Island shore out to Jeffreys Ledge some 30 miles off shore; off the mouth of Casco Bay and for some distance thence eastward; and the vicinity of Wedgeport, on the west coast of Nova Scotia, where the International tuna matches are held. Fewer are seen along the eastern coast of Maine, though we are told that a fishery for tuna has developed during the current summer off Southwest Harbor, Mount Desert Island,<sup>17</sup> and in the New Brunswick side of the Bay of Fundy.

It is especially interesting that there are so few tuna in the Passamaquoddy region in most years that the capture of even an occasional fish in the local weirs causes comment, for the astounding abundance of small herring there would seem to offer them an inexhaustible supply of food. But a summer comes now and then when they are far more plentiful there than usual; thus Passamaquoddy waters are said to have "teemed with tuna" in the summer of 1937<sup>18</sup> when as many as 7 were taken at Campobello in a single seining; and several were reported again and a few caught in Passamaquoddy Bay in the summer of 1945.<sup>19</sup>

Dr. Huntsman writes us that "schools" were reported there in the summer of 1951, when the water was warmer than usual. And Leslie Scattergood reports 22, ranging from 113 to 161

pounds, caught in a herring weir at Grand Manan during that October.

The regional contrasts in local abundance within our Gulf may be illustrated for a representative year by the reported catches of tuna by counties around the coast from southwest to northeast, for 1945.

Massachusetts:	Pounds
Barnstable (chiefly Cape Cod Bay)-----	301,900
Plymouth-----	600
Essex-----	50,300
Maine:	
York-----	45,300
Cumberland } vicinity of Casco Bay-----	815,300
Sagadahoc }	
Lincoln-----	900
Knox (Penobscot Bay)-----	0
Hancock-----	0
Washington-----	0
Nova Scotia:	
Annapolis-----	0
Yarmouth-----	35,800
Shelburne to Cape Sable-----	0

In most years the tuna that are seen and caught near Provincetown at the tip of Cape Cod, and in Cape Cod Bay, are small (so-called "school fish" weighing less than 200 pounds with many as small as 30 to 70 pounds; and few of those caught there in most years are large. The smallest reported in the inner part of the Gulf of Maine was a run of 20- to 26-pound fish (2-year-olds) taken in Cape Cod Bay in October 1950.<sup>20</sup> And good catches of "school" fish of 30-70 pounds, but few larger, if any, are being made again off the tip of Cape Cod around the shores of Cape Cod Bay at this writing (August 5, 1951), and have been for several weeks past. Large numbers of even smaller tuna, averaging about 11 pounds, have been encountered on the southwestern part of Georges Bank (p. 344), and many of these little ones (from 8 pounds or so upwards) are caught off southern New England every summer and autumn, especially near Block Island.<sup>21</sup> On the other hand, most of those found northward from Cape Ann, and in the Nova Scotian side of the Gulf are large, few of them as small as 100 pounds. Thus, the average live weights of 1,641 tuna that were landed at Portland, Maine, during the period 1926 to 1935, varied between 495 pounds

<sup>16</sup> Reported by Henry Moore in the *Boston Herald*, July 31, 1950.

<sup>17</sup> Information supplied by Frank Mather, of the Woods Hole Oceanographic Institution.

<sup>18</sup> *Atlantic Fisherman*, vol. 18, No. 9, October 1937, p. 28.

<sup>19</sup> *Atlantic Fisherman*, vol. 26, No. 8, September 1945, p. 52.

<sup>20</sup> Reported by Frank Mather of the Woods Hole Oceanographic Institution.

<sup>21</sup> Frank Mather, of the Woods Hole Oceanographic Institution, reports a catch of 110 of them, weighing about 10 pounds, off No Mans Land, on September 16, 1951.

and about 630 pounds yearly, as appears from the following table.<sup>22</sup>

Year	Number	Largest	Smallest	Average
1926.....	90	945	416	515
1928.....	176	858	74	510
1929.....	152	905	447	630
1930.....	172	967	423	620
1931.....	107	840	420	565
1932.....	91	800	409	500
1933.....	162	909	93	495
1934.....	268	955	68	530
1935.....	423	913	33	525

Thirty-two fish caught at the mouth of Casco Bay in 1950 averaged 468 pounds, the heaviest 643 pounds;<sup>23</sup> the smallest among 34 measured by Crane,<sup>24</sup> at Portland, Maine, weighed 65 pounds, the heaviest 860 pounds. And many fish are taken of 700 pounds and heavier. Similarly, 23 tuna caught during the international match at Wedgeport, Nova Scotia, in the second week of August 1950, weighed from 362 pounds to 744 pounds, and 72 taken there during the match of the previous year averaged about 360 pounds, the largest weighing 857 pounds. Also, most of the tuna caught in the Gulf of St. Lawrence are rather large.

The reason for this regional segregation of tuna of different sizes is not known, or for the variation therein from year to year. We suspect that temperature is chiefly responsible; i. e., that the larger fish are more tolerant than the small of the lower temperatures prevailing in the northern and northeastern parts of the Gulf, and in more northerly regions. Especially suggestive in this connection is the fact that the tuna run so large off Wedgeport, western Nova Scotia, where the abundant herring offer excellent feeding conditions, but where the water does not ordinarily warm above about 54° F. along the open coast, though to a somewhat higher figure locally, in enclosed situations.

So many tuna come so very close inshore in Cape Cod Bay that nearly all of the commercial catch made there is taken in the traps; large schools have even been sighted within Provincetown Harbor (on October 11, 1950, for example<sup>25</sup>) and occasionally a tuna comes into the surf either to strip the reel of some surf fisherman or to be landed (p. 347). The tuna that are taken north of Cape Ann are farther out; all of them, however, are caught

within 30 miles or so of the land, at farthest. And while a great concentration of tuna was encountered by the *Albatross III* on the southwestern part of Georges Bank, on September 18, 1950, when 25 were hooked and landed, all very small, about 11 pounds apiece, it is unusual to see any large number on the offshore banks.

The tuna that are seen or caught in our Gulf all are near the surface, or at least where the water is not more than 35 to 40 fathoms deep. How deep down they might be found is not known. But it is likely that they tend to keep within 50 fathoms or so of the surface, for the deeper water in the Gulf is colder than tuna appear to like (p. 341).

In some years the tuna appear to remain fairly stationary in whatever part of the Gulf they visit, for weeks at a time, as is indicated in the consistency of catches, or the sightings reported, which is equally true of them in Newfoundland waters, according to Wulff.<sup>26</sup> In other years they may disappear suddenly from one locality or another, after a brief stay, and without any apparent reason. In 1926, for example, when about 70 fish were taken in July off Casco Bay, only 17 were caught there in August, 3 in September, and only 1 in October (the 4th).<sup>27</sup> In 1950 they deserted the Ipswich Bay-Plum Island region during the last week of August, not to reappear there in any numbers that season, though they continued plentiful enough off the Maine coast farther north to be worth fishing for until the end of September, with some in the Cape Cod Bay-Provincetown region until early October.

There are tuna in good numbers along the outer Nova Scotia coast, off Shelburne, the vicinity of Liverpool at the mouth of the Mersey River, the mouth of the La Have River, Mahone Bay, and St. Margaret Bay being centers of abundance as appear from landings of 258,000 pounds in Lunenburg County and 201,000 pounds in Halifax County in 1950. A few, also, are seen and caught around Cape Breton. It was here that the record size fish was taken with rod and reel (p. 344).

Catch records suggest that only a few visit the southern side of the Gulf of St. Lawrence; 400 pounds were reported from the Gulf shore of Cape Breton in 1944, none in 1946, and it was only in one year (1925) that any were reported (975

<sup>22</sup> Data gathered by the late W. H. Rich of the U. S. Bureau of Fisheries.

<sup>23</sup> Caught by Capt. Earl Larrabee; reported in *Saltwater Sportsman* for Aug. 25, 1950.

<sup>24</sup> *Zoologica*, New York Zool. Soc., vol. 21, No. 16, 1936, p. 207.

<sup>25</sup> Reported in *Cape Cod Standard Times*, October 11, 1950.

<sup>26</sup> International Game Fish Assoc., Yearbook, 1943, p. 65.

<sup>27</sup> Data from Walter H. Rich of Portland, Maine.

pounds)<sup>28</sup> from Prince Edward Island during the period 1917 to 1928. They may visit the west coast of Newfoundland more regularly; for Wulff speaks of them as common and gives a photograph of tuna finning at the surface in Bonne Bay,<sup>29</sup> but we have not heard anything to suggest that they are anywhere near so plentiful there as they are in Nova Scotian waters or southward. Wulff writes of them as "few" on the southern Newfoundland coast, at present; but they appear to be regular visitors to Conception and Trinity Bays on the southeast coast; Mr. Tibbetts informed us that he once saw an abundance of tuna in Notre Dame Bay, midway of the east coast of Newfoundland; and they are reported from Hamilton Inlet, Labrador, their most northerly known outpost on the American Coast of the Atlantic.

Most of the tuna disappear from the coasts of Maine and of northern Massachusetts by the end of September, or by the first part of October at the latest, depending on whether the season is an early one or a late.<sup>30</sup> But considerable numbers remain in Cape Cod Bay and around the tip of Cape Cod until well into October, or even into November in some years. Thus in 1950 large schools were seen in Provincetown Harbor, and more than 5,000 pounds of small fish, averaging about 75 pounds, were landed there on October 11,<sup>31</sup> while in 1949 about 2,000 pounds were caught nearby between November 1 and 14.

The dates of the earliest and latest catches, made by a set of 8 traps, at North Truro, Cape Cod Bay, during the period 1943 to 1952<sup>32</sup> are illustrative.

Year	Earliest catch	Latest catch
1943.....	July 8	Oct. 6
1944.....	June 29	.....
1945.....	June 25	Oct. 9
1946.....	June 15	Oct. 26
1947.....	June 21	Oct. 28
1948.....	June 11	Oct. 28
1949.....	June 7	Nov. 14
1951.....	July 7	Oct. 15
1952.....	June 24	Oct. 24

The monthly catches, by these same traps, mark July and August as the most productive

months. The number of pounds of tuna (dressed weight) follows:

Month	Largest catch	Smallest catch
June.....	17, 520	0
July.....	148, 139	12, 255
August.....	185, 305	5, 029
September.....	70, 125	<sup>33</sup> 2, 365
October.....	43, 603	330
November <sup>34</sup> .....	2, 197	0

Catches have also been reported along western Nova Scotia as late as the third week in October, and Wulff writes of tuna lingering through the month in the bays of Newfoundland, which is as late as they remain in any part of our Gulf.

Tuna are never reported as seen moving southward on their way out of the Gulf to their winter quarters; they drop just out of sight.

The wintering grounds of the particular bodies of tuna that summer in the Gulf of Maine, and of those that go farther east and north, are not known. Small (20-50 lb.) fish, it is true, have been caught occasionally in coastal waters off southern New England from January to March; off Block Island, for example, in 1928.<sup>35</sup> But the bulk of the northern contingents certainly travel farther. It is probable that they winter in deep water as the Mediterranean tuna do, perhaps along the continental slope off our Middle Atlantic coast, perhaps so much farther south that some of the tuna seen (and caught) in spring in the Straits of Florida are our Gulf of Maine and Nova Scotian fish, on their way north again.

We are equally in the dark as to the spawning grounds of the American tuna, for although the Gulf of Maine fish are of breeding age, no ripe ones have ever been seen off the New England or Canadian coasts, or even fish approaching ripeness.

*Abundance.*—We dare not guess how many tuna are in our Gulf in any summer, there being no way to estimate how large a proportion of them the yearly catch represents. We suspect that they are fewer than reports would suggest, for being so large, a few hundred of them make a great show if they are at the surface, whereas an equal number of mackerel, for instance, would never be noticed. Neither is any definite information available as to their annual fluctuations in

<sup>28</sup> Sella, Internat. Rev. Ges. Hydrobiol., Hydrogr., vol. 25, 1931, p. 50.

<sup>29</sup> Internat. Game Fish Assoc. Yearbook, 1943, p. 66.

<sup>30</sup> In 1950 seven tuna of 200-300 pounds were caught off Boars Head, Malne, during the first week of October.

<sup>31</sup> Reported in Cape Cod Standard Times, October 11, 1950.

<sup>32</sup> Information contributed by the Pond Village Cold Storage Co.

<sup>33</sup> The year 1944 is omitted from the calculation for September-November, because the traps were not fished after September 14th that year.

<sup>34</sup> The only catch recorded for November was 2,197 pounds in 1949.

<sup>35</sup> Sella, Internat. Rev. Gesanten Hydrobiol., Hydrogr., vol. 25, 1931, p. 62.

abundance, though fishermen are well aware that their numbers in any part of the Gulf do vary widely from year to year. Thus it is on record that they were scarce in the Massachusetts Bay region for two or three years prior to 1904, but were plentiful that summer. Commercial landings suggest that they were scarce again in 1943, when the landings came to only about 380,000 pounds for Maine and Massachusetts combined.<sup>36</sup>

But they appear to have been much more plentiful again off the Maine coast in 1945 (catch there about 850,000 lb.); more plentiful than they have been since, if the commercial landings are a reliable index to the ups and downs of the tuna population, which they may not be. The following catch statistics of tuna landings (in pounds) suggest that the stock built up more slowly, from the 1943 low in Massachusetts waters, to a peak in 1948, which was a big year on the Ipswich Bay grounds (p. 343), as well as in Cape Cod Bay.

Year	Maine	Massachusetts
1943.....	25, 000	129, 500
1944.....	463, 500	272, 900
1945.....	859, 500	356, 400
1946.....	421, 800	571, 100
1947.....	186, 600	726, 400
1948.....	229, 100	1, 627, 000

In 1949, the catch by traps in Cape Cod Bay alone was 811,160 pounds, suggesting a total of more than a million pounds from the Gulf of Maine coast of Massachusetts.

During that banner season 2,164 large tuna were taken on hand lines where the druggers work, off Ipswich Bay; while 806 fish (305,300 lb.) were taken off Wedgeport, Nova Scotia, in 1948, 1,760 fish (449,362 lb.) in 1949.

But they were scarce in 1950, to judge from reports coming in from all along our coast: a week's fishing, for instance, by the same number of rods and at about the same date, yielded only about half as many on the famous Soldiers Reef off Wedgeport during the International Match that summer as it had the year before. Many fewer were caught by anglers in Cape Cod Bay in 1950 than in 1949, and the tuna disappeared from the Ipswich Bay region unusually early that year, as noted above (p. 344). It is too early (August 5) to forecast how the 1951 season may develop.

<sup>36</sup> The weights given in the Fisheries statistics are for the dressed fish, and represent about 80 percent of the live weight.

The largest Gulf of Maine catches of which we have heard were of 336 fish, weighing about 75,000 pounds taken at one lift of 3 traps set for mackerel on the Barnstable shore of Cape Cod Bay, Aug. 5, 1948;<sup>37</sup> and of 120,000 pounds of fish ranging from 25 to 30 pounds seined some 50 miles east of Cape Cod on September 18, 1951, by the *Western Explorer*, chartered by the U. S. Fish and Wildlife Service for experimental fishing for tuna.

*Importance.*—Horse mackerel were formerly regarded as a nuisance on the Atlantic coast, for bands of them made trouble for fishermen by following herring or mackerel into the traps and pounds, to tear their way out again through the net unless harpooned. Many years ago, when fish oil was more valuable than now, a few were sometimes harpooned for oil, which was tried out of the heads and bellies, but there was no sale for their meat. The tuna, however, has been highly valued as a food fish for many years, not only in the Mediterranean, but on the west coast of the United States. And a local demand has developed on our coast, supplied chiefly by local fisheries off Casco Bay, in the Cape Ann-Boone Island region, and in the Cape Cod Bay region.

With this increasing demand, the reported landings on the Maine and Massachusetts coasts have risen from about 94,000 pounds in 1919, to around 250,000 pounds yearly in the early 1930's, and to about 1 to nearly 2 million pounds for the years 1945 to 1948, this last representing around 3,000–6,000 fish, if they averaged 300–400 pounds in weight (see table, p. 346). The average value to the fisherman in 1946 was about 7–9 cents per pound and all that are caught now sell readily. The annual catches off the entire coast of Nova Scotia ranged from 152,000 pounds to about 1,550,000 pounds during the period 1917 to 1928; from 402,000 to 1,820,000 pounds for the 5 years 1942–46.

The commercial catch off the coasts of Maine is made mostly by harpoon; that off northern Massachusetts by hook and line and by harpoon; that off the Cape Cod Bay region mostly in the traps.<sup>38</sup>

<sup>37</sup> A photograph of part of the catch was published in the Boston Herald, August 6, 1948.

<sup>38</sup> In 1945 about 60 percent of the catch reported for Maine was by harpoon, almost all the remainder on hand lines; in 1946 about 98 percent was harpooned. About 86 percent of the Massachusetts catch was taken in traps of one sort or another in 1945, about 90 percent in 1946.

But experiments are in progress, by the U. S. Fish and Wildlife Service, to find whether a profitable seine fishery or long line fishery can be developed for these great fish in our Gulf, with the hope of providing a more dependable supply, and through a longer season.

The sporting qualities of the tuna in our Gulf deserve a word, though an extended account would be out of place here. Encouraged by the famous tuna fishing off the coast of southern California, and by the knowledge that tuna run much larger in the Gulf of Maine than they do on the Pacific coast, several anglers had caught these huge fish with light tackle at various points in New England and Nova Scotia by 1925, when the first edition of this book appeared. Small tuna will often take artificial lures especially if trolled at high speed and close to the vessel's stern, while large ones will take a hook baited with herring, mackerel, or other fish. And tuna fishing has now grown to be so popular and successful a sport that many party boats go out regularly off Provincetown, in Cape Cod Bay, to the Ipswich Bay-Isles of Shoals-Boone Island region, off Casco Bay, and off Wedgeport on the Nova Scotian side.<sup>39</sup>

To date, the largest tuna that has been landed on rod and reel in the Gulf of Maine was one of 932 pounds, caught by H. E. Teller at Wedgeport, Nova Scotia, September 11, 1951 (p. 340). Another of 927 pounds was caught in Ipswich Bay, August 4, 1940, by Dr. J. B. Vernaglia. We have heard of one of 180 pounds landed with ordinary surf-casting tackle on the beach at Plum Island, a

<sup>39</sup> Farrington (Field and Stream magazine for August 1950, p. 84) has recently given an interesting account of the methods employed by rod and reel anglers, in these localities. Crane (Zoologica, N. Y. Zool. Soc., vol. 21, No. 16, 1936, p. 210) describes in a readable way the small boat harpoon fishing for tuna off Casco Bay, Maine.

notable feat.<sup>40</sup> Even a small tuna, such as a thirty-pounder that was caught on a black plug by Wm. Lakaitis, surf casting at North Truro on the night of July 28, 1951, is a far more stronger adversary in the surf than a striped bass of equal size.

**Spanish mackerel** *Scomberomorus maculatus*  
(Mitchill) 1815

Jordan and Evermann, 1896-1900, p. 874.

*Description.*—The Spanish mackerel has the outline of the slender mackerel rather than of the stout bonito, its body being nearly  $4\frac{1}{2}$  to 5 times as long as it is deep. But there is no danger of confusing it with either of the true mackerels, first, because its two dorsal fins (like those of the bonitos) are hardly separated, and second, because of its color pattern. Its high second dorsal, slender form, and spotted sides mark it off at first glance from our bonitos, while its color, slender form, long first-dorsal fin, and the outline of its second dorsal distinguish it from a small tuna. The most clear-cut distinction between the Spanish and its close relatives the king mackerel and the cavalla, is that the pectoral fins of the Spanish are naked but those of the last two are mostly covered with scales. The ventral fins, also, originate definitely behind the origin of the first dorsal in the Spanish, under it or only a very little rearward in the king; and the color differs.

The most distinctive anatomic character of the Spanish, king, and cavalla among our local scombroids is the large conical jaw teeth. The caudal peduncle of the spanish mackerel is keeled; its lateral line wavy; its first dorsal fin (17 to 18

<sup>40</sup> Landed on August 12, 1950, by M. L. Insleyn.

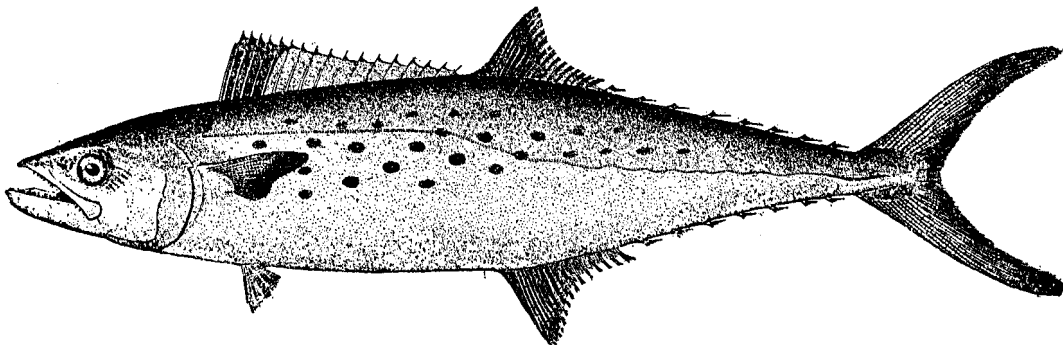


FIGURE 182.—Spanish mackerel (*Scomberomorus maculatus*). From Goode. Drawing by H. L. Todd.

spined) is triangular; its second dorsal (14 to 18 rays) is concave and originates a short distance in front of the anal, which is similar to it in form and size. It has 8 or 9 dorsal and as many anal finlets. Its pectorals are naked; its caudal is deeply lunate, with the outer rays decidedly longer than those of the common mackerel. It has 32 teeth, or fewer, in each jaw.

*Color.*—The Spanish mackerel is dark bluish or blue green above, pale below, like all scombroids, and silvery, its sides marked with many small, oblong-oval, dull orange or yellowish, spots, both above the lateral line and below, these spots being a very diagnostic character. The fact that the membrane of the front one-third of its first dorsal fin is black (blue in the king, p. 348), whereas its rear part is greenish white, is an equally useful field mark. The second dorsal and pectoral fins are pale yellowish with dusky edges; the anal and the ventrals are white.

*Size.*—The maximum weight is about 9 or 10 pounds,<sup>41</sup> maximum length about 36 inches, but the fish average less than 3 pounds as caught.

*General range.*—Both coasts of North America, north commonly as far as Chesapeake Bay in the Atlantic, and to Maine as a stray; south to Brazil.

*Occurrence in the Gulf of Maine.*—The Spanish mackerel is a summer visitor all along the Atlantic coast of the United States, as far north as New York; less regularly along the southern coasts of New England, though a few are taken during most summers at Woods Hole. But it is only a stray in the colder waters of the Gulf of Maine, where occasional fish are taken in Cape Cod Bay every

<sup>41</sup> A weight of 25 pounds is recorded by Smith (North Carolina Geol. Econ. Surv., vol. 2, 1907, p. 191) for a specimen observed in a Washington, D. C., fish market. If the identity was correct and this was not the closely related king mackerel *Scomberomorus regalis* it must be considered a case of gigantism.

year or two. In 1896 the local catch rose to 37 fish (Provincetown and Truro traps), and there is record of it at Lynn, Mass. But Spanish mackerel are so rare north of this point that Monhegan Island is the only locality-record for Maine, and the most northerly known outpost for the species.

**King mackerel** *Scomberomorus regalis* (Bloch)  
1793

#### KINGFISH

Jordan and Evermann, 1896-1900, p. 875.

*Description.*—The king mackerel resembles the Spanish mackerel closely in general appearance, but its pectoral fins are mostly covered with scales; its ventrals are below the first dorsal, instead of definitely behind the origin of the latter; its head is relatively longer, its nose more pointed, its teeth more numerous (about 40 in each jaw), triangular and very sharp pointed; and the upper half of its first dorsal is deep blue. Furthermore, the king mackerel is marked by a narrow brownish stripe running from close behind each pectoral fin to the base of the caudal, crossing the lateral line as the latter bows downward below the second dorsal fin. Its side spots, too, are mostly below the lateral line and arranged in rows, whereas the spots of the Spanish mackerel are irregularly scattered, with about as many above the lateral line as below it.

*Size.*—Said to reach 35 pounds, but the average weight is between 5 and 10 pounds.

*General range.*—Atlantic Coast of North America, Cape Cod to Brazil, abundant among the West Indies and around southern Florida.

*Occurrence in the Gulf of Maine.*—This southern fish is recorded by Dr. W. C. Kendall at Monomoy, at the southern elbow of Cape Cod, but it has not been taken elsewhere in the Gulf of Maine.

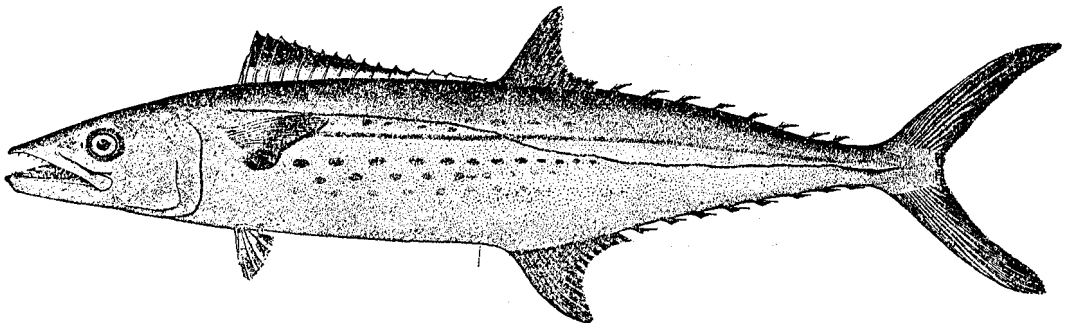


FIGURE 183.—King mackerel (*Scomberomorus regalis*), Key West, Florida. From Goode. Drawing by H. L. Todd.



*Cavalla* *Scomberomorus cavalla* (Cuvier) 1829 <sup>42</sup>

CERO

Jordan and Evermann, 1896-1900, p. 875.

*Description.*—The pectorals of the cavalla are scaly, and its anal fin, like that of the king mackerel originates about under the origin of its second dorsal, in which it differs from the Spanish mackerel (p. 347). In fact, it resembles the king mackerel so closely in general appearance that the one might easily be taken for the other by anybody not used to handling the two fish as southern fisherman are. But the lateral line (very conspicuous in both) is a sure clue to identity, for this dips downward abruptly in the cavalla under the forepart of the second dorsal fin, but slopes down only gradually there in the king mackerel. Other points of difference are that the outline of the first dorsal fin is concave in the cavalla (nearly straight in the king); that the cavalla has a large number of teeth (about 40 in each jaw, as against about 30); that its body

is more slender (about one-sixth as deep as it is long); and that the upper forepart of its first dorsal fin is not noticeably darker than the remainder of the fin.

*Color.*—Iron gray above, silvery lower down on the sides and on the belly; the sides marked with darker gray or yellowish spots, which tend to disappear in large fish.

*Size.*—Said to reach a length of a little more than 5 feet, and a weight of about 100 pounds. The rod and reel record is 73½ pounds, for one taken off Bimini, Bahamas, February 1935, by L. B. Harrison.

*General range.*—Warm parts of the Atlantic; south to Brazil in the western side; north regularly to North Carolina (June-November);<sup>43</sup> occasionally to southern Massachusetts; and as a stray to the southern part of the Gulf of Maine.

*Occurrence in the Gulf of Maine.*—The only Gulf of Maine record of which we know is of one 20¼ inches long (to base of caudal fin) taken in a trap at North Truro, Cape Cod, in August 1949.<sup>44</sup>

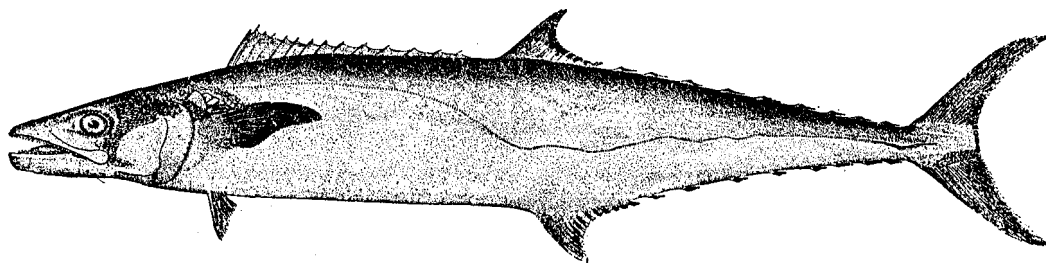


FIGURE 184.—Cavalla (*Scomberomorus cavalla*), Woods Hole. From Goode. Drawing by H. L. Todd.

## THE ESCOLARS. FAMILY GEMPYLIDAE

These fishes are closely allied to the true mackerels, the most obvious differences being that they lack the keels on the sides of the caudal peduncle so characteristic of the mackerels.

*Escolar* *Ruvettus pretiosus* Cocco 1829

OILFISH; SCOURFISH; PLAINTAIL

Jordan and Evermann, 1896-1900, p. 879.

*Description.*—This fish suggests the mackerel family in its slender fusiform shape and in the general arrangement of its fins. And its first (spiny) dorsal (13 to 15 spines), like that of the Spanish mackerel, is much longer than the second dorsal (18 soft rays). But it is separable at a

glance from all Gulf of Maine mackerels by the facts that it has only 2 dorsal finlets and 2 anal finlets, and that its skin is set with bony plates armed with short spines instead of being velvety with small scales, as it is in the case of the mackerel tribe. The caudal fin is deeply forked. The first dorsal is much lower than the second, and the anal is situated below the second dorsal, which it parallels in its outlines.

*Color.*—Described as purplish brown, darkest above, with blackish patches, and with the inside of the mouth dusky.

<sup>42</sup> Fowler (Proc. Acad. Nat. Sci. Philadelphia, vol. 56, 1905, p. 766) refers this species to a new subgenus *Sterra*.

<sup>43</sup> Taylor (Survey Marine Fisheries North Carolina: University of North Carolina Press, 1951, pp. 261-265) has given an interesting survey of the seasonal presence of various southern game fishes off the North Carolina coast.

<sup>44</sup> This specimen was received through the kindness of John Worthington and the Pond Village Cold Storage Co.

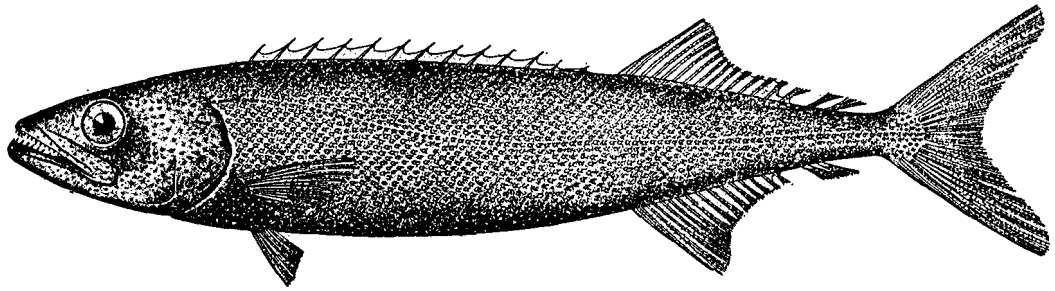


FIGURE 185.—Escolar (*Ruvettus pretiosus*), Georges Bank. From Goode and Bean. Drawing by J. C. van Hook.

*Size*.—The escolar grows to a weight of at least 100 pounds.

*General range*.—Tropical parts of the Atlantic, and the Mediterranean, in moderately deep water (usually 100 to 400 fathoms); also widespread in warm latitudes in the North Pacific<sup>45</sup> and in East Indian waters. It is plentiful around Cuba though not reported from Puerto Rico; is known from Bermuda; and it has been taken as a stray as far north as the Bay of Biscay in the east and to the Grand Banks of Newfoundland in the west.

There are regular fisheries for it off Cuba and about the Canaries; also in the Pacific.<sup>46</sup>

*Occurrence in the Gulf of Maine*.—Two escolars, respectively, 49 inches long and 6 feet long, were brought in to the United States Fish Commission from Georges Bank during the autumn of 1891.<sup>46</sup> It has not been seen in the Gulf of Maine region since then. The nearest record of it to the southward, with which we are acquainted, is of two trawled about 92 miles off Cape May, N. J., in January 1950.<sup>47</sup>

## THE CUTLASSFISHES.

## FAMILY TRICHIURIDAE

The cutlassfishes are characterized by a scaleless, band-shaped body tapering to a slim pointed tail, with one dorsal fin extending the whole length of the body; the anal is also long but is very low. The ventrals are absent or rudimentary, and there is no distinct caudal fin. Their large mouth is armed with strong teeth of various sizes. They inhabit the surface waters of tropical seas.

### Cutlassfish *Trichiurus lepturus* Linnaeus 1758

HAIRTAIL; SCABBARDFISH; SILVER EEL; RIBBAND-FISH

Jordan and Evermann, 1896-1900, p. 889.

*Description*.—The most striking characteristics of the cutlassfish are its band-like form tapering to a pointed whiplike tail without caudal fin; its single long dorsal fin (about 135 rays) originating close behind the eyes, about two-thirds as high at its midlength as the body is deep, and diminishing to nothing some distance in front of the tip of the tail; its long anal composed of very low detached spines pointing backward; and its long barbed fangs in the front of the mouth, four in the upper and two in the lower jaw. The depth of the body

equals about one-thirteenth to one-fifteenth of its total length, about one-seventh to one eighth of which is occupied by the head. The snout is pointed, the mouth gapes back to below the eye and the lower jaw projects beyond the upper. Each of the jaws is armed with 7 to 10 smaller teeth behind the fangs. The anal fin is reduced to a series of short inconspicuous spines, about 100 to 110 in number, without connecting fin membrane, running back from the vent nearly to the tip of the tail. The small pectorals are situated a little in advance of the rear corners of the gill covers. There are no ventral fins and the skin is scaleless.

*Color*.—Plain silvery all over. The dorsal fin is plain yellowish or dusky green in life, dark edged or speckled along the margin with black; the tips of the jaws dusky.

*Size*.—Maximum length about 5 feet.

*General range*.—All warm seas; abundant in the West Indies and Gulf of Mexico; not rare along the

<sup>45</sup> Gudger (*American Naturalist*, vol. 62, 1928, p. 467) and Nordhoff (*Natural History*, vol. 28, 1928, p. 40) give accounts of the geographic distribution of the escolar, and of the fisheries for it in tropical waters.

<sup>46</sup> Approximate location 41° 40' N., 67° 44' W. See Goode and Bean, *Smithsonian Contrib. Knowl.*, vol. 30, 1895, p. 197.

<sup>47</sup> LaMonte, *Marine Life*, vol. 1, No. 8, 1950, p. 40.