

Eel *Anguilla rostrata* (LeSueur) 1817

AMERICAN EEL; SILVER EEL; FRESH-WATER EEL;
ELVER (YOUNG)

Jordan and Evermann 1896-1900, p. 348, *A. chrysope*
Rafinesque 1817.

Description.—In the common American eel the dorsal fin originates far behind the pectorals, this character is enough to distinguish it from the conger, from which it also differs in that the lower jaw projects beyond the upper or at least equals it in length, and its eyes are small and round. Furthermore, it develops scales as it grows, though these are so small that they might be overlooked. The eel, however, has a pointed snout, like the conger, a large mouth gaping back as far as the middle of the eye or past it; and its gill slits are set vertically on the sides of the neck, their upper corners abreast of the center of the base of the pectoral fin. It is very closely related to the European eel (*Anguilla vulgaris*), but has fewer vertebrae (average about 107 as compared with about 114 or 115 in the European species).

Color.—The colors of eels vary widely with the bottom on which they live. As a rule they are dark muddy brown or olive-brown above, more or less tinged with yellow on the sides; the lower

surface paler brown and yellow, with dirty yellowish-white belly. It is common knowledge that eels are dark if living on dark mud but much paler on pale sand. And Parker⁵³ has found that they can change from pale to dark in about 1½ hours and from dark to pale in a little more than 3 hours, if moved from a white background to a black or vice versa, under a strong light.

Size.—Eels are said to grow to 4 feet in length and to 16½ pounds in weight. Full-grown females average only about 2 to 3½ feet, however, and males are smaller. Any eel more than 18 inches long would probably be a female, and one more than 24 inches in length would certainly be one. The smallest mature males are about 11 to 12 inches long, females about 18 inches.

Habits.—The life history of the eel remained a mystery until very recently. It has been common knowledge for centuries that young elvers run up into fresh water in spring, and adults journey downstream in autumn. A host of myths grew up to explain the utter absence of ripe eels of either sex, either in fresh water or along the seacoast. But it was only a few years ago that the breeding places of the European and American eels were discovered and the history of their larvae

⁵³ Jour. of Exper. Zool., vol. 98, 1945, No. 3, pp. 211-234.

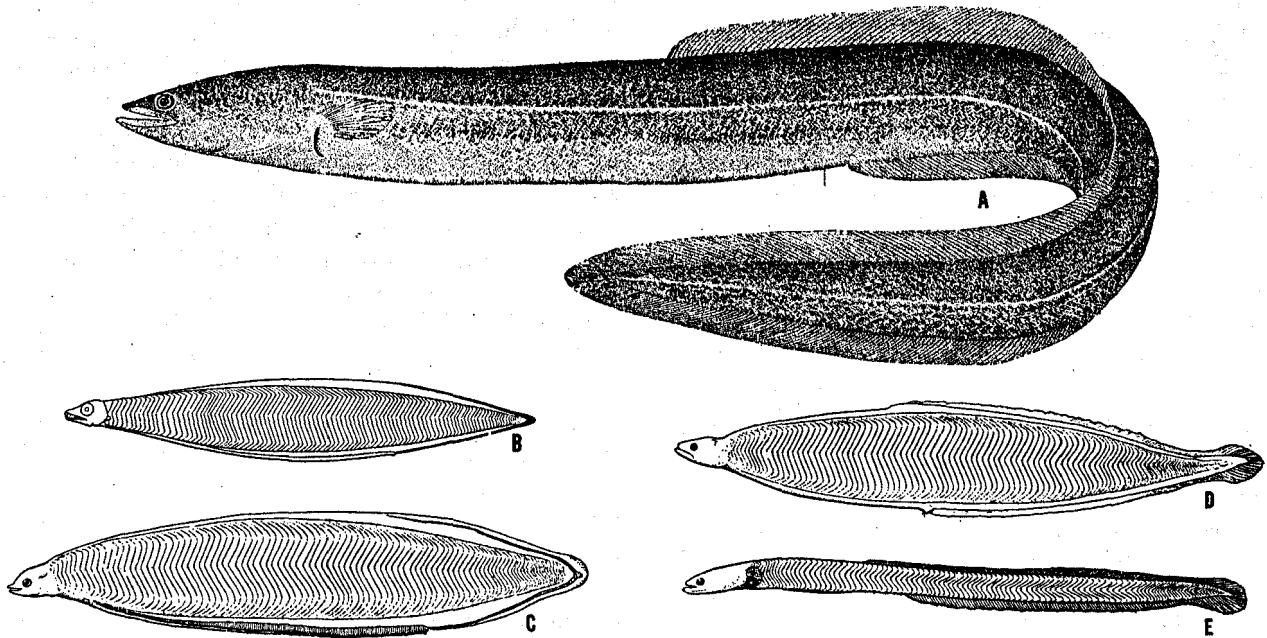


FIGURE 69.—Eel (*Anguilla rostrata*). A, adult, Connecticut River, Massachusetts; from Goode, drawing by H. L. Todd; B, "Leptocephalus" stage, 49 mm.; C, "Leptocephalus" stage, 55 mm.; D, "Leptocephalus" stage, 58 mm.; E, transformation stage, 61 mm. B-E, after Schmidt.

traced, chiefly by the persevering researches of the Danish scientist, Johannes Schmidt.⁵⁴ Now we know that the life history of the eel is just the antithesis of that of the salmon, shad, and alewife, for eels breed far out at sea, but make their growth either in estuarine situations or in fresh water.

The young elvers, averaging from 2 to 3½ inches in length, appear along our shores in spring. As yet we have few data on the exact date of their arrival on the Gulf of Maine coast. They appear as early as March at Woods Hole; by mid- or late April both in Narragansett Bay and in Passamaquoddy Bay at the mouth of the Bay of Fundy, while Welsh encountered a tremendous run in Little River, near Gloucester, on May 5, 1913, suggesting that they may be expected in the mouths of most Gulf of Maine streams during that month. And they are found ascending streams in the Bay of Fundy region during the summer. A run may last for a month or more in one stream, only for a few days in another. And there is a noticeable segregation even at this early stage, some of the elvers remaining in tidal marshes, in harbors, in bays back of barrier beaches, and in other similar situations, some even along the open coast, especially where there are beds of eel grass (*Zostera*); while others go into fresh water, some of them ascending the larger rivers for tremendous distances.⁵⁵

It is now generally believed that most of the eels that are caught in fresh water are females. But some of the females remain in salt marshes and harbors, to judge from the large size of many of the eels that are caught there. And nothing is known as to what preference the males of the American eel may show in this respect.

It is no wonder that the ability of the elvers to surmount obstacles as they run upstream is proverbial, for they clamber over falls, dams, and other obstructions, even working their way up over damp rocks as Welsh saw them doing in Little River, where they were so plentiful on May 5 and 7, 1913, that he caught 1,500 in one scoop

of a small dip net and 545 with a few grabs of his bare hand. Elvers in equal multitudes have often been described in other streams, American as well as European. Eels can live out of water so long as to give rise to the story that they often travel overland. There is no positive evidence for this. But Sella⁵⁶ has proved, by experiments with European eels marked so as to be recognizable if recaptured, that they can carry out journeys as long as 31 miles (50 kilometers) along underground waterways. Doubtless it is this ability that explains the presence of eels in certain ponds that have no visible outlet nor inlet, a fact often attested.

It is true in a general way that eels seek muddy bottom and still water, as has been said so commonly. But this is not always so whether in salt water or in fresh. Thus the rocky pool at the outer end of the outlet from Little Harbor, Cohasset, on the south shore of Massachusetts Bay, is a good place to catch eels; and large ones are only too common in swiftflowing, sandy trout streams on Cape Cod; we have had one follow and nibble at the trout we were dragging behind us on a line. The fact is, they can live and thrive wherever food is to be had, which applies to them in estuarine situations and in fresh water.

No animal food, living or dead is refused, and the diet of the eels in any locality depends less on choice than on what is available. Small fish of many varieties, shrimps, crabs, lobsters, and smaller crustacea, together with refuse of any kind (for they are scavengers) make up the bulk of the diet in salt, estuarine, and brackish water. Being very greedy, any bait will do to catch an eel. They are chiefly nocturnal in habit, as every fisherman knows, usually lying buried in the mud by day to venture abroad by night. But eels, large and small, are so often seen swimming about, and so often bite by day that this cannot be laid down as a general rule.

Eels tolerate a wide range of temperature. But it is common knowledge that those inhabiting the salt marshes and estuaries of our Gulf, and its tributary streams, mostly lie inactive in the mud during the winter.

Eels grow slowly. Hildebrand and Schroeder⁵⁷ concluded from a series of measurements taken at different seasons in lower Chesapeake Bay that those

⁵⁴ The life history of the eel is presented in more detail than is possible here by Schmidt (Philos. Trans. Roy. Soc. London, Series B, vol. 211 (1922) 1923, pp. 179-208, summarized in Nature, vol. 110, 1922, p. 716), and by Cunningham (Nature, vol. 113, 1924, p. 199). See also Schmidt (Rapp. et Proc.-Verb. Cons. Perm. Internat. Explor. Mer, vol. 5, No. 4, 1906, pp. 137-204, pls. 7-13); for a popular account see Smith (Nat. Geog. Mag., vol. 24, No. 10, October 1913, p. 1140).

⁵⁵ Eels are native in Lake Ontario which they reach by way of the St. Lawrence River; and up the Mississippi drainage systems even as far as North Dakota, Wisconsin, Ohio, and western Pennsylvania.

⁵⁶ Mem. R. Comit. Talassogr. Ital., vol. 158, 1929.

⁵⁷ Bull. U. S. Bur. Fish., vol. 43, 1928, p. 114.

2½ inches long in April are about 5 inches long a year later, or about 2 years after their transformation. The winter rings on the scales have shown that full grown adults of the European species are from 5 to 20 years old, depending on food supply, and other conditions; this is corroborated for the American species by the fact that Dr. Hugh M. Smith, former Commissioner of the United States Bureau of Fisheries, found that a female, on the way down the Potomac, was in her twelfth year.

At the approach of sexual maturity, which takes place in the fall, the eels that are in fresh water drop downstream, traveling mostly at night. They now cease feeding, as do those that have been living in the river mouths, bays, and estuaries; the color of the back changes from olive to almost black, the ventral side turns silvery, and the eyes of the males grow to twice their previous size. Both males and females then move out to sea, and it is not until after they reach salt water that the ovaries mature. In fact, no perfectly ripe female eel has ever been seen, and only one ripe male (of the European species).

So little is the life history of the eel understood by our fishermen that we again emphasize the undoubted fact that no eel ever spawns in fresh water.

The eels drop wholly out of sight when once they leave the shore;⁴⁸ no one knows how deep they swim, but they certainly journey out beyond the continental slope into the oceanic basin before depositing their eggs. Schmidt has been able to outline the chief spawning center of the American species (from the captures of its youngest larvae) as between latitudes 20° and 30° N. and between longitudes 60° and 78° W.; i. e., east of Florida and of the Bahamas south of Bermuda. But it may also spawn (always in deep water) farther north as well.⁴⁹

The American eel spawns in midwinter, thus occupying one to two months in its journey from the coast to the spawning ground, for Schmidt found very young larvae (7 to 8 mm.) in February. Eels, like Pacific salmon, die after spawning, the evidence of this being that no spent eels have ever been seen and that large eels have never been

known to run upstream again. Smith suggests that they probably "jellyfy" and disintegrate, as the conger does.

Eels (European) are among the most prolific fish, ordinary females averaging 5 to 10 million eggs and the largest ones certainly 15 to 20 million. It is doubtful whether eggs laid by the American eel have been seen, or of the European either, for that matter.⁶⁰ But it is generally supposed that they float in the upper or intermediate water layers until hatching. The larval, so-called "leptocephalus" stage, like that of all the true eels, is very different in appearance from the adult, being ribbon-like and perfectly transparent, with small pointed head; and it has very large teeth, though it is generally believed to take no food until the time of its metamorphosis. These leptocephali of our eel, living near the surface, have been found off our coasts as far north as the Grand Banks, but never east of longitude 50° W.

Inasmuch as the breeding areas of the American and European eels overlap, not the least interesting phase of the lives of the two is that the larvae of the American species should work so consistently to the western side of the Atlantic, and those of the European to the eastern side that no specimen of the former has ever been taken in Europe or of the latter in America.

The American eel takes only about one-third as long as the European to pass through its larval stage; i. e., hardly a year, as against 2 to 3 years. The leptocephali reach their full length of 60 to 65 mm. by December or January, when metamorphosis takes place to the "elver"; the most obvious changes being a shrinkage in the depth and length of the body but an increase in its thickness to cylindrical form, loss of the larval teeth, and total alteration in the aspect of head and jaws, while the digestive tract becomes functional.

It is not until they approach our shores, however, that the adult pigmentation develops or that the elver begins to feed, a change that is accompanied by a second decrease in size. How such feeble swimmers as the leptocephali find

⁴⁸ Large eels, on their seaward journey, have occasionally been caught by otter trawlers in the western part of the British Channel, but we know of no such occurrence on this side of the Atlantic.

⁴⁹ See Schmidt (Ann. Rep. Smithsonian Inst., (1924) 1925, pp. 279-314) for a readable account of the investigations which enabled him to chart the breeding places and seasons of the American and European eels.

⁶⁰ Four eggs taken on the *Arcturus* expedition near Bermuda in 1925 were provisionally identified as those of the American eel by Fish who has pictured them and the larvae hatched from one of them (Zoologica, New York Zool. Soc., vol. 23, 1927, pp. 290-293, figs. 103-107). But the date at which they were taken (July 15-17) makes it more likely that they belonged to some other member of the eel tribe.

their way into the neighborhood of the land remains a mystery. It seems certain, however, that all the young eels bound for the Gulf of Maine complete the major part of their metamorphosis while they still are far offshore. Thus we have never taken one in the leptocephalus stage in the Gulf of Maine in all our tow-nettings, whereas (more significant) the *Albatross* towed three young eels in the so-called "glass-eel" stage, 54 to 59 mm. long, of practically adult form but still transparent, during her spring cruise in 1920, one of them on Georges Bank, March 11; a second on Browns Bank, April 16; and one in the western basin of the Gulf off Cape Ann, February 23. Evidently they were intercepted on their way in to land. And since all three were on the surface, we may take it that glass eels, like leptocephali, keep to the uppermost water layers during their journey.

General range.—Coasts and streams of West Greenland,⁶¹ eastern Newfoundland,⁶² Strait of Belle Isle, and northern side of the Gulf of St. Lawrence south to the Gulf of Mexico, Panama, West Indies, and (rarely) to the northern coast of South America; also Bermuda; running up into fresh water but going out to sea to spawn p. 153.

Occurrence in the Gulf of Maine.—The occurrence of the eel around the periphery of our Gulf can be described in the one word "universal." There is, we believe, no harbor, stream mouth, muddy estuary, or tidal marsh from Cape Sable on the east to the elbow of Cape Cod on the west but supports eels in some numbers, and they run up every Gulf of Maine stream, large or small, from which they eventually find their way into the ponds at the headwaters unless barred by insurmountable barriers such as very high falls. Examples of long journeys by eels upstream, in New England rivers, are to the Connecticut Lakes, New Hampshire, at the head of the Connecticut River; to the Rangeley Lakes at the head of the Androscoggin, and to Matagamon Lake, at the head of the East Branch of the Penobscot. Eels are even caught in certain ponds without outlets, as noted above (p. 152). On the other hand, we have seen a few (and some large ones) along the open coast, at Cohasset, for example, but always

close in to the shore line and in only a few feet of water, where flounder fishermen catch them from time to time.

Importance.—Schmidt has suggested that the American eel is not as plentiful in actual numbers as the European, arguing from the facts that its larvae have not proven so common on the high seas, and that the American catch of eels (about 2,000 tons yearly) was but a fraction as large as the European catch (about 10,000 tons annually). But it is not safe to draw any conclusions from the statistics because the American catch is limited more by the fact that eels are not much in demand, than by the available supply. And the local demand is less for them today than it was 30 years ago, as is reflected in a decrease in the reported landings from about 305,000 pounds for Maine and about 240,000 pounds for Massachusetts in 1919 to about 19,000 pounds for Maine and about 32,000 pounds for Massachusetts in 1947. The yearly landings of eels along the Canadian shore of our Gulf and from the tributary fresh waters are 30,000–40,000 pounds nowadays.

Practically the entire coastwise catch is made in salt marshes, estuaries and stream mouths; the numbers captured up stream are negligible of recent years, except in New Brunswick where 16,000 pounds were caught in the lower sections of the St. John River System in 1950.⁶³ In Germany, however, where the demand for eels is much greater, the yearly catch is nearly four times as great for rivers and other fresh waters as it is for the coast. And many millions of elvers were transplanted, during the 1930's, from British rivers (the Severn in particular) to landlocked bodies of water in Central Europe which the young eels could not reach naturally.

The greater part of the catch is made in nets and celpots; and some are speared, mostly in late autumn and winter, often through the ice.

American conger *Conger oceanica* (Mitchell)
1818⁶⁴

SEA EEL

Jordan and Evermann, *Leptocephalus conger* (Linnaeus 1758), 1896–1900, p. 354.

⁶³ Information from A. H. Leim.

⁶⁴ The American conger had long been considered identical with the European. But Schmidt (*Nature*, vol. 128, 1931, p. 602) has recently shown that it is a distinct species, characterized by having fewer vertebrae; a relationship paralleling that between the American and European eels of the genus *Anguilla*.

⁶¹ Jensen (*Invest. of the Dana in West Greenland Waters, 1925*, Extr. Rapp. et Proc. -Verb Cons. Internat. Expl. Mer, vol. 39, 1926, p. 101) records the American eel as one of the four fresh-water fishes known from the west coast of Greenland.

⁶² Reported by Dr. G. W. Jeffers as common.

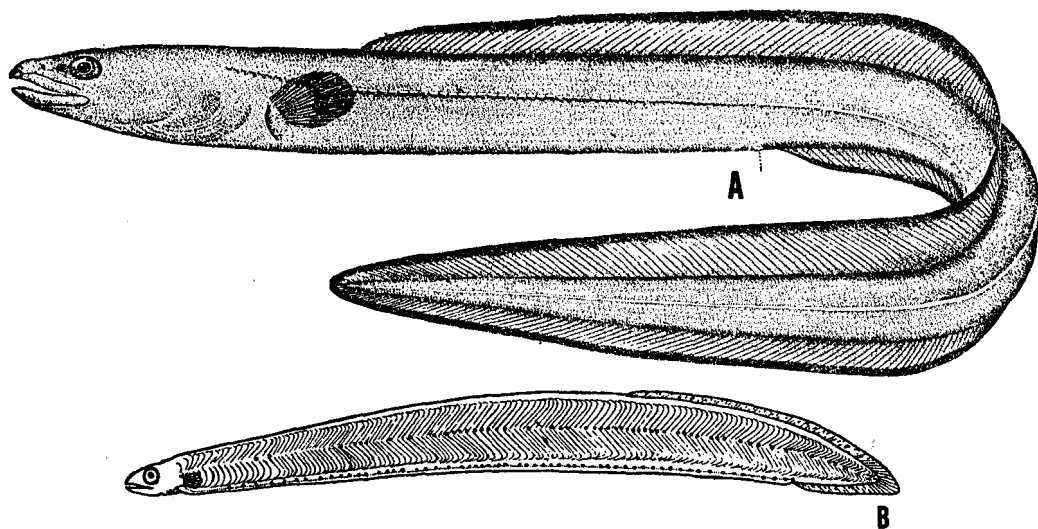


FIGURE 70.—American conger (*Conger oceanica*). A, adult, Connecticut; from Goode, drawing by H. L. Todd; B, "Leptocephalus" stage, 84 mm., Chesapeake Bay.

Description.—The readiest characters by which to distinguish the conger from other eels are noted in the key (p. 150); notably the origin of the dorsal fin above or only very slightly behind the tip of the pectoral when the latter is laid back, the rather long-pointed snout, the large mouth cleft back at least as far as the middle of the eye, and the scaleless skin. The conger has many more vertebrae than the common eel and there are other skeletal differences.⁶⁵ The conformation of the tip of the snout likewise helps to identify the conger, for its upper jaw usually projects beyond the lower, whereas in the common eel the reverse is true, or at least the lower equals the upper. Furthermore, the eyes of the conger are oval and larger than the round eyes of the common eel.

To give an idea of the proportions of the conger, we need only add that the distance from tip of snout to dorsal fin is about one-fifth of the total length; the length of the snout is one-fourth that of the head; the length of the pectorals is equal to one-third to one-fourth of the distance from dorsal fin to tip of snout; and that the body is of the snake-like form characteristic of eels in general.

Color.—Bluish gray or grayish brown above, sometimes of a reddish tinge, sometimes almost black; paler on the sides; dingy white below.

Size.—This is a much larger fish than the common eel. The larger ones taken off southern

New England and New Jersey are said to measure 4 feet up to 7 feet in length. The general run of those caught weigh 4 to 12 pounds, the heaviest we have seen weighed about 22 pounds. But the North American species never attains the enormous size reached by the European species; the largest European conger reliably reported, of which we have read, was 9 feet long, and weighed 160 pounds.⁶⁶

Habits.—The depth range of the conger is from close to the coastline (they are caught from the dock at Woods Hole) out to the edge of the continental shelf, the deepest record for it being for one that we trawled at 142 fathoms off southern New England, on the *Albatross III*, in May 1950. It feeds chiefly on fish: butterfish, herring, and eels have been found in their stomachs at Woods Hole. They also prey on shrimps and small mollusks at times. And we have caught them (and have seen them caught) on crabs, on soft clams (*Mya*), on sea clams (*Mactra*) and on cut fish bait.

It is now well established that the European species (hence no doubt the American also) breeds but once during its life and then perishes like the common eel. Ripe congers are never caught on hook and line, for they cease to feed, hence to bite, for some time previous. But the males of the European species, kept in aquaria,

⁶⁵ For an account of these, see Smitt (*Scandinavian Fishes*, vol. 2, 1895 pp. 1015-1017, 1037.

⁶⁶ Jenkins, *Fishes of the British Isles*, 1925, p. 275; see also Day, *Fishes of Great Britain*, vol. 2, 1884, p. 253, for large European congers.

have repeatedly been known to become fully ripe, females nearly so,⁶⁷ then invariably dying. The ripening of the sexual products is accompanied by changes in the shape of the head; in the loss of the teeth; and in a jellification of the bones, while the eyes of the males become enormous and the females become much distended by the ovaries. It is probable that the American conger ripens off the coast of southern New England in summer; European congeners in captivity have been known to do so every month in the year except October and November.

It seems that the conger, like the common eel, moves out from the coast to spawn, for its young larvae have never been taken inshore, and Dr. Johannes Schmidt's⁶⁸ discovery of very young larvae in the West Indian region, but nowhere else, points to this as the chief spawning ground of the American conger, if not the only one.

The congeners are extremely prolific fish, the number of eggs a European female may produce having been estimated as high as 3 to 6 millions. American conger eggs have never been identified, for although eggs taken over the tilefish grounds 30 miles south of Nantucket lightship in July 1900⁶⁹ have been credited to this species, there is no certainty that this was their true parentage.

It has long been known that the congeners, like the common eels, pass through a peculiar ribbon-like larval stage (the so-called "leptocephalus") very broad and thin and perfectly transparent, with a very small head.⁷⁰ In fact the first leptocephalus ever seen (about 1763) was the larval European conger. But its identity was not established definitely until 1886, when the famous French zoologist, Delage,⁷¹ reared one through its metamorphosis at the biological station at Roscoff.

The leptocephalus stage of the conger is relatively more slender than that of the common eel, it grows larger (to a length of 150-160 mm.), and its vertebrae and muscle segments are far more numerous (140-149 in the American conger,

154-163 in the European) than in the common eels (about 107 in the American eel and about 114 in the European). But the number of body segments (visible only under a lens) is not of itself a safe clue to identity, for there are as many or more in the long-nosed eel (p. 158) which has been reported in the Gulf; also in the morays, and in various other members of the eel tribe.⁷²

The duration of the larval period of the conger is not known. The process of metamorphosis consists essentially in a thickening and narrowing of the body, an enlargement of the head, the formation of the swim bladder and permanent teeth, and the development of pigment in the skin, a change that occupied about two months (May to July) in the case of Delage's European specimen. His young conger was 9.3 centimeters (3.6 inches) long at its completion.⁷³

General range.—Continental shelf of eastern America: adults are known north to the tip of Cape Cod; larval stages to eastern Maine. Its southern boundary cannot be stated until the congeners of the coasts of North and of South America have been critically compared. It is represented by a closely allied species (*Conger conger*) in the eastern North Atlantic.

Occurrence in the Gulf of Maine.—The only records for adult congeners within the limits set here for the Gulf of Maine are of one taken at North Truro, Cape Cod; a second specimen trawled close to Provincetown in Cape Cod Bay, July 5, 1951, by Capt. Herman Tasha; and a third, trawled south of Nantucket shoals by *Albatross III*, in mid May 1950.⁷⁴ But the conger must be much more plentiful at times off the shoals than the foregoing would suggest for Capt. Henry Klim of the dragger *Eugene H* reports trawling 1,400 pounds of them there, at 76 fathoms, March 25-30, 1951.⁷⁵ And its curious band-like "leptocephalus" larvae have been found within the Gulf on several occasions. Thus, half a dozen specimens were picked up on the beach at Cherryfield and Old Orchard, Maine, and at Nahant, Mass.,

⁶⁷ Cunningham (Jour. Mar. Biol. Assoc. United Kingdom, N. Ser., vol. 2, 1891-92, pp. 16-42) gives an interesting account of this and other phases of the life history of the conger.

⁶⁸ See Nature, vol. 128, 1931, p. 602, for a discussion of this question by Dr. Schmidt.

⁶⁹ Eigenmann, Bull. U. S. Bur. Fish., vol. 21, 1902, p. 37.

⁷⁰ For photographs of the leptocephalus stage of the European conger, see Schmidt, Rapp. et Proc. Verb. Cons. Perm. Internat. Explor. Mer, vol. 5, No. 4, 1906, pl. 9, figs. 8, 9; and Meddelelser Komm. Havundersøggelsor, Ser. Fiskeri, vol. 3, No. 6, pl. 1, figs. 1-3.

⁷¹ Comptes Rendus Acad. Sci. Paris, vol. 103, 1886, p. 692.

⁷² Fish (Zoologica, New York Zool. Soc., vol. 8, 1927, pp. 307-308) gives a table of the numbers of body segments for various eels and for "leptocephalus" larvae of known and unknown parentage.

⁷³ Schmidtlein (Mittell., Zool. Stat. Neapel, vol. I, 1879, p. 135) speaks of young "congers" at Naples in April as hardly one-third as long as this, a discrepancy suggesting that these may actually have belonged to one of the Muraenoid eels.

⁷⁴ Local reports of congeners do not necessarily relate to the true conger, for the eel pout (p. 510), which is common in the Gulf, is often misnamed thus.

⁷⁵ At lat. 40° N., long. 69° 50' W.

more than a half century ago. Two specimens, also picked up on the beach, were sent up from Newburyport, Mass., in November 1929; and A. H. Clark, of the U. S. National Museum, informs us that he has found many larvae of the leptocephalus type at Manchester, Mass., which probably were congers to judge from their size.

The conger occurs regularly and commonly to the west and south of Cape Cod, being taken near Woods Hole from July into the autumn, and about Block Island from August until November. Very little is known about their movements. But we suspect that they shift offshore into deeper and warmer water for the winter, judging from their absence then in shoal water, contrasted with the large offshore catch in March mentioned above (p. 156) and with the fact that we saw several trawled at 50 to 142 fathoms off southern New England on the *Albatross III*, in May in 1950.

Slime eel *Simenchelys parasiticus* Gill 1879

SNUB-NOSED EEL

Jordan and Evermann, 1896-1900, p. 349.

Description.—The most distinctive characters of the slime eel, its eel-like form, snub nose, long dorsal fin, and soft and slimy body, have been mentioned already (p. 150). It is stouter and more sway-bellied than the common eel, very soft, and with a more tapering tail. The dorsal fin originates a short distance behind the tips of the pectorals when the latter are laid back against the body, and the anal runs forward on the lower surface almost to the vent, which is situated about midway of the body. The head is much shorter than in either the common eel or the conger; the mouth is small, gaping back only about half way to the forward edge of the eye, with upper and

lower jaws of equal length and each armed with a single series of small, close-set cutting teeth. The gill openings are small, and instead of being vertical and on the sides of the neck as they are in the common eel, they are longitudinal and lower down on the throat.

Color.—Dark brown, with the belly only a little paler than the back, though usually more or less silvery.

Size.—About 2 feet long.

Habits.—It is partly parasitic in habit, burrowing into the bodies of halibut and other large fish, circumstances under which a considerable number of specimens have been brought in by fishermen. Very likely it was common inshore in the old days when halibut were plentiful there. It also lives independently on the bottom. Nothing is known of its manner of life beyond this, nor of its breeding habits. We may add from experience that it is as slimy as a hag and drips with sheets of mucus when drawn out of the water.

General range.—The continental slope, and the slopes of the offshore banks, from abreast of the eastern end of Long Island to the Newfoundland Banks, in depths ranging from 200 to more than 900 fathoms; also in deep water about the Azores, and represented in Japanese waters by an extremely close relative, if, indeed, it is separable at all from the Atlantic slime eel.⁷⁶

Occurrence in the Gulf of Maine.—There is no definite record of the snub-nosed eel actually within the southern rim of the Gulf so far as we can learn, and our only first-hand experience with it was on the slope south of Nantucket lightship, where we captured 21 in a Monaco deep-sea trap

⁷⁶ The Japanese slime eel, described first as a distinct species (*Leptosomus*) by Tanaka in 1908, has been classed more recently by him (*Fishes of Japan*, vol. 42, 1928, p. 810, pl. 173, fig. 476) as identical with the Atlantic *parasiticus*.

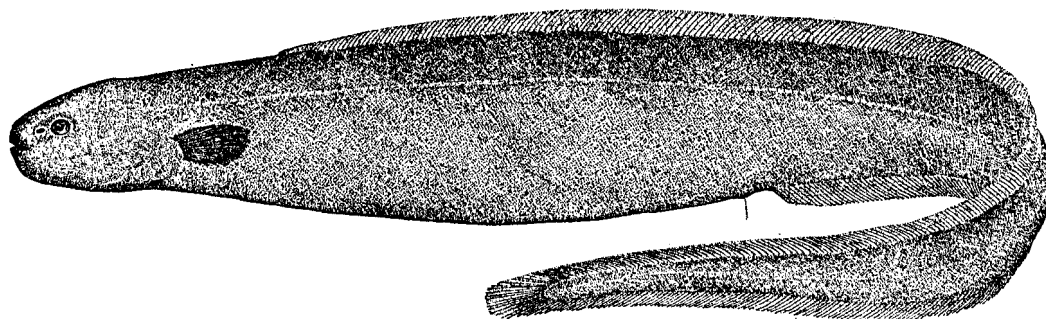


FIGURE 71.—Slime eel (*Simenchelys parasiticus*), off Sable Island Bank. From Goode and Bean. Drawing by H. L. Todd.

in 455 fathoms, on the *Grampus* in July 1908. It must be extremely abundant along that zone, however, for so many to find their way into the trap in as short a set as two hours. And it has been recorded so often in water as shoal as 200 fathoms that it may be expected in the bottom of the Eastern Channel and in the southeastern deeps of the Gulf of Maine.

Long-nosed eel *Synaphobranchus pinnatus*
(Gronow) 1854

Jordan and Evermann, 1896-1900, p. 351.

Description.—This deep-sea species, a typical eel in general appearance, is readily identifiable among its tribe by the fact that while its dorsal fin originates about as far back as in the common eel (p. 151), relative to the length of the fish, its point of origin is considerably behind the vent instead of in front of the latter, and that its anal fin originates considerably in front of the dorsal fin instead of behind it as is the case in all other Gulf of Maine eels. Furthermore, its mouth is much wider, gaping far back of the eye, and its snout is pointed. The most interesting anatomic characteristic of this eel is that its gill openings, opening longitudinally on the lower side of the throat, join together in front, apparently as a single V-shaped aperture, though actually they are separate within.

Color.—Grayish, darkest below, with the vertical fins darker behind but pale-edged in front, and with the inside of the mouth blue black.

Size.—The largest of 89 specimens measured by Goode and Bean was nearly 22 inches (545 mm.) long, the smallest about 9 inches (221 mm.) The largest we trawled on the *Caryn*, in June 1949, was 24 inches (605 mm.) long. Collett⁷⁷ mentions one 26½ inches (675 mm.) long from the Azores.

⁷⁷ Result. des Camp. Sci. Prince de Monaco, Pt. 10, 1896, p. 154.

Habits.—Nothing is known of its habits except that it is a ground fish; that the readiness with which it bites a baited hook proves it predaceous; and that specimens in spawning condition have been taken in summer.⁷⁸ On June 17, 1949 in lat. 42° 38' N., long. 64° 04' W., in 400-460 fathoms, we trawled many on the *Caryn*, both males and females, 18½ to 24 inches (470-605 mm.) long that had well developed gonads, one female having already spawned. The ripe eggs are orange in color and about 1 mm. in diameter. In its development it passes through a leptocephalus stage even more slender than that of the American conger (p. 156), and its body segments (144-149) overlap those of the American conger (140-149) in number.

General range.—This deep-water species has a wide distribution. In the western side of the North Atlantic it has been taken at many localities along the continental slope from the offing of South Carolina to the Grand Banks; it is known in the east from the Cape Verdes; off Morocco; from the Canaries; from the Azores; near Madeira; also from the Faroe Bank and Faroe-Shetland Channel. And its leptocephalan larvae have been taken in such numbers from north of Spain to south of Iceland that it must be one of the most plentiful of deep-water fishes there.⁷⁹ It is also recorded off Brazil in the South Atlantic; likewise in the Arabian Sea; about the Philippines; and in Japanese waters, or is represented there by a very close relative. Most of the captures have been from depths of 300 to about 2,000 fathoms, but it has been taken as shoal as 129 fathoms.

⁷⁸ The "leptocephalus" larvae of the long-nosed eel are described, with photographs by Schmidt (Rapp. et Proc. Verb. Cons. Perm. Internat. Explor. Mer, vol. 5, No. 4, 1906, p. 191, pl. 9, figs. 4-6; and Meddel. Komm. Havundersøgelser, Ser. Fiskeri, vol. 3, No. 6, 1909, p. 7).

⁷⁹ This fact is commented on by Schmidt (Rapp. Cons. Perm. Internat. Explor. Mer, vol. 5, No. 4, 1906, p. 191). For further details as to its distribution see Koefoed, Rept. Michael Sars North Atlantic Exped., (1910), vol. 4, Pt. 1, 1927, pp. 11, 14.

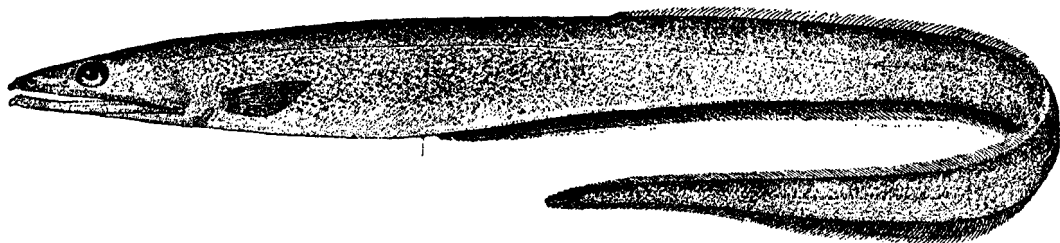


FIGURE 72.—Long-nosed eel (*Synaphobranchus pinnatus*), La Have Bank. From Goode and Bean. Drawing by H. L. Todd.

Occurrence in the Gulf of Maine.—This eel has not actually been reported within the geographic limits of the Gulf. But it is to be expected in the eastern channel and possibly above 150 fathoms along the slopes of Georges Bank, for fishermen have caught them in water as shallow as that off La Have Bank, while they have been trawled in 168 fathoms and 129 fathoms off southern New England by the *Fish Hawk* and *Albatross*. So many of them have been brought in by fishermen⁸⁰ from deep water off the fishing banks to the eastward of longitude 65°, and so many have been trawled along the continental slope thence westward,⁸¹ that this eel must be one of the commonest of fishes below 150 to 200 fathoms, all the way from the Grand Banks to abreast of New York.

Snake eel *Omocheilus cruentifer* (Goode and Bean) 1895

Jordan and Evermann, 1896–1900, p. 377, *Pisodonophis cruentifer*.

Description.—The most striking feature of the snake eel and one that distinguishes it from all other Gulf of Maine eels is that the tip of its tail is hard and pointed. Other distinctive features are that it is only about one thirty-seventh to one thirty-eighth as deep as it is long; that its dorsal fin originates only a short distance behind the tips of the pectorals when these are laid back; that its anal fin originates far behind its dorsal fin; that its snout is bluntly pointed; and that its mouth gapes rearward considerably beyond its eyes (but not so far back as in the long-nosed eel, p. 158). The dorsal and anal fins end a little in front of the tip of the tail. The gill openings

⁸⁰ Many such instances are listed in the Rept. U. S. Comm. Fish. (1879) 1882, p. 787.

⁸¹ Goode and Bean, Smithsonian Contrib. Knowl., vol. 30, 1895, pp. 143–144.

are short new-moon-shaped slits, close in front of the bases of the pectoral fins. Its “peculiar and savage physiognomy” was stressed by its describers.⁸²

Color.—Originally described as uniform brownish yellow. But those that we have seen have been uniform light brown below as well as above, large ones darker than small ones. A young one about 2½ inches (6½ cm.) long was pale with dark speckles.

Size.—The largest yet seen was 16¾ inches long.

Habits.—The original account of the snake eel includes the information that specimens had been received that had been taken from the bodies of other fish, evidence that it is a parasitic-boring form. Nothing else is known of its habits.

General range.—Western side of the Gulf of Maine to the offing of Cape Henry, Va.

Occurrence in the Gulf of Maine.—The snake eel was originally described in 1895 from 6 specimens trawled off Nantucket by the *Fish Hawk*, and a number have been taken thence southward to the latitude of Cape Henry, Va., by the *Albatross II*, in depths of 24 to 245 fathoms. The only report of it within the Gulf of Maine is by its describers of specimens taken by fishermen on Jeffreys Bank many years ago.

Snipe eel *Nemichthys scolopaceus* Richardson 1848

Jordan and Evermann, 1896–1900, p. 369.

Description.—The snipe eel is easily recognizable by its extremely slender body (the fish may be 75 times as long as deep), with its tail tapering to a thread, and by its elongate, slender, bill-like jaws, one as long as the other, the upper one curving upward, but the lower more nearly

⁸² Goode and Bean, Smithsonian Contrib. Knowl., vol. 30, 1895, p. 147.

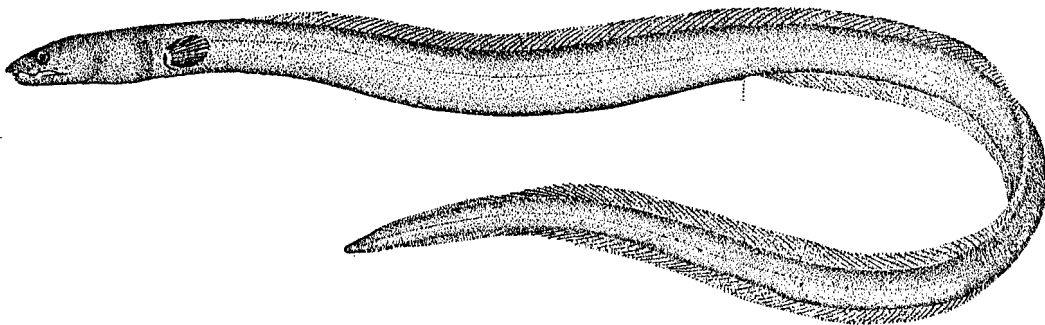


FIGURE 73.—Snake eel (*Omocheilus cruentifer*), continental slope south of Nantucket Shoals. From Goode and Bean. Drawing by H. L. Todd.

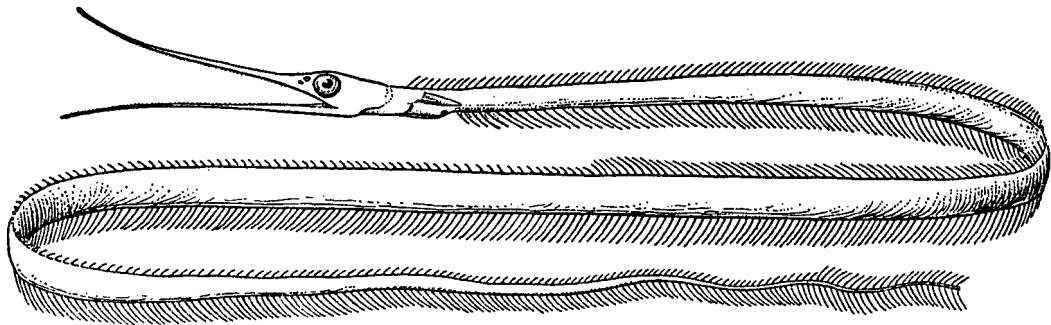


FIGURE 74.—Snipe eel (*Nemichthys scolopaceus*). Drawing by E. N. Fischer, from Bigelow and Welsh.

straight. The head is much deeper than the neck, with large eyes. The dorsal fin originates in front of the pectorals, the anal about abreast of the tip of the pectorals, and both dorsal and anal run back to the tip of the tail.

There has been some confusion in the published accounts and illustrations as to the dorsal and anal fins, for while Vaillant⁸³ shows both as about as high throughout their length as the fish is deep, Goode and Bean⁸⁴ picture the dorsal as much higher than the anal (the artist evidently having transposed the two fins), whereas Brauer⁸⁵ represents the anal as approximately twice as high as the dorsal and the latter as soft rayed in its anterior and posterior portions but composed of short thorn-like spines along its central third. The fins of two specimens taken off New England, now in the collections of the Museum of Comparative Zoology are as follows:

Dorsal, soft-rayed and nearly as high as the body is deep for its first half; back of that it consists of a series of very short, stiff rays that extend to the tip of the tail.

Anal, soft-rayed throughout its length and about as high as the body is deep, tapering to almost nothing on the tail.

The confusion has been due in part to the rather fragmentary state in which these deep-water fish usually arrive on board, but at the same time it is probable that two distinct species have been confused under the name *scolopaceus*, as Brauer suspected.

THE LANCET FISHES. FAMILY ALEPISAUROIDAE

The lancet fishes have one long and very high dorsal fin, soft-rayed from end to end; a small

⁸³ Poissons. Exped. Sci. Travailleur et Talisman, 1888, pl. 7, figs. 2 and 2a.

⁸⁴ Smithsonian Contrib. Knowl., vol. 31, 1895, pl. 46, fig. 170.

⁸⁵ Tiefsee-Fische, Wiss. Ergeb. Deutsch. Tiefsee-Exped. (1898-1899), vol. 15, Pt. I, 1900, p. 126, pl. 9, fig. 1.

Color.—Described as pale to dark brown above with the belly and anal fin blackish after preservation. Judging from experience with other deep-sea fishes and from Brauer's plate (which, however, may be another species), we suspect that it is chocolate brown above in life and velvety black below.

Size.—Maximum length about 3 feet.

Habits.—Although commonly spoken of as a "deep-sea" fish, this species is undoubtedly an inhabitant of the mid depths, not of the bottom, and judging from the occurrence of other black fishes it probably finds its upper limit at 100 to 200 fathoms. Nothing further is known of its habits, but Mowbray's⁸⁶ capture near Bermuda of a snipe eel clinging by its jaws to the tail of a large red snapper has suggested that such may be a regular habit of this curious species.

General range.—The snipe eel has been taken in deep water at many stations off the east coast of North America between latitudes 31° and 42°N., longitudes 65° and 75°W.; also in the South Atlantic; near the Azores; near Madeira; off the Cape Verde Islands; off West Africa; and in the Pacific of New Guinea.

Occurrence in the Gulf of Maine.—One specimen taken from the stomach of a codfish caught on Georges Bank in 45 fathoms is the only Gulf of Maine record, but several have been taken in depths of from 300 to 2,000 fathoms on the seaward slope of the bank.

adipose fin behind the dorsal fin, like that of a salmon or smelt; a deeply forked caudal fin; a short anal, most of which is behind the rear end of the dorsal; large pointed pectorals and ven-

⁸⁶Copeia, No. 108, 1922, p. 49.

trals; and a very wide mouth with large teeth. Several species are known, all belonging to deep water; only one has been taken within the province covered by this report. Their closest affinities seem to lie with the lanternfishes (p. 141).

Lancetfish *Alepisaurus ferox* Lowe 1833

HANSAWFISH

Jordan and Evermann, 1896-1900, p. 595.

Description.—The combination of a long and very high dorsal fin, soft-rayed from end to end, with the presence of an adipose fin behind it, distinguishes the lancetfish from all other Gulf of Maine fishes. The body is slender, somewhat flattened sidewise, deepest at the gill covers, and tapers back to a slender caudal peduncle. The snout is long and pointed, the mouth wide, gaping back of the eye, and each jaw has two or three large fangs, besides smaller teeth. The dorsal fin (41 to 44 rays) originates on the nape and occupies the greater length of the back, is rounded in outline, about twice as high as the fish is deep, and can be depressed in a groove along the back. The adipose fin recalls that of the smelt in form and location. The caudal is very deeply forked; its upper lobe is prolonged as a long filament, and although most of the specimens so far seen have lost this we have an excellent photograph showing it. The anal fin originates under the last dorsal ray, and is deeply concave in outline. The ventrals are about halfway between the anal and the tip of the

snout, while the pectorals are considerably longer than the body is deep and are situated very low down on the sides. There are no scales and the fins are exceedingly fragile.

Color.—Sides described as metallic silvery. We have not seen a newly taken specimen.

Size.—The collection of the Boston Society of Natural History contains the cast of a specimen about 6 feet long that was taken off Nova Scotia in August 1910, and this is probably about the maximum size.

Habits.—This is an oceanic species, of the mid-depths, appearing only as a stray shoaler than 200 fathoms. Nothing is known of its habits. A Block Island specimen had eaten a small spiny dogfish.

General range.—Widely distributed in the deep waters of the Atlantic, also reported from the northeastern Pacific.⁸⁷

Occurrence in the Gulf of Maine.—A specimen brought in by a fisherman from Georges Bank⁸⁸ about 1878 or 1879 is its only claim to mention here. Goode and Bean and Vladykov and McKenzie⁸⁹ have reported other captures of lancetfishes from La Have Bank, from southeast of Emerald Bank and Banquereau. Another specimen 5½ feet long was caught alive in the surf on Block Island, R. I., March 12, 1928, and reported by Mrs. Elizabeth Dickins who sent us a photograph of it.

⁸⁷ Crawford (Copela, No. 104, 1927, p. 66) reports several *A. ferox* from the halibut banks off the northwestern coast of British Columbia.

⁸⁸ No definite information is available as to this specimen.

⁸⁹ Proc. Nova Scotia Inst. Sci., vol. 19, 1935, p. 63.

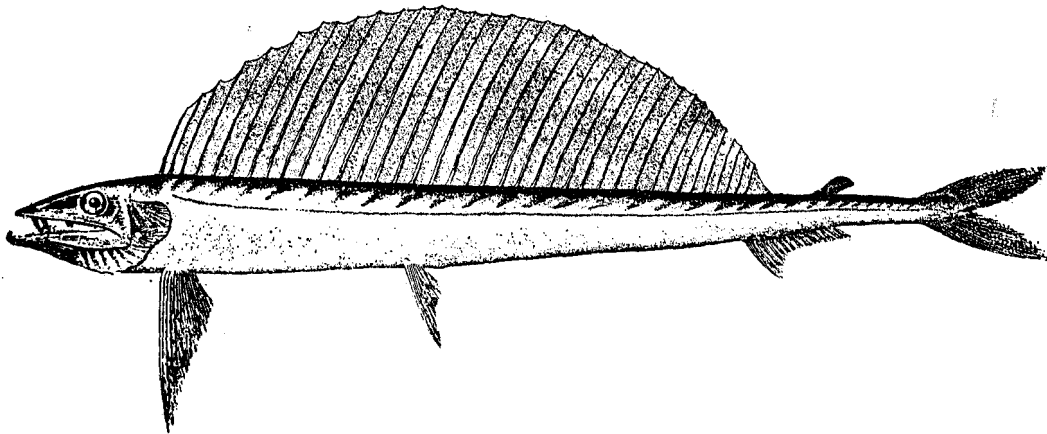


FIGURE 75.—Lancetfish (*Alepisaurus ferox*). New York market specimen. From Jordan and Evermann. Drawing by H. L. Todd.

THE MUMMICHOGS OR KILLIFISHES. FAMILY POECILIIDAE

The mummichogs are small fishes made recognizable by having only one short soft-rayed dorsal fin situated far back, and ventrals situated on the abdomen, combined with a small mouth at the tip of the snout, a very thick caudal peduncle, and a rounded tail fin. The family is represented in the Gulf of Maine by three species, two of *Fundulus* and one of *Cyprinodon*, the former slender and the latter deep in outline, a difference in body form sufficient to distinguish the one genus from the other at a glance. The teeth are likewise different in the two genera, those of *Fundulus* being sharp-pointed, whereas they are wedge-shaped in *Cyprinodon* and incisorlike. The two local species of *Fundulus* are separable by their markings, *majalis* of all ages being barred or streaked with black while the adult *heteroclitus* is not.

Common mummichog *Fundulus heteroclitus*
(Linnaeus) 1766

KILLIFISH; SALT-WATER MINNOW; CHUB; MUMMY

Jordan and Evermann, 1896-1900, p. 640.

Description.—This is a stout-bodied little fish, about one-fourth as deep as long, its body thickest just back of the pectoral fins, whence it tapers to the tail. Both its back and its belly are rounded, but the top of the head is flat between the eyes. The snout, as seen from above, is blunt. The mouth is at the tip of the snout and is so small that it does not gape back to the eye. Perhaps the most striking feature of *Fundulus* is its very deep caudal

peduncle and rounded caudal fin. The fins are of moderate size, the dorsal situated behind the middle of the body above the anal, the pectorals broad and rounded. Both head and body are covered with large rounded scales. On males in breeding condition the scales on the sides of the head and those on the flanks below and behind the dorsal fin develop fingerlike processes on their free edges, called "contact organs."

The mummichog shows a striking sexual dimorphism in the dorsal and anal fins, which are not only larger in the male than in the female, and the anals of a different shape,⁹⁰ but are more muscular and are used as claspers in the act of spawning.

Color.—Males and females differ in color as well as in the sizes of the fins. Out of breeding season the males are dark greenish or steel blue above, with white and yellow spots, and marked on the sides with narrow irregular silvery bars or mottlings made up a series of dots. The belly is white, pale yellow, or orange; the dorsal, anal, and caudal fins are dark green or dusky with pale mottlings; the front edges of the anal and of the ventrals are yellow. Sometimes there is a dark-edged, pale-centered eyespot on the rear part of the dorsal fin. At spawning time the pigmentation of the male is generally intensified, the back and upper sides darkening almost to black, while the yellow of the belly becomes more brilliant and the body generally takes on steel-blue reflections. The females (much paler than the males) are uni-

⁹⁰ A detailed account of the sexual differences is given by Newman (Biol. Bull., vol. 12, No. 5, 1907, pp. 314-348).

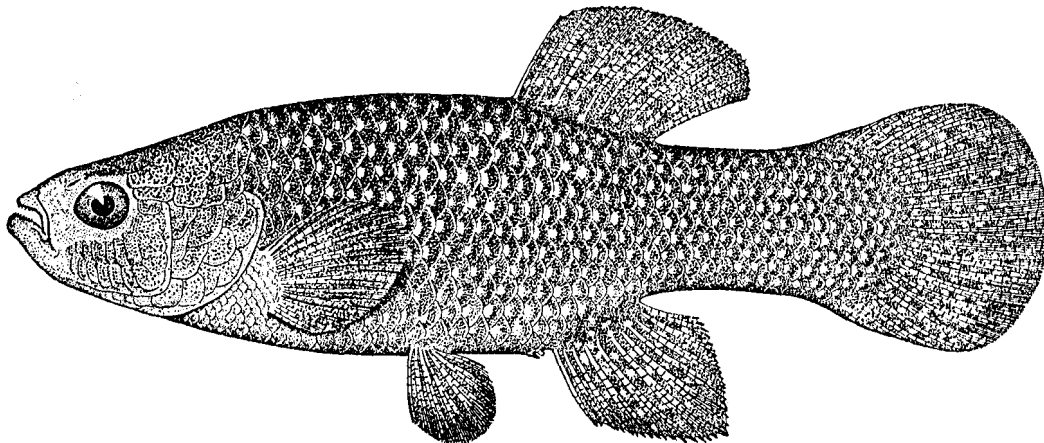


FIGURE 76.—Common mummichog (*Fundulus heteroclitus*), Maryland. From Jordan and Evermann. Drawing by A. H. Baldwin.

form olive to bottle green, darker above, lighter below, without definite markings though their sides often show faint and indefinite crossbars of a deeper tone of the same hue. Their fins are much paler than those of males. Very young fry of both sexes show dark transverse bars on the sides, but these bars are lost with growth.

Killifishes vary in shade from very pale to dark, according to the color of their surroundings. And recent experiments⁹¹ have proved that their ability to change from light to dark depends on the sense of sight.

Size.—The maximum length is 5 to 6 inches, but adult mummichogs are seldom more than 3½ to 4 inches long in the Gulf of Maine. Several varieties of this species have been described, but they are so closely allied that it is not necessary to discuss them here.

Habits.—The home of the mummichog is along sheltered shores where the tide flows over beds of eelgrass or salt hay (*Spartina*), among which shoals of "mummies" may often be seen moving in with the flood tide. They abound in the tidal creeks that cut the salt marshes, on the shores of our harbors, and in the brackish water at the mouths of our streams and estuaries, particularly in little muddy pools, creeks, and ditches. So closely, indeed, do they hug the shore that a line drawn 100 yards out from land would probably inclose practically all the mummichogs in the Gulf of Maine. Where the shore is bold and rocky, as it is about the Bay of Fundy, the mummichog is practically restricted to brackish water, and it often goes up into fresh water. At the other extreme, it is not likely that they ever descend to a depth of more than a couple of fathoms in their journeys in and out of the creeks or along the shore.

Mummichogs are so resistant to a lack of oxygen, to the presence of carbon dioxide, and to unfavorable surroundings generally, that they can survive in very foul water. At ebb tide "mummies" are often trapped in little pools where they remain until the next tide if the water holds, often huddled together in swarms. Should the pool go dry, they work their way for the time being into the mud, where we have often found them.⁹² And it is probable that they can flop overland for a few

yards to some other drain as the striped mummichog does.

They winter in a more or less sluggish state on the bottoms of the deeper holes or creeks, where they have been found buried 6 or 8 inches deep in the mud,⁹³ and there is no evidence that they move out to sea during the cold season; in short, this is one of the most stationary of fishes.

Food.—"Mummies" are omnivorous, feeding on all sorts of edible things, vegetable as well as animal. They have been found full of diatoms, eelgrass, and other vegetable matter; foraminifera; shrimps and other small Crustacea, also small mollusks; and they sometimes have small fish in their stomachs.⁹⁴

They soon congregate about any dead fish or other bit of carrion, to prey either upon it or upon the amphipod scavengers that gather on such dainties and they eat their own or each other's eggs at spawning time.

Spawning probably takes place at the same season in the Gulf of Maine as on the southern coast of New England; i. e., in June, July, and early August. As sexual activity approaches, the males (now brilliantly tinted) court and pursue the females, rivalry among them being very keen; those that are the most highly colored or most excited usually driving off the others. Sometimes they fight fiercely. They spawn in a few inches of water, seeking shady spots. At the moment of spawning the male clasps the female with his anal and dorsal fins just back of her anal and dorsal, usually forcing her against some stone or against the bottom, the bodies of both are bent into an S and their tails vibrate rapidly while the eggs and the milt are extruded.⁹⁵ Occasionally, pairs clasp and spawn free in the water without coming in contact with any object, and sometimes a female is seen to pursue and court a male.

The eggs, which are about 2 mm. in diameter, colorless or pale yellowish and surrounded by a firm capsule, sink and become so sticky on contact with the water that they mass together in clumps, or stick fast to sand grains or to anything else they chance to rest upon. Incubation occupies from 9 to 18 days, the exact duration probably

⁹¹ Chichester, Amer. Naturalist, vol. 54, 1920, p. 551.

⁹² Lists of stomach contents are given by Field (Rept. U. S. Comm. Fish., (1906) 1907, p. 29).

⁹³ Newman (Biol. Bull., vol. 12, No. 5, April 1907, p. 315) gives an interesting account of the courtship and spawning, from which the preceding is condensed.

⁹⁴ Parker and Lanchner, Amer. Jour. of Physiol., vol. 61, 1922, p. 548.

⁹⁵ This habit is described by Mast (Jour. of Animal Behavior, vol. 5, No. 5, 1915, p. 351).

depending on temperature. The larva is about 7 to 7.7 mm. long at hatching, its yolk absorbed already, and its pectoral and caudal fins fully formed. By the time the little fish has grown to 11 mm. the dorsal and anal fin rays are present in full number, and the first trace of the ventrals is to be seen. At 16 mm. the ventrals are apparent, and fry of 20 mm. resemble their parents.

General range.—Coast of North America, from the Gulf of St. Lawrence to Texas. Port au Port Bay, on the west coast of Newfoundland,⁶⁶ is the most northerly record that we have found for it.

Occurrence in the Gulf of Maine.—The “mummie” is one of the few fish which can fairly be characterized as “universal” in suitable locations around the entire coastline of the Gulf. We dare say that there is not a single bit of salt marsh, muddy creek, harbor, sheltered shore line, or brackish estuary, where they are not to be found, from the elbow of Cape Cod around to Cape Sable.

⁶⁶ Johansen (Canadian Naturalist, vol. 40, February 1926, p. 34).

Importance.—The mummichog is of some commercial value as bait, but only locally. It is also a favorite for biological experiment.

Striped mummichog *Fundulus majalis* (Walbaum) 1792

MUMMICHOG; MUMMY; KILLIFISH

Jordan and Evermann, 1896–1900, p. 637.

Description.—This fish resembles the common mummichog closely in general form, in the shape of its dorsal and anal fins, in its sexual dimorphism, and in the development of “contact organs” on the scales of breeding males. But it is more slender, its snout more pointed, its body more definitely fusiform, tapering toward both head and tail, and its caudal peduncle not so stout. But the color pattern is the most striking difference between the two, both sexes of *Fundulus majalis* being definitely barred with black at maturity as well as when young. In the male the barring is transverse throughout life, the stripes increasing

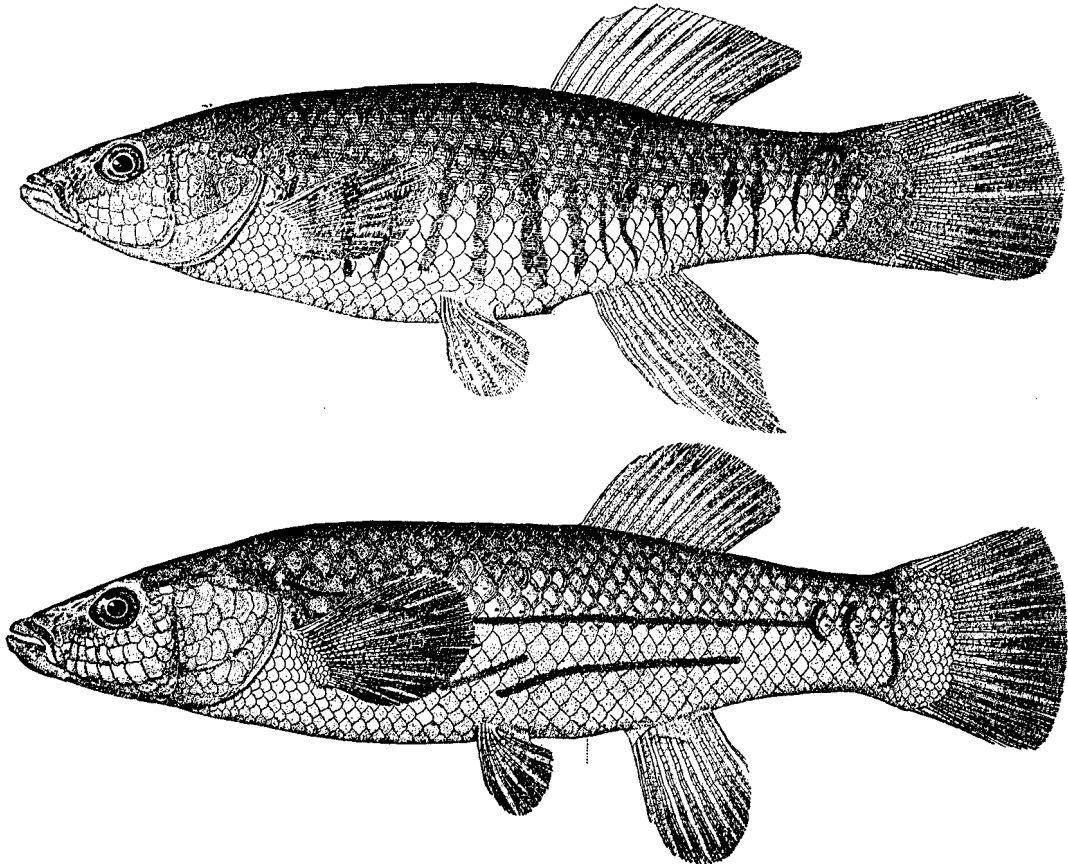


FIGURE 77.—Striped mummichog (*Fundulus majalis*). Upper, male, Woods Hole; lower, female, Maryland. From Jordan and Evermann.

in number from 7 to 12 in the young to 14 to 20 in adult fish. When the females reach a length of about two inches, however, the original 7 to 12 transverse bars are transformed with growth into two or three longitudinal stripes on each side, the upper stripe running uninterrupted from gill opening to tail, the lower stripes in two segments, the one from close behind the pectoral to above the ventral, the other thence backward to close behind the rear edge of the anal fin. One or two transverse bars persist however on the caudal peduncle, even on the oldest females.

Color.—This is a decidedly paler fish than the other "mummie." Apart from the black bars the male is dark olive green above with silvery sides, a greenish-yellow belly, and a black spot on the rear part of the dorsal fin; his pectorals and caudal are pale yellowish. The male becomes more brilliant at breeding time, the back turning almost black, the lower sides and belly changing to orange or golden, and the fins to bright yellow. The female is olive green above and white below, striped as described above.

Size.—This is a larger fish than the common mummichog, occasionally growing to a length of 7 inches and often to 6 inches.

Habits.—The striped mummie parallels the common mummie in being restricted to the immediate neighborhood of the land, and in its way of life, except that it keeps more strictly to salt water, and is found more often along open beaches. Its most interesting habit is its ability to flop back into the water if it becomes stranded with the receding tide, jumping unerringly toward the water in almost every instance, and progressing from several inches to several feet at each jump.⁹⁷ And so noted are they for this peculiar ability that a special article has been devoted to it.⁹⁸ Their diet consists of small animals including mollusks, crustaceans, fish, insects, and insect larvae. Westward and southward from Cape Cod they spawn from late spring to late summer.

General range.—Coast of the United States, from the vicinity of Boston, Mass., to Florida.

Occurrence in the Gulf of Maine.—The striped mummie is very abundant along the southern shores of New England, westward from Cape Cod. But the only published records for it in

the gulf are for the vicinity of Boston and Salem, many years ago, and we had not seen it north of Cape Cod before 1937. In that autumn, however, B. Preston Clark brought in four specimens that he had taken at Cohasset, on the southern shore of Massachusetts Bay; it was reported to us as in numbers there in 1939,⁹⁹ and we have seen small schools of them in recent summers in the salt marshes at the entrance to Cohasset Harbor, as well as nearby. If this little fish actually has extended its regular range northward and if its dispersal-route has been via the Cape Cod Canal, as has been suggested,¹ it is to be expected anywhere in the marshes around Cape Cod Bay and along the southern shore of Massachusetts Bay, and we suspect that a resident population is to be found in the Nauset Marshes and in Pleasant Bay, on the outer shore of Cape Cod.

Sheepshead minnow *Cyprinodon variegatus*
Lacépède 1803

Jordan and Evermann, 1896-1900, p. 671.

Description.—The sheepshead minnow is so deep bodied (its body is nearly half as deep as long, not counting the tail fin) that it is not apt to be mistaken for either of the mummichogs. And it is separated further from the mummichogs by its teeth, which are large, wedge-shaped and with tricuspid cutting edges, instead of small and pointed. It is a flat-sided little fish, with high arched back, small flat-topped head, small terminal mouth hardly gaping back to the forward edge of the eye, and it has the thick caudal peduncle characteristic of its family. Its tail is square (rounded in the mummichogs), and the fact that almost the whole of its dorsal fin is in front of the anal instead of over it affords another point of difference. The pectorals are large, reaching back past the base of the ventrals, which seem very small by contrast. Both its body and its head are covered with large rounded scales, largest on top of the head and on the cheeks, with one much larger than the others just above the pectoral fin. Young fish are proportionally more slender than old ones. The dorsal, ventral, and anal fins are higher in the males of this species than in the females, much as they

⁹⁷ Hildebrand and Schroeder, Bull. U. S. Bur. Fish, vol. 48, Pt. 1 1928 p. 141.

⁹⁸ Mast, Jour. of Anima Behavior, vol. 5, No. 5, 1915, pp. 341-350.

⁹⁹ By John W. Lowes.

¹ Schroeder, Copela, 1937, No. 4, p. 238.

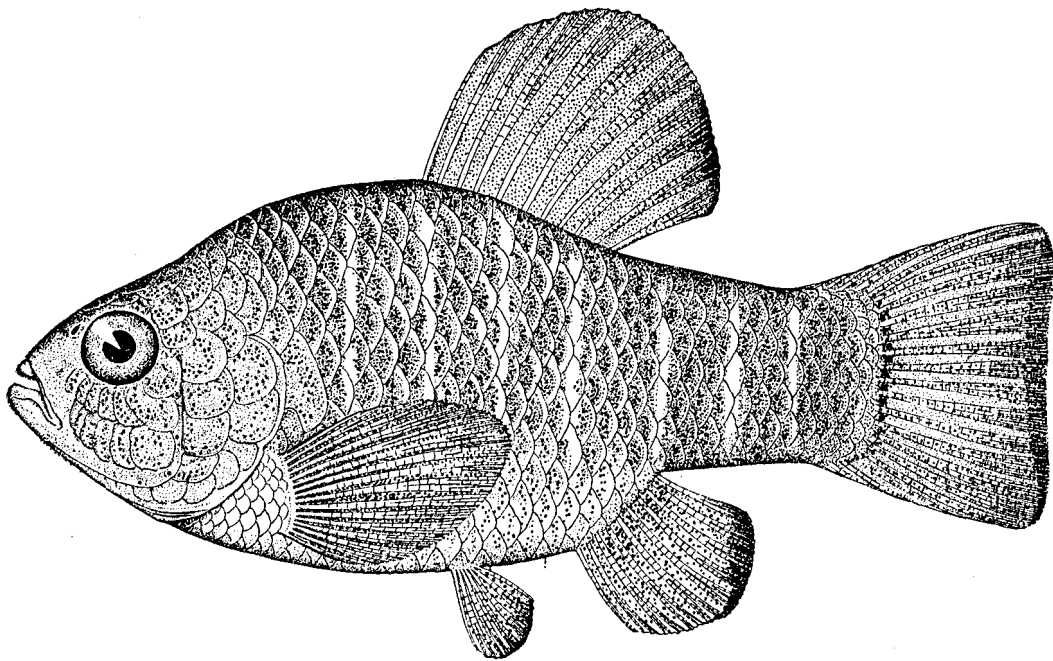


FIGURE 78.—Sheepshead minnow (*Cyprinodon variegatus*), Maryland. From Jordan and Evermann. Drawing by A. H. Baldwin.

are in the mummichogs. The male is deeper bodied and the average size is larger than that of the female.

Color.—Out of breeding season both males and females are olive above (males rather darker and greener than females) with pale yellow or yellowish-white belly, dusky dorsal fin, and pale orange pectoral, ventral, and anal fins. The young of both sexes are irregularly barred with black transverse stripes, which persist through life in the female but become obscured in adult males. Females, furthermore, have a black spot on the rear corner of the dorsal fin, which is lacking in males, while the caudal fin of the male is marked by two black cross stripes, one at the base and the other at the margin. In breeding season the male assumes a brilliant coat, his upper parts turning to steel blue in front of the dorsal fin with a greenish luster behind it, while his belly brightens to a deep salmon, his ventrals and anal change to dusky margined with orange, and the front edge of his dorsal turns orange.

Size.—The largest specimens are about 3 inches long.

Habits.—The sheepshead minnow (like the common mummichog) is confined to the shallow waters of inlets, harbors, and the heads of bays, and salt marshes, often in brackish water. Its diet is

partly vegetable, partly animal. It is very pugnacious, often killing fishes larger than itself, making repeated attacks with its sharp teeth and finally devouring its victim. Its breeding habits recall those of the mummichog (p. 163), the males fighting fiercely among themselves and clasping the females just forward of the tail with dorsal and anal fin, while the eggs and milt are extruded. Spawning takes place in shallow water from April to September, the eggs maturing a few at a time, so that any given female spawns at intervals throughout the season. The eggs sink and stick together in clumps by numerous threads. They are 1.2 to 1.4 mm. in diameter, with one large oil globule and many minute ones. Incubation occupies 5 or 6 days, and even at hatching the larvae (4 mm. long) show alternate light and dark cross-bands. At a length of 9 mm. all the fins are formed, and at 12 mm. the fry show most of the characters of its parents.²

General range.—Atlantic coast of the United States, Cape Cod to Mexico, in brackish as well as in salt water.

Occurrence in the Gulf of Maine.—This fish, like many others, finds its northern limit at Cape Cod

² An account of courtship and spawning is given by Newman (Biol. Bull., vol. 12, No. 5, 1907, p. 336) and of development by Kuntz (Bull., U. S. Bur. of Fish., vol. 34, (1914) 1916, p. 409).

and would not deserve mention here at all were it not recorded from the Cape by Storer. West and south of Cape Cod, however, as at Woods Hole,

it is common enough in suitable situations. We have seined many of them with *Fundulus* at the head of Buzzards Bay.

THE BILLFISHES OR SILVER GARS. FAMILY BELONIDAE

The most noticeable feature of the billfishes is that both of their jaws are prolonged to form a long slim beak well armed with teeth. Their bodies are very slender, and their anal, dorsal, and ventral fins set far back. They have no finlets between the dorsal and anal fins and the caudal, the absence of these being the readiest field mark to separate the billfishes from the needlefishes (*Scomberesox*, p. 170). They are swift-swimming, predaceous fishes, represented by many species, most of them American. Only two have ever been recorded in the Gulf of Maine.³

KEY TO GULF OF MAINE BILLFISHES

Body as thick as it is deep; dorsal, anal, and caudal fins only moderately concave.....Silver Gar, p. 167
Body less than $\frac{1}{2}$ as thick as it is deep; dorsal, anal, and caudal fins deeply concave.....Garfish, p. 168

Silver gar *Tylosurus marinus* (Walbaum) 1792⁴

BILLFISH; SALT-WATER GAR; SEA PIKE; AND
VARIOUS OTHER LOCAL NAMES

Jordan and Evermann, 1896-1900, p. 714.

Description.—Its long bill and slender body give the gar so peculiar an aspect that it is not likely to be confused with any other Gulf of Maine fish

³ The closely allied houndfish (*Tylosurus acus* Lacépède 1803) has been taken at Nantucket, but has not been found within the Gulf of Maine. Since it may appear there as a stray from the south, we may point out that it is easily distinguished from the silver gar by its deeply forked tail and by the fact that its dorsal and anal fins are much longer, the former with 23 rays, the latter with 21. The following characters in combination will serve to identify it among the several tropical gars; mouth nearly closable and upper jaw not arched; dorsal and anal fins long; beak at least twice as long as rest of head; greatest depth of body not more than two-thirds as great as length of pectoral fin; no lateral stripe.

⁴ Jordan, Evermann, and Clark (Rept. U. S. Comm. Fish., (1928) Pt. 2, 1930, p. 196) place this species in the genus *Strongylura* Van Hasselt 1824.

other than the half beak (p. 169), the needle fish (p. 170), or its own close relative *Ablennes* (p. 168). And it is easily distinguishable from the first of these by the fact that both of its jaws are prolonged instead of only the lower; from the second by lacking detached finlets on its back between its dorsal and caudal fins. The most conspicuous differences between the silver gar and *Ablennes* (p. 168) is that the body of the former is thicker than it is deep, and that its fins are only moderately concave, whereas the latter is so strongly flattened sidewise that it is less than one-half as thick as it is deep with deeply concave fins.

The head of the adult silver gar occupies nearly one-third of the total length of the fish; the upper jaw, from the eye forward, is twice as long as the rest of the head; both jaws are armed with sharp teeth; and the eyes are large. The long, slender body is only about one-twentieth as deep as long, rounded (not laterally flattened) in cross section, and thicker than deep. Both the body and the sides of the head are scaly. The dorsal fin, with 13 to 17 rays, and the anal fin, with 17 to 21 rays, are alike in outline, the anterior rays of both being much longer than those toward the rear, and the rear two-thirds of each can be depressed along the back and nearly concealed in a groove, while the forward one-third continues erect. Both fins, too, are situated far back, with the dorsal arising a little behind the forward end of the anal.

The ventral fins stand about halfway between a point below the eye and the base of the caudal. The margin of the caudal fin is only moderately concave, this fact being the readiest field mark to separate this particular gar from the only other species of its genus (*Tylosurus acus*) taken yet near the Gulf of Maine (see footnote, p. 167), for the tail of the latter is deeply forked. There is a distinct

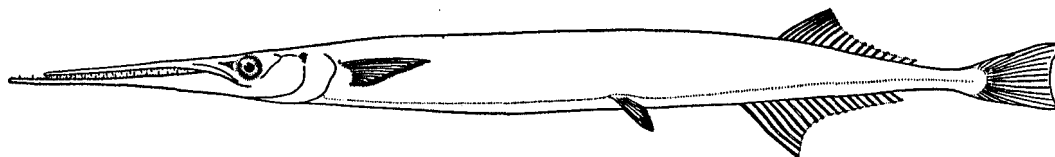


FIGURE 79.—Silver gar (*Tylosurus marinus*).

longitudinal ridge, or low keel, along either side of the caudal peduncle.⁵

Color.—Greenish above, silvery on the sides, white below; a bluish silvery stripe along each side becoming broader and less distinct toward the tail; snout dark green; there is a blackish blotch deeper than long on the upper part of the cheek. The fins are without markings for the most part; the dorsal may be somewhat dusky, and the caudal bluish at its base.

Size.—The silver gar grows to a length of about 4 feet.

General range.—Maine to Texas; abundant along the South Atlantic and Gulf coasts of the United States, often running up fresh rivers above tide water.

Occurrence in the Gulf of Maine.—The silver gar is common enough along the southern shores of New England, e. g., in Rhode Island waters and at Woods Hole where quite a few are found from June to October. Like many other southern fishes, however, it seldom journeys eastward past Cape Cod, the only definite records of it within the Gulf of Maine being of several collected by Dr. William C. Kendall at Monomoy Island, forming the southern elbow of Cape Cod; at Wolfs Neck, Freeport, and Casco Bay, Maine, and of one found by Crane⁶ in the stomach of a tuna that she examined at Portland, Maine, in July 1936. We have not seen it in the Gulf, nor have we heard even a rumor of its presence there from fishermen, good evidence that it is as rare a straggler as the few records indicate, for large silver gars are not

⁵ There are many other species of gars in tropical seas, any one of which might stray northward with the Gulf Stream and so to the Gulf of Maine. The silver gar is identifiable among them by the following combination of characters (no one character alone marks it out among its relatives): mouth capable of being nearly closed; caudal peduncle with keels; dorsal and anal fins short, the former with 13-17 rays, the latter with 17-21 rays; caudal fin only moderately concave; eyes at least one-third as broad as the head is long behind the eyes; body not excessively slender but at least one-fifth to one-sixth as deep as head (including jaws) is long; body not very strongly compressed sidewise; Jordan and Evermann (Bull. 47, U. S. Nat. Mus., Pt. 1, 1896, p. 709) gives a useful key to the species of the family.

⁶ Zoologica, New York Zool. Soc., vol. 21, No. 16, 1936, p. 211.

fish to be overlooked. With so little claim to mention here, we need merely note that it is voracious, feeding on all sorts of smaller fishes, and that it runs inshore, possibly even into river mouths, to spawn. The eggs, described by Ryder,⁷ are about 3.6 mm. (one-seventh of an inch) in diameter, and stick together and to any object they may touch, by long threads scattered over their surface.

Garfish *Ablennes hians* (Cuvier and Valenciennes)
1846

Jordan and Evermann, 1896-1900, p. 718, *Athlennes hians*.⁸

Description.—This gar resembles the silver gar (*Tylosurus*) closely in general appearance, as well as in the nature and arrangement of its fins; especially in the fact that the rear parts of its dorsal and caudal fins can be depressed and almost completely concealed in a groove, with the forward parts still remaining erect. But its body is so strongly flattened sidewise as to be less than one-half as thick as it is deep, instead of about as thick as deep, or thicker, as it is in the silver gar. The dorsal fin, also, arises farther back relative to the anal fin, than is the case in the silver gar. The tail fin is broadly forked, the dorsal and anal fins deeply concave.

Color.—Back greenish with bluish green reflections; lower part of sides bright silvery, also the abdomen; snout greenish; dorsal fin mostly greenish, but with the rays black-tipped; tail fin greenish. Some individuals have the sides plain silvery, but others are marked with dark blotches or indistinct sooty or blue crossbars.⁹

Size.—Up to 3 feet long, or more.

⁷ Bull. U. S. Fish Comm., vol. 1, 1882, p. 283.

⁸ The original spelling was *Athlennes* (Jordan and Fordice, Proc. U. S. Nat. Mus., vol. 9, 1896, p. 342). But Jordan and Evermann (Bull. 47, U. S. Nat. Mus., Pt. 1, 1896, p. 717, footnote) state that "*Ablennes*" was intended.

⁹ Smith (Sea Fishes of Southern Africa, 1949, pl. 7, fig. 26) gives a colored illustration of one with blue crossbars.

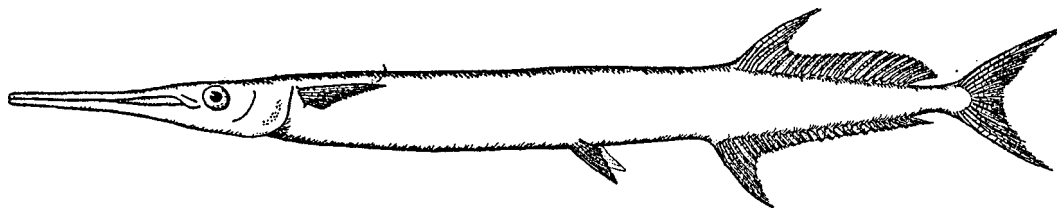


FIGURE 80.—Garfish (*Ablennes hians*), specimens from North Truro, Mass., and from Acapulco, Mexico. Drawing by H. B. Bigelow.

General range and occurrence in the Gulf of Maine.—Widespread in tropical seas;¹⁰ Brazil to Chesapeake Bay in the western Atlantic, and northward as a stray to Cape Cod. A specimen

of this tropical fish, about 23½ inches (594 mm.) long to the fork of the tail, was taken in a fish trap on the shore of Cape Cod Bay at North Truro, Mass., on August 15, 1949.¹¹

THE HALFBEAKS. FAMILY HEMIRAMPHIDAE

The halfbeaks are close allies of the billfishes (*Belonidae*, p. 167), but it is only the lower jaw that is greatly prolonged while the upper jaw is short in the only species of present concern. They are largely herbivorous, feeding mainly on green algae. There are many species in warm seas, only one of which is known to reach the Gulf of Maine.

Halfbeak *Hyporhamphus unifasciatus* (Ranzani) 1842 SKIPJACK

Jordan and Evermann, 1896–1900, p. 721 (*Hyporhamphus roberti* (Cuvier and Valenciennes) 1846).

Description.—The most striking feature of this halfbeak and one which is enough of itself to mark it off from every other fish known from the Gulf of Maine, is the fact that while the lower jaw is very long, the upper jaw is short.¹²

This is a slender fish, its body only one-sixth to one-tenth as deep as long (younger fish are still more slender), tapering slightly toward head and tail. Its dorsal (14 to 16 rays) and anal (15 to 17 rays) fins are situated far back and opposite each other, as in the silver gar, and are about equal in length and alike in outline. There are no detached finlets between them and the caudal

fin. The ventrals stand about midway between a point below the eye and the base of the caudal. The teeth are small and the scales are largest on the upper surface of the head. The beak is much shorter in young fish than it is in adults.

Color.—Translucent bottle green above with silvery tinge, each side with a narrow but well-defined silvery band running from the pectoral fin to the caudal fin, the sides darkest above and paler below this band. The tip of the lower jaw is crimson in life, with a short filament, and three narrow dark streaks run along the middle of the back. The forward parts of the dorsal and anal fins and the tips of the caudal fins are dusky. The lining of the belly is black.

Size.—Adults are seldom more than 1 foot long.

General range.—Tropical and subtropical on both coasts of America and in the Gulf of Mexico; abundant off the South Atlantic United States, not uncommon northward to Cape Cod, and straying to the coast of Maine.

Occurrence in the Gulf of Maine.—In our cool boreal waters the halfbeak is only a rare stray from the south, previously recorded only twice in the Gulf of Maine, i. e., from Machias and from Casco Bay, Maine, many years ago in each case. We can now add one taken in Quincy Bay, Boston Harbor, July 10, 1951, by Gordon Faust; another off Revere (also in Boston Harbor) on the 19th of the month, by John M. Hodson; a third, taken in a trap at Sandwich, September 24 of the same year,¹³ and several dozen taken in a pound net at Small Point, Maine, July 14–15, reported by Leslie Scattergood.

¹⁰ We have seen specimens from Acapulco, west coast of Mexico; Panama; Mauritius; and Zanzibar.

¹¹ This specimen was presented to the Museum of Comparative Zoology by John Worthington of the Pond Village Cold Storage Co., North Truro, Mass.

¹² Should a halfbeak be taken in the Gulf of Maine it would be well to consult Meek and Hildebrand (*Field Museum of Natural History, Zool. Series, vol. 15, Pt. 1, p. 232, 1923*) for there are several other species that might reach us as strays, either via the Gulf Stream route or from offshore. One, indeed (*Euleptorhamphus velox*), has been taken at Nantucket. Its lower jaw is even longer and more slender than that of the halfbeak, its body is more flattened sidewise, and its pectoral fins are longer.

¹³ These specimens are in the Harvard Museum of Comparative Zoology.

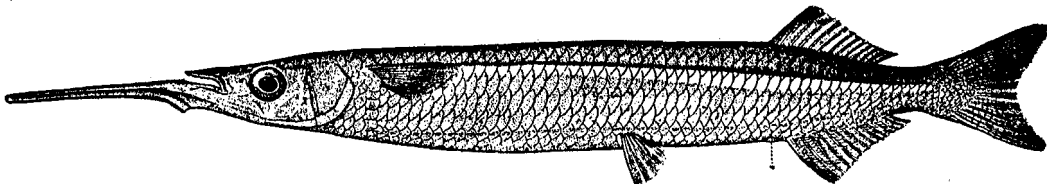


FIGURE 81.—Halfbeak (*Hyporhamphus unifasciatus*), Chesapeake Bay. From Jordan and Evermann. Drawing by H. L. Todd.

THE NEEDLEFISHES. FAMILY SCOMBERESOCIDAE

Both jaws (of the adult) are elongated to form a slender beak in the needlefishes, as in the billfishes (p. 167), and the anal, dorsal, and ventral fins are set far back. But the presence of several finlets between the dorsal and anal fins and the caudal in the needlefishes (which the billfishes lack) is a ready field mark for their identification. Furthermore, their teeth are small and weak, and their bodies only moderately slender. Four or five species are known in warm seas, one of which is not uncommon in the Gulf of Maine.

Needlefish *Scomberesox saurus* (Walbaum) 1792

BILLFISH; SKIPPER; SAURY

Jordan and Evermann, 1896-1900, p. 725.

Description.—The needlefish resembles the silver gars in its slender form and in the fact that both its upper and lower jaws are prolonged, but

greenish; the lower parts are silvery with golden gloss. Young fry, which live in the surface waters of the open Atlantic, have dark blue backs and silvery sides.

Size.—Up to 18 inches long. Those caught along Cape Cod run a foot and more in length.

Habits.—The skipper is an oceanic fish. So far as known it always lives close to the surface; so much so indeed that in English waters, where it is plentiful in summer, few are caught in nets set as deep as a fathom or two. Its hordes are preyed upon by porpoises and by all the larger predaceous fishes; cod and pollock, for instance, feed greedily upon them, as do bluefish. When they strand on the beaches, as often happens, it is probably while they are fleeing from their enemies. At sea they attempt to escape by leaping, whole companies of them breaking the surface together as has often been described, and as we have seen them doing in Massachusetts Bay.

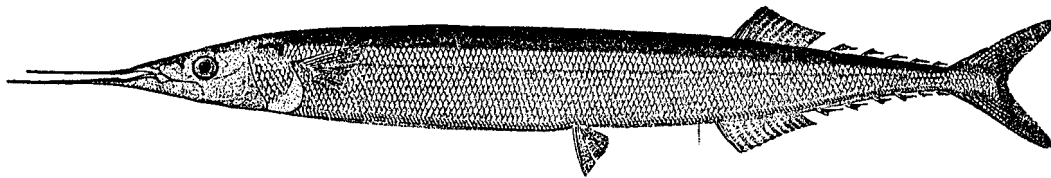


FIGURE 82.—Needlefish (*Scomberesox saurus*). Adult, Woods Hole. From Goode. Drawing by H. L. Todd.

it differs from the gars in having a series of five or six little separate finlets, both on its back in the space between the dorsal fin and the caudal, and on its lower side between the anal fin and the caudal. Its body is about nine times as long (not counting caudal fin) as deep, flattened side-wise, tapering toward the head and tail, with slender caudal peduncle, and all its fins are small. Its dorsal fin originates slightly behind the origin of its anal; these two fins are alike in outline and stand far back. Its ventrals are situated about midway the length of the body. Its caudal is deeply forked and symmetrical, much like the tail of a mackerel. Its trunk is covered with small scales as is a patch on each gill cover. Its lower jaw projects a little beyond the upper, and its teeth are pointed but very small.

Color.—Olive green above with a silver band on each side at the level of the eye and about as broad as the latter. There is a dark green spot above the base of each pectoral; the dorsal fin is



FIGURE 83.—Needlefish, young, about 2½ inches long. After Murray and Hjort.

It is not likely that they ever spawn in the cool waters of the Gulf of Maine, for we have never taken their fry in our tow nets, although they are among the most numerous of young fish in the open Atlantic between the latitudes of 11° or 12° N. and 40° N. Although their eggs are covered with filaments like those of the silver gars,¹⁴ they are not adhesive as the latter are, but drift near the surface. The most interesting phase in the development of the skipper is that its jaws do not commence to elongate until the fry have grown

¹⁴ Skipper eggs were so described by Haeckel (*Archiv für Anatomie, Physiologie, und Wissenschaftliche Medizin*, 1855, p. 23, pl. 5, fig. 15), 75 years ago. They were not seen again until 1910 when similar eggs, 2.2 mm. in diameter, covered with filaments, were towed in the Atlantic by the *Michael Sars* (Murray and Hjort, *Depths of the Ocean*, 1912, p. 742, fig. 531).

to about 1½ inches (40 mm.), and that the lower jaw out-strips the upper at first, so that fry of 4 to 6 inches (100 to 150 mm.) look more like little halfbeaks ("Hemiramphus" stage) than like their own parents.

European students tell us that the skipper feeds on the smaller pelagic Crustacea and probably also on small fish, for it is sometimes caught on hook and line. One examined by Linton at Woods Hole contained chiefly annelid worms, fragments of fish, copepods and crustacean larvae, with some vegetable debris.

General range.—Temperate parts of the Atlantic, Pacific, and Indian Oceans, known in the open sea as far north as northern Norway off the European coast, and to southern Newfoundland and southern Nova Scotia¹⁵ off the eastern American coast.

Occurrence in the Gulf of Maine.—While the skipper is a straggler to our Gulf from warmer waters offshore or farther south, it has been taken along the northern coasts of New England more often than have any of its relatives; specifically along Cape Cod; at Provincetown; at several locations in Massachusetts Bay where we have seen schools of them; at Annisquam a few miles north of Cape Ann; at Old Orchard (Maine); in Casco Bay; at Monhegan Island; in the central part of the Gulf;¹⁶ among the islands at the northern entrance to the Bay of Fundy; and on the northern part of Georges Bank, where one was gaffed from the *Albatross II* on September 20, 1928. But we find no record of it along the Nova Scotia shore of the Gulf of Maine. The inner curve of

Cape Cod from Provincetown to Wellfleet seems to be a regular center of abundance for it, as Storer long ago remarked, for schools of billfish are picked up in the traps along that stretch of beach almost every year, the catch occasionally amounting to hundreds of barrels, and hosts of them have been known to strand there. Its numbers fluctuate greatly from year to year, however, and it often fails to appear.¹⁷

They are likely to be taken any time from mid-June to October or November, the largest catches usually being made late in summer.¹⁸ We have seen several schools skipping, as is their common habit, off the Scituate shore on the southern side of Massachusetts Bay. But skippers are so much less common farther within Massachusetts Bay that some fishermen had never heard of them there. They appear only as strays north of Cape Ann. But it would not be astonishing if a large school were to be encountered anywhere within the Gulf; witness their occasional abundance off northern Nova Scotia.¹⁹ When skippers do invade the waters of our Gulf, they may be expected in multitudes, for they usually travel in vast schools. Day,²⁰ for example, mentions the capture of 100,000 in a single haul in British waters.

Commercial importance.—The skipper is not of much commercial importance, being too sporadic in its appearances. However, when large catches are made on Cape Cod they find a ready sale near by. If too many are caught for the local trade to absorb, they are sent to Boston, where they are sold for bait.

THE FLYING FISHES. FAMILY EXOCOETIDAE

The typical flying fishes have one dorsal fin and one anal fin, both of them soft rayed, both of them located far rearward, and with the anal below the dorsal. Their ventral fins are well behind their pectorals, their tails are very deeply forked with the extreme tips rounded, the lower lobe the longer, and they have small mouths and large rounded scales. Their most distinctive feature is that their pectorals are so long and so stiff that their owners can plane through the air

on them, several feet above the water, which they do mostly in attempts to escape their enemies, and as has been described, time and again. Jordan and Evermann have given a popular account of this so-called "flight" (really not flight at all, for the flying fish does not flap its wings) in their

¹⁷ Blake (*American Naturalist*, vol. 4, 1870, p. 521) remarked that while years before he saw thousands stranded at Provincetown not one was seen in 1870. It failed in 1921, also, and no doubt in many intervening years.

¹⁸ We are indebted for information on the local abundance of billfish on Cape Cod to Capt. L. B. Goodspeed, a fisherman of long experience and close observation.

¹⁹ Cornish (*Contrib. Canadian Biol.*, 1902-1905 (1907), p. 83) states that large schools can often be seen at Canso skipping over the water as they flee from the pollock.

²⁰ The fishes of Great Britain and Ireland, vol. 2, 1880-1884, p. 152.

¹⁵ Cornish (*Contrib. Canadian Biol.*, (1902-1905) 1907, p. 83) states that large schools can often be seen at Canso, Nova Scotia, skipping over the water as they flee from the pollock.

¹⁶ The Museum of Comparative Zoology has a specimen, taken 115 miles southeast of Portland Lightship.

Guide to the Study of Fishes, 1905, p. 157. For a more detailed study, based similarly on first-hand observations, we refer the reader to Hubbs, Papers of the Michigan Academy of Sciences, vol. 17, 1933, pp. 575-611. Voyagers in tropical seas are perhaps more familiar with flying fishes than with any other fishes. And they are often seen in the warm ultramarine-blue waters of the Gulf Stream abreast of our northeastern coast. But none of them are to be expected in the boreal waters of our Gulf except as the rarest of strays.

A flying fish could hardly be mistaken for anything else, except possible for a flying gurnard (p. 472). But a glance should be enough to tell which of them one has in hand, for the flying fishes have stiff, narrow, pointed wings, only on dorsal fin and a very deeply forked tail, whereas the so-called wings of the flying gurnard are broad, rounded, and extremely flexible; they have two dorsal fins, and a tail fin that is only weakly concave in outline.

Flying Fish *Cypselurus heterurus* (Rafinesque) 1810

Jordan and Evermann, 1896-1900, p. 2836.

Distinctive features of flying fishes of the genus *Cypselurus*, among its tribe, are pectoral fins so long that they overlap the anal fin considerably when laid back; ventrals standing far rearward and nearly or quite half as long as the pectorals; anal fin with its point of origin only a little forward of the mid-point of the base of the dorsal fin; and second ray of the pectoral fins branched. The species *heterurus* has a plain gray dorsal fin; it has no teeth on the palatine bone in the roof of its mouth; and the pale edging of the outer margin of its pectoral fins is extremely narrow. The

number of its scales is distinctive, also, as is the number of its vertebrae. But these last two characters are matters for the specialist.

Color.—Dark blue gray on the back and on the upper part of the sides, silvery lower down on the sides, and below; the dorsal fin is plain gray, the rear margin of the pectorals with a very narrow pale edging.

Size.—The species *heterurus* is one of the larger flying fishes, commonly growing to a length of about 1 foot (to the base of the tail fin).

Occurrence in the Gulf of Maine.—A flying fish, about 9¼ inches long to the fork of the tail, seemingly of this species but not in good enough condition for certain identification, was taken in a trap of the Pond Village Cold Storage Co. at North Truro, on the Massachusetts Bay shore of Cape Cod, on August 4, 1952. This is the only record of one of its tribe, from our Gulf. And the only record of a flying fish from Nova Scotian coastal waters is by Jones, of one taken at Sable Island, in 1859.

Flying fishes are taken now and then at Woods Hole, the species *heterurus* perhaps more often than any other, according to published report, but several of the kinds to be expected in the Gulf Stream off our coast resemble one another very closely indeed. So we suggest that if a flying fish should be taken in our Gulf that does not seem to fit the accompanying illustration (fig. 83A) it be forwarded either to the Fisheries Laboratory of the U. S. Fish and Wildlife Service, Woods Hole, Massachusetts; to the Department of Fishes, U. S. National Museum, Washington, D. C.; or to the Department of Fishes, Museum of Comparative Zoology, Cambridge, Massachusetts, to be named.

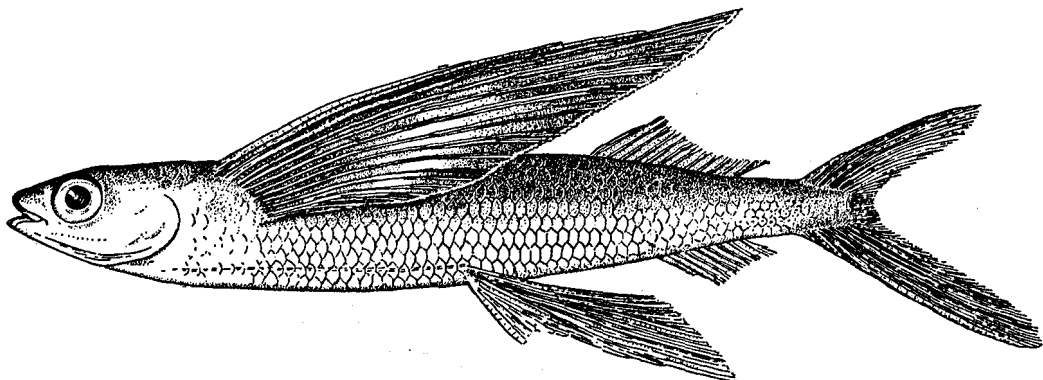


FIGURE 83A.—Flyingfish (*Cypselurus heterurus*). After Bruun and a specimen from North Truro, Mass. Drawing by Jessie Sawyer.

THE SILVER HAKE AND COD FAMILIES—FAMILIES MERLUCCIIDAE AND GADIDAE

The silver hakes and the cods are so closely allied that many European ichthyologists group them in a single family. American practice, however, is to separate them because of certain differences in the structure of the skull and ribs. They are soft-finned fishes, lacking true spines at any stage in development (though in one local species, the silver hake, the basal parts of the dorsal and anal fin rays are so stiff as to feel like

spines to the touch), but they are distinguishable from all other soft-rayed Gulf of Maine fishes by the fact that their large ventral fins are situated under the pectorals or in front of them, and not behind them, as they are in the herrings and salmons. They and their relatives, the grenadiers (p. 243), are separated from most of the typical spiny-rayed fishes by the structure of the skull.²¹

Key To Gulf Of Maine Hakes, Cods, And Other Species

1. There are three separate dorsal fins and two anal fins..... 2
 There are two separate and well developed dorsal fins..... 5
 There is only one well developed dorsal fin..... 11
2. The lateral line is black; there is a black blotch on each shoulder..... Haddock, p. 199
 The lateral line is pale; there is no shoulder blotch..... 3
3. The lower jaw projects beyond the upper; the chin barbel is very small, if there is one..... Pollock, p. 213
 The upper jaw projects beyond the lower; the chin barbel is large..... 4
4. The ventral fins are narrow, and prolonged as filamentous feelers that are as long as the rest of the fin; the eyes are small..... Tomcod, p. 196
 The ventral fins are broad, and their filamentous tips are less than one-third as long as the remainder of the fin; the eyes are large..... Cod, p. 182
5. The anal fin originates considerably in front of the point of origin of the second dorsal fin..... Hake, p. 233
 The anal fin originates under the point of origin of the second dorsal fin or behind it..... 6
6. The ventral fins are short and of ordinary form..... Silver hake, p. 173
 The ventral fins are very long and feeler-like..... 7
7. The first dorsal fin is hardly higher than the second dorsal, and none of its rays are prolonged or filamentous.....
 Spotted hake, p. 230
 The first dorsal fin is much higher than the second dorsal, with one or two long filamentous rays..... 8
8. The ventral fins reach nearly or quite as far back as the rear end of the anal fin..... Long-finned hake, p. 232
 The ventral fins do not reach back to the middle of the anal fin..... 9
9. The anal fin is so deeply notched about midway of its length as to suggest two separate fins..... Blue hake, p. 233
 The anal fin is of about equal height from end to end..... 10
10. There are about 140 rows of scales along the lateral line from gill opening to base of caudal fin; the upper jaw bone reaches back to below the rear edge of the eye..... White hake, p. 221
 There are only about 110 rows of scales along the lateral line; the upper jaw bone reaches back only as far as the rear edge of the pupil..... Squirrel hake, p. 223
11. There are no isolated rays in front of the dorsal fin, nor barbels on the top of the snout..... Cusk, p. 238
 The dorsal fin is preceded by a fringe of short rays and one long ray; the top of the snout bears barbels as well as the chin..... 12
12. There are three barbels on the top of the nose..... Four-bearded rockling, p. 234
 There are only two barbels on the top of the nose..... Three-bearded rockling, p. 237

Silver hake *Merluccius bilinearis* (Mitchill) 1814

WHITING; NEW ENGLAND HAKE

Jordan and Evermann, 1896-1900, p. 2530.

Description.—The presence of two separate and well developed dorsal fins, both of them soft-rayed, the second much longer than the first, combined with the location of the ventrals on the chest, is sufficient field mark to distinguish the silver hake from all other Gulf of Maine fishes except for the

true hakes (genus *Urophycis*, p. 221). And there is no danger of confusing it with any of the latter, for it lacks the chin barbels so characteristic of them, and its ventrals are of the ordinary finlike form, whereas those of the true hakes are altered into long feelers. It is a rather slender fish, about five to six times as long as it is deep, its body rounded in front of the vent but flattened sidewise behind it, with large flat-topped head occupying

²¹ The hypercoracoid bone lacks an aperture (technically a "foramen").

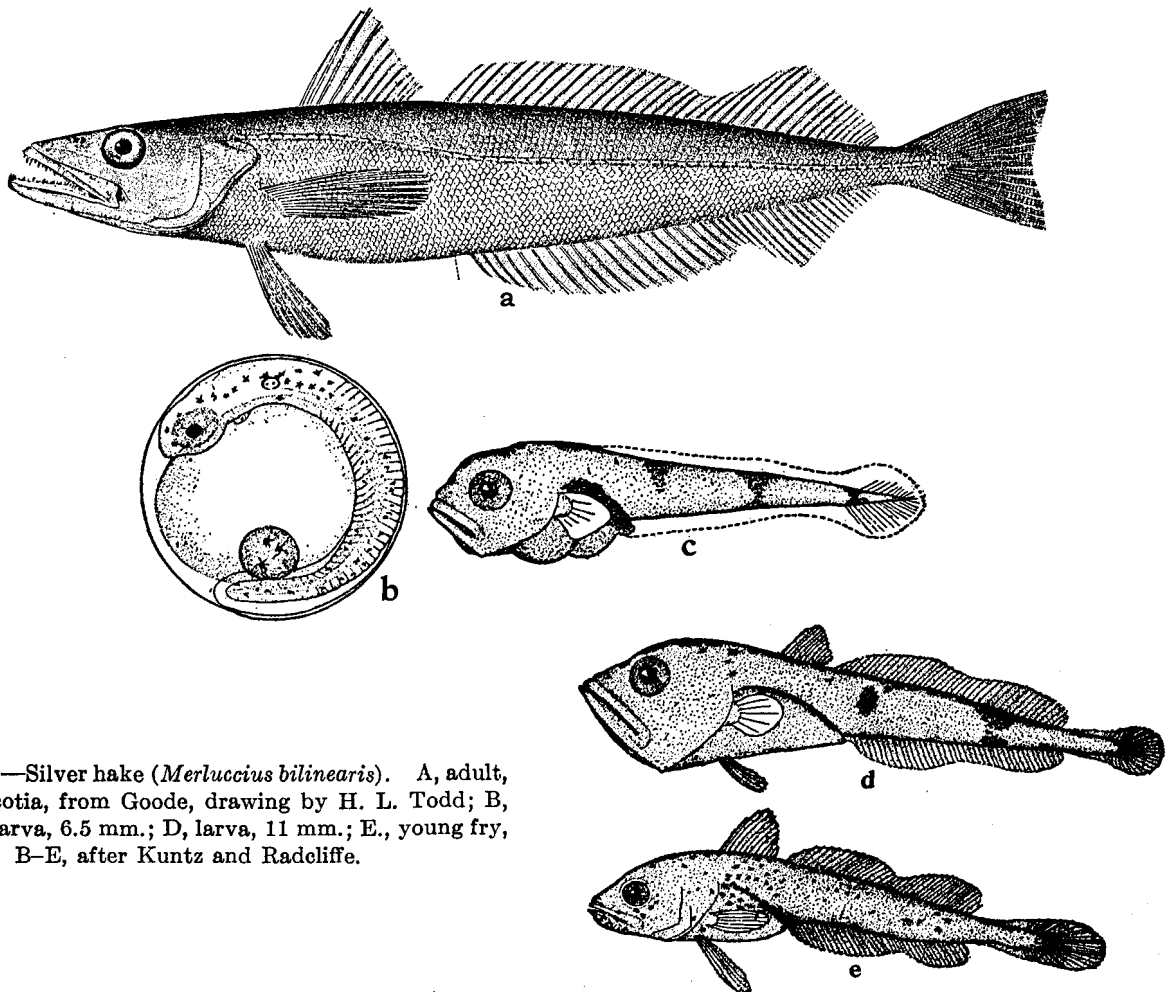


FIGURE 84.—Silver hake (*Merluccius bilinearis*). A, adult, Nova Scotia, from Goode, drawing by H. L. Todd; B, egg; C, larva, 6.5 mm.; D, larva, 11 mm.; E., young fry, 23 mm. B-E, after Kuntz and Radcliffe.

about one-fourth of the total length; large eyes; and wide mouth armed with two or more rows of sharp recurved teeth, and with the lower jaw projecting beyond the upper.

The first dorsal fin (11 to 14 rays) originates close behind the gill openings, is roughly an equilateral triangle in shape, and is separated by a short space from the second dorsal. The second dorsal (38 to 41 rays) is about four times as long as the first dorsal, but hardly more than half as high, and is of distinctive outline, being deeply emarginate two-thirds of the way back, with the rear section the higher of the two. The anal fin (38 to 41 rays) corresponds in height and in shape to the second dorsal, under which it stands. The caudal fin is square tipped when widespreading, but its rear margin is weakly concave, otherwise. The pectorals are rather narrow, their tips slightly rounded, and they reach back far enough to overlap the second dorsal a little. The ventral fins,

situated slightly in front of the pectorals, are perceptibly shorter than the latter, with about half as many rays (7).

Color.—The silver hake is dark gray above of brownish cast; but silvery-iridescent, as its name implies, or with golden reflections. The lower part of its sides and its belly are silvery. The inside of its mouth is dusky, the lining of its belly blackish. The fish is brightly iridescent when taken from the water, but fades soon after death.

Size.—Maximum size about 2½ feet long and about 5 pounds in weight, but adults average only about 14 inches long.

Habits.—Silver hake are strong swift swimmers, well armed and extremely voracious. They prey on herring and on any other of the smaller schooling fish, such as young mackerel, menhaden, alewives, and silversides. Probably a complete diet list would include the young of practically all the common Gulf of Maine fishes, for Vinal Edwards

recorded the following from silver hake taken at Woods Hole: alewife, butterfish, cunner, herring, mackerel, menhaden, launce, scup, silversides, smelt, also the young of its own species. A 2¾-inch silver hake, taken at Orient, N. Y., had 75 herring, 3 inches long, in its stomach.²² And it is probable that the silver hake that frequent Georges Bank feed chiefly on young haddock. They eat squid when occasion offers. The small ones in particular prey regularly on large shrimp (*Pandalus*) in the deep troughs in our Gulf, where experimental trawlings by the *Atlantis* in the summer of 1936 took about four times as many silver hake at stations where these shrimps were abundant as at stations where shrimps were scarce.²³ They sometimes take crabs, and bite freely on almost any bait, such as clams or cut fish.

Though silver hake do not school in definite bodies, multitudes of them often swim together, and such bands sometimes drive herring ashore, and strand themselves, in the pursuit. Events of this sort are oftenest reported in early autumn when the spent fish are feeding ravenously after the effort of spawning, but this may also happen at any time during the summer. Thus, Prof. A. E. Gross saw the beach at Sandy Neck, Barnstable, Mass., covered with them on several occasions in June and July 1920.²⁴ Doctor Huntsman informs us that spent fish frequently strand on the beaches on both sides of the Bay of Fundy in September. We once saw an army of silver hake harrying a school of small herring on a shelving beach at Cohasset, Mass. We half filled our canoe with pursuers and pursued, with our bare hands.

It is said that European silver hake rest on the bottom by day and hunt by night, and it is usually at night that the American fish run up into the shallows and enter the traps. But strandings also take place by day. Silver hake, like many other rapacious species, are wanderers, independent of depth within wide limits, and of the sea floor. Sometimes they swim close to the bottom, sometimes in the upper levels of the water, their vertical movements being governed chiefly by their pursuit of prey. Their upper limit is the tide line; at the other extreme they have been trawled repeatedly as deep as 150 to 400 fathoms on the continental slope off southern New England, and

as deep as 296 fathoms off North Carolina.²⁵ When they are on bottom they are caught indifferently on sandy or pebbly ground, or on mud (as in the deep trough west of Jeffreys Ledge, p. 175); seldom around rocks.

The lowest temperatures in which we have known of silver hake being taken have been between 38° and 40° F. (probably), in the bottom of the deep trough west of Jeffreys Ledge, August 1936,²⁶ about 40° F. (4.4° C.) at 28 fathoms off New York, February 28, 1929, and about 39.5° F. (4.2° C.) at 19 fathoms in the same general region, February 5, 1930.²⁷ And most of the winter and early spring records for it have been where the bottom temperature was warmer than about 43° F. (6° C.).²⁸ At the other extreme, we have never heard of them in any numbers where the water was warmer than about 64° F. (18° C.); the monthly catches made in Cape Cod Bay (see p. 180) are especially instructive in this regard.

Breeding habits.—The silver hake is the most important summer spawner among Gulf of Maine fishes that are important commercially, just as the haddock is for spring and the pollock for autumn. The Gulf is probably its most prolific nursery, too, and it spawns over the outer part of the Nova Scotia Banks also, as far east as Sable Island, Dannevig²⁹ having recorded large egg catches in the offing of Halifax. But this is probably its eastern breeding limit, for the Canadian Fisheries Expedition found no silver hake eggs or fry on Banquereau or Misaine Banks; in the Laurentian Channel; or on the Newfoundland Banks. In the opposite direction, eggs in fair numbers have been taken in the tow nets off Woods Hole in July and August; the *Albatross II* has found them and the resultant larvae near shore off Long Island in June and July, with eggs as far south as the offing of Cape May; and the young fry have been caught off New York³⁰ from spring to autumn.

We have no evidence that silver hake commence to spawn before June, north of Cape Cod, our earliest egg record having been for the 11th of that

²² Goode and Bean, *Smithsonian Contrib. Knowl.*, vol. 30, 1895, p. 387.

²³ No temperature was taken, but 38.6° F. (3.66° C.) was recorded there at 85 fathoms, on August 15, 1914, and 39.8° F. (4.33° C.) at 72 fathoms on August 15, 1913.

²⁴ Specimens trawled by *Albatross II*.

²⁵ *Albatross II* trawled a considerable number at stations scattered along the continental slope, from the offing of southern New England to the offing of Chesapeake Bay, in February 1929 and 1930, and in April 1930.

²⁶ *Canad. Fish. Exped. (1914-1915)*, 1919, p. 27.

²⁷ Nichols and Breder, *Zoologica*, New York Zool. Soc., vol. 9, 1927, p. 163.

²⁸ Nichols and Breder, *Zoologica*, N. Y. Zool. Soc., vol. 9, 1927, p. 163.

²⁹ For details, see Bigelow and Schroeder, *Biol. Bull.*, vol. 76, 1939, p. 315.

³⁰ *The Auk*, vol. 40, 1923, p. 19.

month; in our Gulf, egg production (as evidenced by the numbers of eggs taken in our tow nets) is at its height in July and August and continues through September, though less freely, with October 22 as our latest date. Similarly, the Canadian Fisheries Expedition found no silver hake eggs in Nova Scotia waters east of Cape Sable in May, but many in July.

It is impossible to establish the exact temperature at which silver hake are spawning at any particular station without knowing at what level ripe fish are in the water, which may be anywhere between the surface and the bottom with this species. It may be definitely stated, however, that they never spawn in as cold water as cod and haddock usually do in the western Atlantic. In 1915, for example (a representative season), it was not until the entire column of water was slightly warmer than 41° F. at the locality in question that we found the first silver hake eggs in our Gulf. And if the parent fish were in the upper water layers, as they may have been, all the rich spawnings we encountered in the Gulf during that year, and during the next, took place in temperatures considerably higher still. Similarly, the silver hake eggs towed off Halifax by the Canadian Fisheries Expedition in July 1915, and off Shelburne, Nova Scotia, by the *Grampus* on September 6 of that same year may have been spawned in water warmer than 50° F., there being no need to assume that the parent fish were lying in the colder bottom stratum. As the spawning season draws to its close, in September and October, the minimum temperatures for most of our egg stations have been higher than 46°, with one (our latest record for the season) as warm as 57° F. at all depths. These data point to 41° to 45° F. as the lowest temperature limit for the spawning of the silver hake, with most of the eggs produced at 45° to 55° F.

In the case of any fish producing buoyant eggs the tendency of the latter to rise (unless counteracted by active vertical circulation of the water) insures that their development shall take place at the temperature of the upper stratum of water, not at that of the deeper levels where they were spawned. And the silver hake is no exception to this rule. While we have towed its eggs in June, when the surface was still only about 42° F., most of the egg records, and all our rich catches, were all made where the upper 5 fathoms or so were

warmer than 50° and usually warmer than 55° F., with the temperature of the immediate surface 60° or higher in most cases. Similarly, silver hake eggs taken off Halifax by the Canadian Fisheries Expedition in July 1915, and off Shelburne, Nova Scotia, by the *Grampus* on September 6 of that year, may well have been in water at least as warm as 53° F., there being no reason to suppose they were far below the surface.³¹ All this suggests that incubation does not proceed normally in water cooler than about 50°, and that it is most successful in temperatures as high as 55° to 60° F. This evidence that while the eggs of the silver hake may be spawned in low temperatures, a comparatively warm surface layer is necessary for their later development, offers a reasonable explanation for the failure of this fish to breed successfully along the New Brunswick shore of the Bay of Fundy, where active vertical circulation maintains surface temperatures as low as 50° to 55° F. throughout the summer, at least in most years. At the other extreme, the failure of the eggs that had been fertilized artificially to develop in the hatchery at Woods Hole in August temperatures points to 65° to 70° F. as the upper limit to successful incubation.

According to Kuntz and Radcliffe³² only part of the eggs mature at one time, but we know of no estimate of the number of eggs a single female may produce. The eggs are buoyant, transparent, about 0.88 to 0.95 mm. in diameter, with a single yellowish or brownish oil globule of 0.19 to 0.25 mm. Incubation is rapid; Kuntz and Radcliffe assumed a duration of 48 hours at Woods Hole, but it has not been determined for the cooler waters in the Gulf of Maine. The larvae are about 2.8 mm. long at hatching, slender, with small yolk sac, and they are made recognizable by the fact that the vent is located on one side, near the base of the larval fin fold, as is the general rule in the cod family, not at its margin as in most larval fishes, and that the trunk behind the vent is marked with two black and yellow cross bars. The dorsal and anal fins and the caudal fin have all assumed their definite outlines by the time the little fish is 10 to 11 mm. long, and fry of 20 to 25 mm. begin to resemble their parents in general appearance.

³¹ These catches were all made either at the surface or in oblique hauls with open nets.

³² Kuntz and Radcliffe (Bull. U. S. Bur. Fish., vol. 35, 1918, p. 109) describe the spawning and early development.

Evidently the young silver hake take to the deeper water layers toward the end of their first summer or that autumn, when about 1 to 3 inches long, for fry as small as this have been trawled in good numbers off southern New England at 150 fathoms and deeper at that season during the early explorations of the U. S. Fish Commission,³³ by the *Albatross II* off Rockaway and off Long Beach, N. Y., in November 1928. By February they may be anywhere from 1¼ to 5 inches long, depending on how early they are hatched, on when they take to bottom, and on the feeding conditions they find there.³⁴ They may be anywhere from about 2 inches long to about 6½ inches long by April.³⁵

The sizes of the many small silver hake that we have collected at different times of the year, both within the Gulf of Maine and southward as far as the offing of Chesapeake Bay, suggest that they reach an average length of 5½ to 7½ inches when 1 year old, and of about 9½ to 11 inches at 2 years of age, i. e., in their third summer.³⁶ Fish of 11 to 14 inches that dominated the pound-net catches made near Provincetown, August 1939,³⁷ were three-year-olds, probably. The rate of growth has not been traced for the older fish, nor can it be deduced from that of the European silver hake for the latter grows to a considerably greater length, averaging as much as 30 inches at 8 years in the extreme northerly part of its range (Iceland) and considerably larger still, in the southern part (Gulf of Gascony and off Morocco).³⁸ But it is reasonable to assume that the growth of the American fish varies similarly with the latitude (i. e., that it is most rapid in high temperatures) and that the American female, like the European, grows faster than the male. The European *Merluccius* matures at 2 years, which is probably true of the American species as well.

General range.—Continental shelf of eastern North America, northward to the Newfoundland

Banks, southward to the offing of South Carolina;³⁹ most abundant between Cape Sable and New York. It is represented farther offshore and in the Gulf of Mexico by forms, the relationship of which to the *Merluccius* of our northeastern coast has not yet been determined. The silver hake is represented in Europe by a close relative, the European hake (*Merluccius merluccius*), an excellent account of the natural history and migrations of which is given by Le Danois.⁴⁰

Occurrence in the Gulf of Maine.—Silver hake are familiar fish all around the coasts of the Gulf of Maine from Cape Cod to the Bay of Fundy and to the west coast of Nova Scotia. But it has long been a matter of common knowledge that their chief center of abundance is in the southwestern part of the Gulf. Thus in 1945 (most recent year for which detailed regional statistics are available), the reported landings were between 46 and 47 million pounds⁴¹ from off eastern Massachusetts in general, including the shores of Cape Cod out to the western slope of the so-called South Channel, contrasting with only about 4 million pounds for the western and central coasts of Maine, and with only about 6,500 pounds for eastern Maine. Silver hake, it is true, are said to be common in the Passamaquoddy region (more so in some years than in others), also around Grand Manan at the mouth of the Bay of Fundy. And they are reported at various localities along the Nova Scotia side of the Bay and along western Nova Scotia. But they are not mentioned in the statistics of the Canadian catches for these waters, hence cannot be very plentiful there.

Silver hake are numerous over the west-central deeps of the Gulf also; in fact we found this the most plentiful fish at 70 to 90 fathoms in the basins off Cape Cod in the southwestern part of the Gulf and off Mount Desert in the northeastern, in August 1936; also in the trough west of Jeffreys Ledge, where the catches of them averaged 292 fish (maximum 840, minimum 1) as reduced to the common standard of one hour's trawling with an 82-foot shrimp trawl. And it is interesting that the catch there averaged about four times as great

³³ Goode, Fish. and Fish. Ind. U. S., Sect. 1, 1884, p. 242.

³⁴ Fry taken in February of different years by *Albatross II* have ranged from 1¼ inches (31 mm.) long to 4¾ inches (120 mm.).

³⁵ In April 1930 *Albatross II* trawled young fry ranging in length from 2 inches (54 mm.) to 6¾ inches (163 mm.) long at a number of stations from the offing of Rhode Island to the offing of Chesapeake Bay, at 14 to 85 fathoms.

³⁶ For further details, see Bigelow and Schroeder (Biol. Bull., vol. 76, 1939, pp. 319-320, fig. 8).

³⁷ Information supplied by Wm. A. Ellison, Jr.

³⁸ Belloc, Notes et Memoires No. 21, Office Scientifique et Technique des Pêches Maritimes, France, 1923.

³⁹ The silver hake has been said, repeatedly, to range southward to the Bahamas, in deep water, following Jordan and Evermann (Bull. 47, U. S. Nat. Mus., Pt. 3, 1898, p. 2530). But the most southerly positive record we have found for it is off Charleston, S. C. (Blake Sta. 313, lat. 32° 32' N., long. 78° 45' W.; Goode and Bean, Smithsonian Contrib. Knowl., vol. 30, 1896, p. 387).

⁴⁰ Notes et Mem., 2, Off. Sci. Tech. Pêches Maritimes, France, 1920.

⁴¹ "Round" and dressed fish combined.

(494 fish) at the stations where shrimp (*Pandalus*) were plentiful as at the stations where these were scarce (114 fish), evidence that silver hake congregate where feeding conditions are good.⁴²

Reported landings throw little light on the numbers of silver hake that frequent the offshore rim of our Gulf, both because the otter trawls used there are so large-meshed that many pass through, and because most of those that are caught on Georges and Browns Banks are thrown overboard when the price is low.⁴³ Experimental trawling, however, on Georges Bank, April to September 1913, yielded about one-seventh as many silver hake on the average (about 1,800 fish) as haddock (about 14,000 fish) per trip, and the *Albatross III* caught an average of about 150 silver hake, running about one-half pound in weight, per trawl haul, in 250 hauls on various parts of Georges Bank, July, August, and September of 1948, 1949, and 1950. Thus they are moderately plentiful at least over Georges Bank as a whole, and there is no reason to doubt that this applies to Browns Bank equally.

These catches do not suggest any definite concentration on any one part of the bank, at least for summer, except that the largest that were made on its northern part were in hauls from shoaler than 30 fathoms, whereas the largest catches on the southern part were in hauls from deeper than 60 fathoms, a difference which may well have been a matter of the food supply.⁴⁴ In April, however, of 1950, the silver hake were not only more plentiful along the northern edge of the bank (average 305 per haul) than on the southern part (average 77 per haul) but so strictly confined to the deeper levels that the total yield of 66 trawl hauls at shoaler than 60 fathoms was only 11 fish, contrasting with an average catch of 232 fish per haul at 60 fathoms and deeper (25 hauls).⁴⁵

Silver hake spawn along the entire coastal zone from Cape Cod to Grand Manan, as proved by the locations of the egg catches (fig. 85). The sloping

sandy bottom around the northern extremity of Cape Cod and off the eastern slope of the Cape evidently is an important center of reproduction. Thus we found an abundance of eggs off Race Point on July 7, 1915; our tow nets yielded many eggs at two stations off the outer shore of the Cape on July 22 of the following year, when a 15-minute tow there at 20 fathoms, with a net one meter in diameter, produced approximately 25,000 larvae of 3 to 7 mm., the richest haul of young fish we have ever made in our Gulf. And the fish were still spawning there a month later, as proved by the presence of eggs.

Other occasions when we have taken silver-hake eggs in large numbers have been off Duck Island near Mount Desert on July 19 and on August 18, 1915; near Monhegan Island, August 4, 1915; off Wooden Ball Island near the mouth of Penobscot Bay on August 6, 1915; and off Rye, N. H., on July 23 of that same year. But we have never found them in any number in Massachusetts Bay though some eggs have been taken there on several occasions (fig. 85).

Unfortunately, no quantitative hauls were made at any of the more productive egg stations, hence the number of silver-hake eggs present in the water cannot be approximated. But the vertical net yielded about 190 eggs per square meter of sea surface at one station in the eastern basin.

Apparently the silver hake does not breed successfully in the northern side of the Bay of Fundy for neither its eggs nor its fry have ever been found there. But the capture of a few eggs in Petit Passage in our tow nets on June 10, 1915, suggests that it may spawn on the southern side of the bay as the cunner does (p. 478). And it may be expected to do so along the west coast of Nova Scotia, for the Canadian Fisheries Expedition found eggs at several stations off outer Nova Scotia, eastward to the longitude of Canso.

The presence of silver hake on Georges Bank throughout the summer is presumptive evidence of local spawning, though we have taken no silver hake eggs or larvae there.

The locations where we have found its eggs suggest that the silver hake, in the Gulf of Maine, spawns chiefly in water shoaler than 50 fathoms. But we have made one rich haul of its eggs in the center of the eastern basin. And the discovery of its eggs over the continental slope off Nova Scotia

⁴² For further details, see Bigelow and Schroeder (Biol. Bull., vol. 76, 1939, p. 308, table 1; p. 314, table 5).

⁴³ Reported landings, 1945-1947, ranged between 3,000 and about 33,000 pounds for Georges Bank, between 0 and 6,000 pounds for Browns.

⁴⁴ The average catch per haul was 262 fish from shoaler than 30 fathoms and 151 fish from deeper than 60 fathoms on the northern part of the bank; 90 fish per haul from shoaler than 30 fathoms and 285 fish per haul from deeper than 60 fathoms on the southern part.

⁴⁵ Twenty-one trawl hauls at 60 fathoms and shoaler yielded none at all in March; but no hauls were made in that month deeper than 60 fathoms, where the silver hake doubtless were.

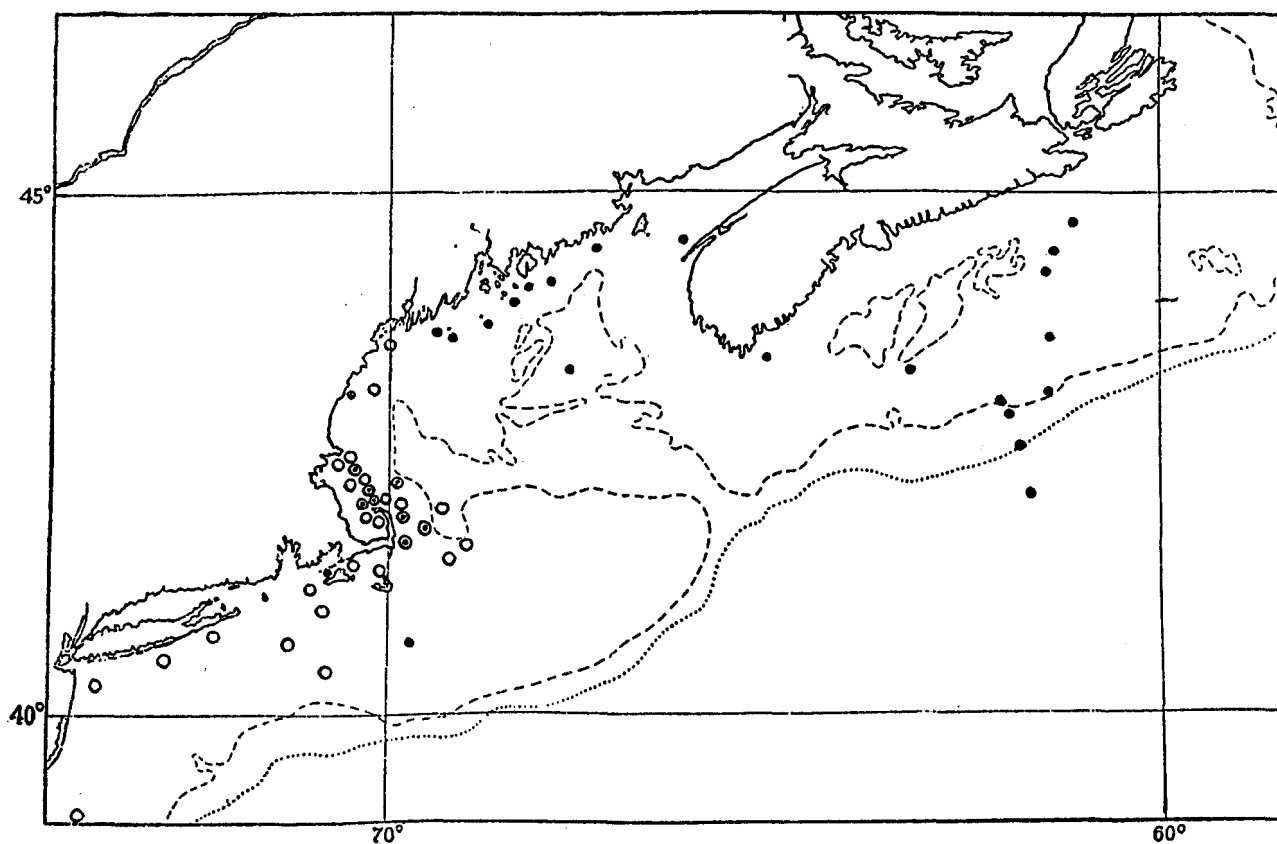


FIGURE 85.—Localities where eggs (●), and larvae (○) of silver hake, or both (○) have been taken.

by the Canadian Fisheries Expedition,⁴⁶ with the presence of ripe fish as well as of spent, in depths as great as 150 fathoms and more off southern New England⁴⁷ proves that it spawns over deep water also. The European silver hake usually spawns in 50 to 100 fathoms.

All our records for the free-drifting larvae of the silver hake in the Gulf; unlike those for its eggs, have been in the southwestern part. And we have towed along the coast of Maine so often in August, September, and October (when the larvae spawned from June to August might have been expected) that our failure to find them east of Cape Elizabeth seems sufficient evidence that they actually are limited, in their regular occurrence, to the southwestern part of the Gulf (they parallel the pelagic stages of the cod, the haddock, and the flatfishes in this) and to the waters westward from Cape Cod. Dannevig, too, has called attention to the absence of larvae of the silver hake in Nova Scotia waters, con-

trasted with the presence of their eggs there.⁴⁸

One possible explanation for this contrast between larvae and eggs is that it may mirror the relative percentage of eggs that hatch in the regions in question. A more likely explanation we think, when taken with other similar facts of distribution, is that it results from a peripheral drift around the shores of the Gulf from northeast to southwest, in which the eggs take part first and then the resultant larvae. This type of circulation, in fact, has been established so well for our Gulf by hydrographic evidence, that some such involuntary migration is inevitable, not only for various buoyant fish eggs and larvae that are produced near the coast line, but likewise for the drifting communities of invertebrates, and of plants.

It is now known that large numbers of the silver hake that descend to the deeper water layers in the southwestern part of the Gulf during their first autumn remain there during the following

⁴⁶ Dannevig, Canadian Fish. Exped., (1914-15) 1919, p. 28.

⁴⁷ Goode, Fish. Ind. U. S., Sect. I, 1884, p. 242.

⁴⁸ Canad. Fish. Exped. (1914-1915) 1919, p. 28.

year, some of them still longer. Thus our experimental trawlings, in August 1936, yielded large numbers of the 1-year-olds at 70 to 90 fathoms in the deep basins off Cape Cod and west of Jefferys Ledge; also off Mount Desert.⁴⁹ And nearly all of the silver hake that come close enough inshore to enter the traps in the southwestern part of the Gulf, or to strand on the beaches there, are good sized individuals of 9 inches and larger. In fact, the only instance that has come to our notice of any considerable inshore catch of one-year-old fish (about 6 to 8 inches long) in the Cape Cod Bay region was near Provincetown, August 1939, when about 1,900 of them were taken during a 14-day period.⁵⁰ Huntsman, however, reports all sizes near shore from yearlings on, in the Passamaquoddy region to the northeast, and in the neighboring parts of the Bay of Fundy.

The silver hake 3 years old and older, that provide the commercial catches, sometimes appear in the Cape Cod Bay-northern Massachusetts region as early as the last week in March, regularly by May. Welsh saw some fish, for example, in Ipswich Bay in March and April in 1913 (a fairly representative season), considerable numbers in May, and an abundance in June. And this may be taken as typical for the whole coast line of the Gulf south of Portland; also for Georges Bank, where the first silver hake were taken by the otter trawlers from April 27 to 29 in 1913, and on almost every trip thereafter. We have not been able to learn how early silver hake appear on the coast of Maine east of Portland, or off western Nova Scotia, where it is only within the past few years that any attention has been paid them.

Around Cape Cod Bay, silver hake are usually the most plentiful in June; disappear more or less during August and September; and reappear in numbers in October, though far fewer than in June, as is illustrated by the average monthly catches made by a set of eight traps at North Truro, for the years 1946-1947 and 1950:⁵¹ June, 185,200 pounds; July, 36,700 pounds; August, 1,206 pounds; September, 1,780 pounds; and October, 10,852 pounds.

Whether their withdrawal thence in summer is a matter of food, or whether they move deeper to escape the heat of summer is a question for the future. Farther offshore in the western side of the Gulf, and to the northward, silver hake are about as plentiful in July and August as they are in June, as indicated by the vessel landings at Boston and Gloucester; somewhat less so in September and October. And what little information we have suggests that summer is the season of greatest plenty for them in the Bay of Fundy region, though there are far fewer of them there.

The great majority of the silver hake vanish from the inshore waters of the Gulf during the late autumn, November seeing the last of them in Massachusetts and Cape Cod Bays, according both to our own observations and to general report. The latest catches made on Georges Bank during the experimental trawlings of 1913 were on December 3 and 12. And though a few are brought in from the grounds off Massachusetts and Cape Cod during January, February, and March, the catches average less than $\frac{1}{170}$ as great for those months as for the period May through October, as illustrated by the monthly landings by trawlers at Boston and Gloucester for 1947:⁵²

January.....	1, 400	July.....	4, 444, 000
February.....	2, 255	August.....	4, 879, 000
March.....	1, 700	September.....	1, 974, 000
April.....	7, 540	October.....	2, 381, 000
May.....	860, 000	November.....	438, 000
June.....	1, 158, 000	December.....	207, 000

It is probable that the fish of the year and those that are only 1 year old winter in the deeper depressions near where they first took to the bottom. It is unlikely that fish as small fish as those we have trawled in these situations, in August, can travel far.

The wintering ground of the Gulf of Maine population of larger silver hake is not known. Many of them may winter near the sea floor in the deep open troughs of the Gulf,⁵³ where the bottom water at 75 to 100 fathoms and deeper continues warmer than 39° F. (4° C.) even at the coldest time of year. Evidence in this direction is that it is only deeper than 60 fathoms that good April catches have been reported on Georges Bank (p. 180). It is also possible that part of them move out to the shelf off southern New England to winter, or

⁴⁹ For further details, see Bigelow and Schroeder, Biol. Bull. vol. 76, 1939, pp. 308, 319-320, fig. 8.

⁵⁰ Information supplied by William A. Ellison, Jr.

⁵¹ Information supplied by the Pond Village Cold Storage Co., North Truro, Mass.

⁵² Pounds of round fish and dressed fish combined.

⁵³ Practically no trawling is done in winter in the deepest parts of the Gulf.

even to the continental slope as the European silver hake do. Scattered catches, in fact, of half-grown silver hake and larger are made by otter trawlers off southern New England, and off New York in January and February.⁵⁴ But it seems more likely that these are fish that either remain there throughout the year or that visit the coasts of New York and of southern New England at other times of year, than that they come from the Gulf of Maine.

Fluctuations in abundance in the Gulf of Maine.—Every shore fisherman in the Massachusetts Bay-Cape Cod region knows that silver hake vary widely in abundance from year to year. Catches by one set of six pound-nets at North Truro on Cape Cod yielded about 60,000 pounds in 1946; 237,000 pounds in 1948; 232,000 pounds in 1949; and only about 10,000 in 1944; but about 458,000 pounds in 1950. Yearly fluctuations of this sort are to be expected at any given locality, in the case of any predaceous wanderer. And there is nothing in the available record to suggest that a major alteration has taken place in the numbers of silver hake in its center of abundance in the Gulf, whether upward or downward, since it has been an important fish on the market.

Occurrence to the westward and eastward of the Gulf of Maine.—Silver hake are described as abundant from October to December as far westward as New York, sometimes in May also, though few are seen there in summer. And yearly catches of some 2 to 5 million pounds of "whiting" by pound nets⁵⁵ suggest that the beaches of New Jersey rival those of the Cape Cod Bay region in the seasonal abundance of silver hake. But we have not heard of any great numbers of them close in shore beyond Cape May, though pound nets do take a few as far south as the mouth of Chesapeake Bay. Farther out on the shelf, silver hake of all sizes are to be found at all times of the year, from the offing of southern New England, westward and southward, in numbers large enough for otter trawlers to land 3 to 5 million pounds yearly in New York and New Jersey,⁵⁶ and smaller amounts in Delaware.

Eastward from our limits we find the silver hake described as abundant⁵⁷ in outer Nova Scotian waters generally. But we have no clue as to their actual numbers there, relative to the Gulf of Maine, for they are not yet important enough commercially to be included in the Canadian fisheries statistics. The experimental cruises of the Newfoundland Fisheries Research Commission took them on Banquereau and Misaine Banks; in the northern side of Cabot Straits; on the southern part of the Grand Banks; and at Bay Bulls on the east coast of the Avalon Peninsula, which is the most northern record for them of which we chance to know. But it seems they are not known anywhere in the Gulf of St. Lawrence.⁵⁸

Importance.—Silver hake are as sweet a fish as one could ask, if eaten fresh or if slack salted overnight and used for breakfast next morning. But they soften so fast that there was no regular market demand for them of old, and most of those that were caught incidentally were thrown overboard. In fact, we can remember seeing them used locally for fertilizer. Thus only some 37,000 pounds were saved in Maine and Massachusetts combined, even as recently as 1895. But improved methods of freezing fish were followed by landings of about two million pounds by 1902; of between four and five million pounds in 1905, rising through the years of the first world war to more than 14 million pounds in 1919.⁵⁹ The yearly landings then fell off, for some reason, to only about 6 million to 9 million pounds for the period 1924 to 1933, which was far less than the potential catch. But the landings then increased again, as frozen whiting became more popular in the Middle West, to about 15 million pounds in 1935, to about 40 million pounds by 1940, with from 46 million to 74 million pounds during the 6-year period 1942 to 1947.⁶⁰

All but a small part of the Maine and Massachusetts landings, recorded in the following table, are from within the limits of the Gulf of Maine.

The silver hake now ranks fourth or fifth among Gulf of Maine fishes in amount landed. But it

⁵⁴ *Albatross II* trawled 8 fish, 7 to 9 inches long, off New York, February 28, 1929, at 28 fathoms; and the dragger *Eugene H.*, Capt. Henry Klimm, picked up 115 of market size in a week's trip, about 80 miles off Martha's Vineyard, at 47 to 67 fathoms, January-February 1950.

⁵⁵ 1942, 5,343,300 pounds; 1945, 5,842,900 pounds; 1947, 1,784,500 pounds.

⁵⁶ Otter trawl landings of "whiting," for New York and New Jersey combined, were 3,468,200 pounds in 1942; 5,243,700 pounds in 1945; and 7,498,600 pounds in 1947. Delaware trawlers reported 203,500 pounds for 1947.

⁵⁷ Vladyskov and McKenzie, Proc. Nova Scotia Inst. Sci., vol. 19, 1935, p. 72.

⁵⁸ According to Dr. Huntsman all ostensible reports of their presence in the Gulf of St. Lawrence have been based in reality on the other hakes of the genus *Urophycis* (p. 221). And it is these that are meant when "hake" are mentioned in the early publications of the U. S. Fish Commission, such as Baird's (Rept. U. S. Comm. Fish. (1886) 1889, app. A.) report on the fisheries of eastern North America.

⁵⁹ Landings for Maine and Massachusetts combined.

⁶⁰ Maine and Massachusetts combined.

ranks only about seventh in value. In 1945, the year when the catch was largest, its value was \$1,736,200. Its rank is low as a sportman's fish, for while it bites greedily, it puts up only a feeble resistance when hooked.

Year	Catch to nearest 1,000 pounds	Year	Catch to nearest 1,000 pounds
1919.....	14,607,000	1938.....	24,851,000
1924.....	6,377,000	1939.....	27,539,000
1929.....	7,875,000	1940.....	39,990,000
1930.....	7,943,000	1942.....	45,900,000
1931.....	6,936,000	1943.....	48,460,000
1932.....	6,379,000	1944.....	47,373,000
1933.....	8,678,000	1945.....	73,866,000
1935.....	15,420,000	1946.....	48,844,000
1937.....	21,038,000	1947.....	58,936,000

Cod Gadus callarias Linnaeus 1758 ⁶¹
ROCK COD

Jordan and Evermann, 1896-1900, p. 2541.

Description.—The most noticeable external characteristics of the cod, emphasized above in the general survey of the cod family (p. 173), are its three dorsal fins and two anal fins; its lack of fin spines; the location of its ventral fins forward of its pectoral fins, and the fact that its upper jaw protrudes beyond the lower; that its tail is usually nearly square, and that its lateral line is pale, not black.

The cod is a heavy-bodied fish, only slightly flattened sidewise, its body deepest under the first dorsal fin (cod neither very fat nor very lean

⁶¹ Jordan, Evermann, and Clark (Rept. U. S. Comm. Fish. [1928], Pt. 2, 1930, p. 210) use the species name *morrhua* Linnaeus 1758. But the use of *callarias* accords better with modern practice, because it preceded *morrhua* on the same page of the *Systema Naturae*.

are about one-fourth to one-fifth as deep as they are long), tapering to a moderately slender caudal peduncle, and with a head so large that it takes up about one-fourth of the total length of the fish. The nose is conical and blunt at the tip; the mouth wide, with the angle of the jaw reaching back as far as the anterior part of the eye; and there are many very small teeth in both jaws. The first dorsal fin usually (if not always) originates well in front of the midlength of the pectoral fins; it is the highest of the three dorsals, triangular, with rounded apex and convex margin. The second dorsal fin is nearly twice as long as the first dorsal and about twice as long as it is high, decreasing in height from front to rear with slightly convex margin. The third dorsal fin is a little longer than the first dorsal, and is similar to the second dorsal in shape.

The caudal fin is about as broad as the third dorsal fin is long (rather small for the size of the fish) and broom-shaped. The two anal fins stand below the second and third dorsals, to which they correspond in height, in length, and in shape. The number of fin rays was as follows, in a large series of Gulf of Maine cod, 23 to 37 inches long, examined by Welsh.

Number of finrays	Dorsal			Anal	
	First	Second	Third	First	Second
Least.....	13	19	18	20	17
Average.....	15	21	19	22	18
Most.....	16	24	21	24	22

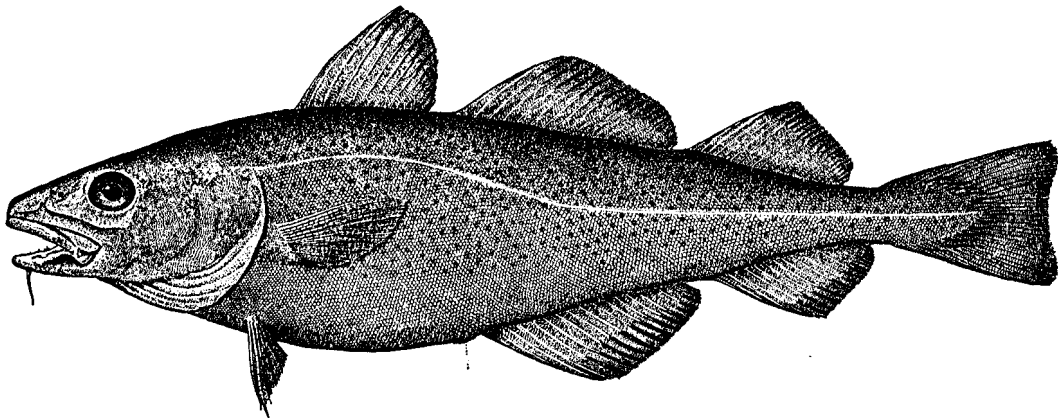


FIGURE 86.—Cod (*Gadus callarias*), Eastport, Maine. From Goode. Drawing by H. L. Todd.

As few as 12 rays have occasionally been recorded for the first dorsal, 16 for the second, 17 for the third, 17 for the first anal and 16 for the second. The pectoral fins, set high up on the sides, reach back as far as the rear end of the first dorsal. The ventral fins are nearly as long as the pectorals in young cod but are shorter, relatively in large fish, with the second ray extending beyond the general outline as a filament for a distance almost one-fourth as long as the entire fin. Both the head and the body are clothed with small scales.

Young cod are easily distinguished from large tomcod by their relatively broad ventral fins with slender filaments, by the location of the first dorsal fin, and by their larger eyes, as explained in the description of that species (p. 196). The pale lateral line readily distinguishes the cod from the haddock; and the square-tipped tail, projecting upper jaw, and spotted color pattern of a cod give it an aspect quite different from that of the pollock.

Color.—Cod vary so widely in color that sundry of its color phases have been named, but all of them fall into two main groups, the gray-green and the red. The back and upper sides of the former range from almost black through dark sooty or brownish gray, olive gray, olive brown, sepia brown, mouse gray, ashy gray, clay colored, and greenish to pale pearly (darker on the back than on the sides); the fins are of the general body tint, and the belly is whitish, usually tinged with the general ground color. The red or "rock" cod vary from dull reddish brown to orange or brick red, with white belly tinged with reddish, and with red, olive, or gray fins. In most cod the upper surface of the body, the sides of the head, and the fins and tail (but not the nose or belly) are thickly speckled with small, round, vague-edged spots. On the "gray" fish these are of a brownish or yellowish cast, darker than the general body color, while they are usually reddish brown or sometimes yellowish on the "red" fish. Occasionally one sees a spotless cod, but these are unusual. The lateral line is invariably paler than the general body tint, pearly gray or reddish according to the hue of the particular fish in question, and it stands out against the darker sides.

Size.—Cod sometimes grow to a tremendous size. A huge one of 211¼ pounds and more than 6 feet long, was caught on a long line off the Massa-

chusetts coast in May 1895;⁶² one that weighed 138 pounds dressed (hence must have weighed 180 pounds or more alive) was brought in from Georges Bank in 1838; and Goode⁶³ mentions several others of 100 to 160 pounds as caught off Massachusetts. But cod of a hundred pounds are exceptional, the largest New England cod of which we have heard recently being one of 90 pounds, that was taken off the coast of Maine early in July 1922. Even a 75-pound fish is a rarity, but 50 to 60 pounders are not unusual. The so-called "large" fish that are caught near shore run about 35 pounds; and "large" ones taken on Georges Bank about 25 pounds. But the shore fish, large and small together, average only between 6 and 12 pounds in weight.

The relationship between length and weight is usually about as follows for fish caught on the in-shore grounds between Cape Ann and Portland, though this varies with the condition of the fish and with their state of sexual development.⁶⁴

Females		Males	
Inches	Pounds	Inches	Pounds
19 to 20	2½- 3	20 to 21	3 - 3¾
21 to 22	3¾- 4	23 to 24	4 - 5½
23 to 24	4½- 7	25 to 26	6¼- 8
25 to 26	5 - 7	27 to 28	7 - 8½
27 to 28	7 - 9	30 to 31	7 - 11
30 to 31	7½-10	32 to 33	7 - 13
32 to 33	9 -13	34 to 35	12 -17
34 to 35	12½-17½	36 to 37	12¾-17
36 to 36½	16 -23	38 to 39	17 -21
38 to 39	18 -22	40 to 41	19 -25
40 to 42	16 -32	43 to 45	25½-29
43 to 44	29½-32	46	43
48½ to 50½	31 -51		
52	50		
57½	54		

A 99½-pound fish recorded by Earll was 62 inches long, and one of 100 pounds caught off Wood Island, Maine, on April 9, 1883, measured 65 inches, its head 17¼ inches. Any fish of 5½ to 6 feet will weigh 100 pounds or more.

Habits.—Cod in one place or another range from the surface down to 250 fathoms at least.

During the first year after the young cod take to bottom (p. 186) many of them live in very shoal water, even along the littoral zone, and many young fry have been taken at Gloucester and elsewhere along the shores of New England, while

⁶² Jordan and Evermann, *American Food and Game Fishes*. 1902, p. 514.

⁶³ Fish Ind. U. S., Sec. 1, 1884, p. 220.

⁶⁴ Based chiefly on measurements given by Earll (Rept. U. S. Comm. Fish. [1878], 1880, p. 734), and on a large series of cod measured fresh from the nets by Welsh during the spring of 1913.

many small cod are caught about the rocks only a fathom or two deep even in summer. But it is certain that many cod fry take to bottom on the offshore banks also, for we have trawled young fry at many localities between Nantucket Shoals and Browns Bank. As a rule, the large cod lie deeper than 7 or 8 fathoms in summer in our latitudes. But the fishing is often good in only 3 to 5 fathoms of water in wintertime, especially in Ipswich Bay. At the other extreme, comparatively few cod are caught much deeper than 100 fathoms within the Gulf of Maine. And although fishermen sometimes do well at much greater depths on the slopes of the offshore banks, the 5- and 75-fathom contours probably include the great majority of all the cod living in the Gulf, summer or winter.

The largest catches of cod are made on rocky and pebbly grounds; on gravel; on sand, and on a particularly gritty type of clay with broken shells. They also frequent the deeper slopes of ledges along shore, where they forage among the Irish moss (*Chondrus crispus*) and among seaweeds of other kinds. Young red ones are especially common in these situations, while one sometimes catches a large rock cod as these dark brown or red fish are called. And the bottoms where cod and hake are found are so distinct that a long line set from a hard patch out over the soft surrounding ground will often catch cod at the one end, hake at the other. But fair catches are sometimes taken on mud, as off Mount Desert, where large- and medium-sized cod are regularly caught on soft ground in winter. And a few very large cod (35-60 lb.) have also been brought in from the mud bottom of the deep basin to the westward of Jeffreys Ledge (about 90 fathoms).

The cod, as appears from the foregoing, is typically a ground fish; except on some journey (a subject to be discussed later) or when following its prey, it usually lies within a fathom or so of the bottom. And large ones keep closer to the ground than small ones as a rule, so that the closer one fishes to bottom the larger the cod are likely to run. But even the large ones sometimes follow herring up to the surface; we have known of large cod gaffed from a vessel's side in Northeast Harbor, Mount Desert Island, in September, while they were chasing sardines. And they come to the surface more commonly on the Grand Banks and along the eastern coast of Labrador,

when they are following capelin. Cod even strand on the Labrador beaches while harrying schools of capelin, but we have never known cod to strand anywhere around the coasts of the Gulf of Maine, as silver hake so often do (p. 175).

The adult cod is at home in any temperature from 32° to 50°-55° F.; in all but the superficial layers of the Gulf of Maine, that is, at all seasons. But experience at the Woods Hole hatchery, proves that freezing may be fatal by the formation of anchor ice. On the other hand, while large cod tend to avoid water warmer than about 50° F., except that they are abundant at times in temperatures as high as 58°-59° F. on Nantucket Shoals (the most southerly year-round cod-ground in the Atlantic). Small cod are somewhat less sensitive to heat than large, a fact reflected in the presence of greater numbers of them in shoal water in summer than of larger fish. The relationship of the spawning of the cod to temperature is discussed below (p. 194).

Food.—When the larval cod first breaks from the egg it subsists on the yolk with which its abdomen is distended (fig. 88), as do most other sea fishes. But this source of nutriment is completely absorbed by the sixth day after hatching, and the future existence of the little fish depends as much on finding a plentiful supply of food as on escaping the enemies by which it is encompassed. So far as known, the larval and post-larval cod subsist almost exclusively on copepods and on other minute Crustacea, during the several months while they are drifting in the upper layers of water.⁶⁵ And this same diet, varied with amphipods, barnacle larvae, and other small crustaceans, as well as with small worms, is the chief dependence of the little cod when they first seek the bottom⁶⁶ but as they grow larger they consume invertebrates in great variety and in enormous amount.

Mollusks, collectively, are probably the largest item in the cod's diet in the Gulf of Maine; any shellfish that a cod encounters is gobbled up, so that their stomachs are mines of information for students of mollusks. Large sea clams (*Macra*),

⁶⁵ Bumpus, Science., N. Ser., vol. 7, 1898, p. 485.

⁶⁶ For further details on the diet of cod larvae and fry, see Brook (5 ann. Rept., Fish. Board Scotland (1886) 1887, p. 327), McIntosh and Masterman (British Marine food fishes, 1897, p. 242), Kendall (Rept. U. S. Comm. Fish. (1896) 1898, p. 179), Bumpus (Science, N. Ser., vol. 7, 1898 p. 485), and Goodchild, Graham and Carruthers (British Minst. Agric. Fish., Fish. Inv., Ser. 2, vol. 8, No. 6, [1925] 1926).

the empty shells of which are often found neatly nested in cod stomachs: cockles (*Polynices*); and sea mussels (*Modiolus*) are staples, all of which they swallow whole. Cod also eat crabs, hermit crabs, lobsters (large and small), shrimps, brittle stars (of which they are sometimes crammed full), sea urchins, sea cucumbers, and sea worms (*Nereis*). Brittle stars and small crabs, for example, had been the chief diet of the cod examined by Welsh on the Isles of Shoals-Boon Island ground in April 1913, while Wilcox⁶⁷ states that a number of 17-pound fish caught in Ipswich Bay were full of large red prawns 2 to 4 inches long (evidently the northern edible shrimp *Pandalus*). And we have found crabs (*Cancer*; *Libinia*) the chief food of the cod on Nantucket shoals.

Tunicates (sea squirts) also bulk large in their diet. Occasionally they eat hydroids, bryozoans, and algae, perhaps taking these for the amphipods that are hidden among them. And in late summer cod frequently feed on ctenophores (*Pleurobrachia pileus*). But while its diet list would probably prove almost as extensive as that of the haddock (p. 202), the cod shows so decided a preference for large shells rather than for small ones that the stomach contents of cod and haddock taken side by side differ noticeably. Nor is it likely that cod root the bottom as haddock do (p. 202), for worms.

Cod pursue and gorge on squid at every opportunity, and on various small fish, particularly on herring, on launce, and (in the north) on capelin; also on shad, mackerel, menhaden, silversides, alewives, silver hake, young haddock, and even on their own young, rising into the upper waters for this purpose when necessary (p. 184). They also pick up flounders, cunners, rock eels (*Pholis*), blennies, sculpins, sea ravens, small hake and skates from the bottom. In fact, they take any fish small enough to swallow, including the hard slim alligatorfish (p. 457) and even the sea horse (p. 315). And Welsh noted that many cod taken near the Isles of Shoals on May 1, 1913 spat up small rosefish from 4 to 6 inches long. The eggs of the longhorn sculpin⁶⁸ and of the eelpout (*Macrozoarces*)⁶⁹ also have been found in cod

stomachs. Adult cod as well as small are also known to feed on pelagic shrimps in the waters around Iceland,⁷⁰ but we have never heard of them doing so in the Gulf of Maine.

Even a wild duck does not escape from a large cod now and then. Thus we have heard of several scoters found in the stomachs of large fish caught off Muskeget Island in 1897; and though sea fowl are not a normal article in their diet, the flesh of the greater shearwater (hagdon) has long been considered excellent cod bait. Objects as indigestible as pieces of wood and rope, fragments of clothing, old boots, jewelry, and other odds and ends have repeatedly been found in cod stomachs. And they often swallow stones; but probably for the anemones, hydroids, and other animals growing thereon, and not to take on ballast for a journey as the old story has it.

Although cod are so rapacious they fast generally while they are spawning; the stomachs of nearly all the ripe fish examined by Earll, and recently by Welsh, were empty.

Experiments performed on the cod in captivity,⁷¹ combined with the general experience of fishermen, suggest that they capture moving objects by sight. But apparently cod (and for that matter other fish), can see clearly only for a few feet, and their greediness in snapping up the naked meat of clams and cockles (foods which they never find in that condition in nature), added to the fact that they bite as readily by night as by day, seems sufficient evidence that they depend largely on smell.

Enemies.—In the Gulf of Maine, large sharks and the spiny dogfish are the worst enemy of the adult cod. Formidable enemies of young cod fry are the small pollock which infest our harbors. These are so fierce that a single pollock 7 or 8 inches long will disperse a school of hundreds of cod fry, driving them to shelter among the weeds and rocks, while Earll remarks that in the aquarium a cod so fears a pollock of equal size that it will invariably hide if possible. Young cod, up to 7 to 8 inches, are also devoured in large numbers by the larger cod.

⁶⁷ Schmidt (Skrift. Komm. Havundersøgelser, No. 1, 1904, p. 70) and Paulsen (Meddelel. Kommls. Havundersøgelser, Serie Plankton, vol. 1, No. 8, 1909, p. 39).

⁷¹ Bateson, Jour. Mar. Biol. Assoc. United Kingdom, N. Ser., vol. 1, 1889-90, p. 241.

⁶⁷ Bull. U. S. Fish. Comm., vol. 6, 1887, p. 95.

⁶⁸ Warfel and Merriman, Copela, 1944, p. 198.

⁶⁹ Olsen and Merriman, Bull. Bingham Oceanogr. Coll., vol. 9, art. 4, 1946, p. 77.

Migrations and wanderings.—It has long been known that cod carry out extensive migrations in some regions, but that they are more nearly stationary in others. European (especially the Scandinavian) biologists have succeeded in tracing the major outlines of their movements for North European seas, and enough evidence has accumulated to show that their travels fall into the same categories in the one side of the Atlantic as in the other. These categories are: (a) involuntary drifts by the eggs and by the larvae before they take to the bottom; (b) the various journeyings by the older cod in search of food; (c) journeys associated with the concentrations of cod on particular spawning grounds; and (d) regular seasonal migrations (with return movement) between different regions that are suitable for cod during different parts of the year.

To begin with, the eggs, larvae, and young fry of the cod, like those of so many other sea fishes, drift helplessly with the current from the time they are spawned until they seek the bottom (a fact established by European observations too numerous to list).⁷² The length of this period (varying in duration in different seas) depends partly on whether the fry are near land or are far out at sea, and partly on whether they are floating over deep water or over shoal. It is not likely to last for more than two months for fish that are hatched on the inshore spawning grounds in the Gulf of Maine, where the bottom is within easy reach. Even so, it is extremely unlikely that any cod fry take to the bottom near where they were spawned.

This matter is discussed further in relation to the occurrence of the cod in our Gulf (p. 190).

The journeyings of the cod that are associated with their spawning are especially extensive along the Norwegian coast, where they have been the subject of much study, leading (among other things) to the very interesting probability that their journeys up and down the coast of Norway are chiefly involuntary, for the ripe fish drifting north become so fat that they tend to be suspended in the water near the surface, whereas the spent fish become so thin that they are deeper down in the water.⁷³ But there is no reason to

suppose that any of our Gulf of Maine cod need travel far to reach the localities where they spawn.

In the extreme northern and southern fringes of their geographic range cod are regularly "migratory" in the common understanding of the term. Thus it is only in summer and early autumn that they visit the waters of the polar current along the eastern coast of Labrador, from which they withdraw again later in the autumn, to pass the winter and spring either to the southward or in deep water. On the other hand, it is only during autumn, winter, and early spring that cod are caught off the coasts of southern New England, of New York, of New Jersey, or further south.

The fish that winter along this westerly and southerly extension of the cod's geographic range appear off southern Massachusetts in mid-October; off western Long Island and off the coast of New Jersey in November; they go back eastward again by the first part of May. And the numbers involved are large enough to support a profitable autumn-winter and early spring fishery from Nantucket to New Jersey.

Tagging experiments carried out by the U. S. Bureau of Fisheries, first at Woods Hole in the winters of 1898-1901,⁷⁴ and in various parts of our Gulf on a much larger scale from 1923-1930,⁷⁵ have shown that most of the fish that take part in this westerly movement pass the summers in the Nantucket Shoals region. But it is clear that a large part of the cod stock that summers on the Shoals fails to join this westerly mass movement in autumn, for fish tagged there in summer have been recaptured there the next winter, while many others have been recaptured there the following spring. And it is established now that the great majority of the cod that live off our coasts from Cape Cod to northern Nova Scotia, in the southern part of the Gulf of St. Lawrence, and on the southern part of the Grand Banks, can fairly be termed "nonmigratory" in a broad sense.

Breeding habits.—The cod is one of the more prolific fishes. A female 39 or 40 inches long may be expected to produce about 3,000,000 eggs yearly, one of 41 inches at least 4,000,000. And Earll estimated the number in a 52½-inch fish weighing 51 pounds at 8,989,094, with 9,100,000 in

⁷² In European seas young cod often live under the disks of the large red jellyfish (*Cyanea*), but they have not yet been found in this situation in the Gulf of Maine.

⁷³ See especially Hjort, *Journal du Conseil, Cons. Perm. Internat. Explor. Mer*, vol. 1, No. 1, 1926, p. 9.

⁷⁴ Smith, Rept. U. S. Comm. Fish (1901) 1902, pp. 193-208.

⁷⁵ 22,884 fish tagged in the region of Nantucket Shoals, and about 30,000 in other parts of the Gulf of Maine, including the offshore Banks, 308 fish recaptured westward from Marthas Vineyard. For further details, see Schroeder (*Bull. U. S. Bureau of Fisheries*, vol. 46, 1930, pp. 1-136).

a 75-pounder. But the average production of eggs is perhaps not more than 1,000,000 for the general run of Gulf of Maine fish.

The eggs are buoyant, transparent, without oil globule, and 1.10 to 1.82 mm. in diameter. Gulf of Maine eggs, artificially fertilized and measured by Welsh, averaged about 1.46 mm. in diameter, but the size varies somewhat with the temperature of the water, being larger in cold than in warm.⁷⁶

The period of incubation for cod eggs depends on temperature. According to experience at the hatcheries, hatching may be expected in 10 or 11 days at 47° F., in 14 or 15 days at 43° F., in 20 to 23 days at 38° to 39° F. and not for 40 days or more if the water is as cold as 32° F. Fertilization can take place and development commence in temperatures even lower than this, as proved by experiments by Krogh and Johansen.⁷⁷ But their observation that the mortality is great among eggs incubated at 32° F. (although full development can take place) corroborates the experience of the

⁷⁶ Fish (Bull. U. S. Bur. Fish., vol. 43, 1929, p. 292) found cod eggs taken in the tow net in Massachusetts Bay to average about 1.53 mm. in February, smaller (1.46 to 1.49 mm.) in December and in May.

⁷⁷ Dannevig, Canadian Fisheries Exped. (1914-1915), 1919, p. 44.

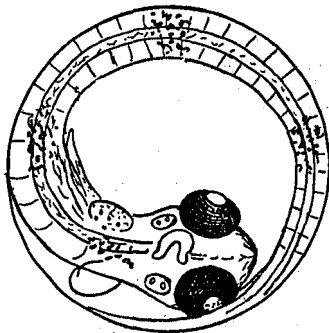


FIGURE 87.—Egg. After Heincke and Ehrenbaum.

hatcheries, where it has proved impossible to hatch more than 25 to 50 percent of the eggs in water as cold as that. And the relative strength of the larvae that are hatched at different temperatures points to 41° to 47° F. as most favorable for incubation. All this suggests that extreme cold prevents the successful reproduction of the cod, not by interfering with spawning (for this can take place in the lowest temperatures to be found anywhere in the open sea, p. 195), but by its effect on the developing eggs. And it is interesting that cod in the tank at Woods Hole produced eggs in February, when the water may have cooled to 30° F. (and quite normally to judge from the fact that the eggs incubated successfully in the warmer water of the hatchery), for these same fish would have spawned naturally in temperatures at least as high as 36°-38° F. if they had been left at liberty.

Newly spawned cod eggs are indistinguishable from those of the haddock, with which they intergrade in size. But shortly before hatching, the pigment of the cod gathers in 4 or 5 distinct patches: one over the region of the pectoral fins, one above the vent, and the others equally spaced behind the latter (fig. 87); whereas in the haddock

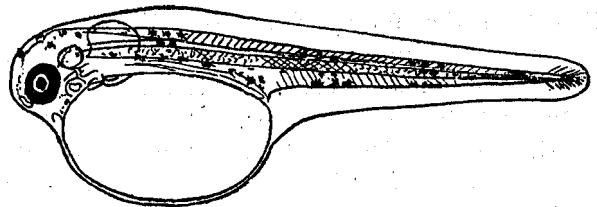


FIGURE 88.—Larva, just hatched, 4 mm. After Masterman.

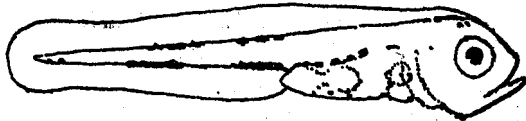


FIGURE 89.—Larva, 4.5 mm. After Schmidt.



FIGURE 90.—Larva, 9 mm. After Schmidt.

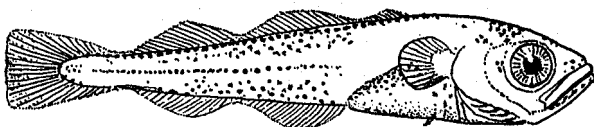


FIGURE 91.—Fry, 20 mm. After Schmidt.

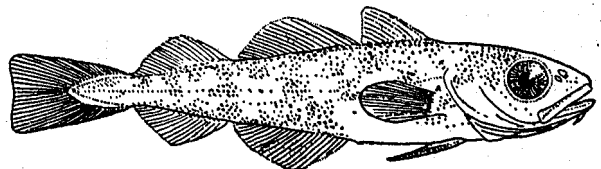


FIGURE 92.—Young, 40 mm. After Schmidt.

COD (*Gadus callarias*), developmental stages, European.

the pigment cells are arranged in a row along the ventral side of the trunk (p. 203). There is also danger of confusing newly spawned cod eggs with those of the witch flounder (p. 287), which they overlap in size; but the black pigment of the cod eggs identifies them as gadoid as soon as this appears, for the embryonic pigment of the witch is yellow. (See also haddock on p. 203.)

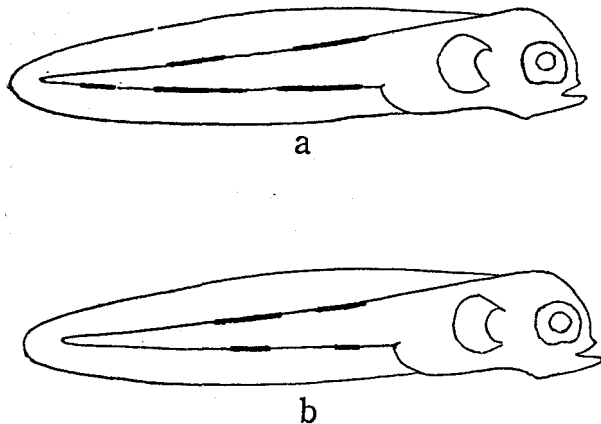


FIGURE 93.—Diagram of the pigmentation of the young larvae of the cod, A, and of the pollock, B. After Schmidt.

The larvae are about 4 mm. long at hatching with the vent (which is close behind the yolk sac) located at the base of the ventral fin fold on one side instead of at its margin, so that the intestine seems to end blindly, as is also the case with haddock and pollock larvae. At this stage young cod much resemble the latter, but are separable from them by the fact that the pigment is in two dorsal and three (rarely two) ventral bars, with the dorsal bars shorter than the ventral bars opposite them, whereas the dorsal bars are longer than the opposing ventral bars (fig. 93) in pollock larvae up to 10 mm. long. Neither is there any danger of confusing cod larvae with haddock even at this early stage, for the latter are not barred but have a continuous row of pigment cells along the ventral margin of the trunk behind the vent, besides other patches on the nape and in the lining of the abdomen.

The young cod float helplessly, when first hatched, yolk uppermost. But they assume the normal position in about 2 days; the yolk being absorbed and the mouth formed in 6 to 12 days, according to temperature, when the larvae are about 4.5 mm. long. As the little cod grows the

pigment bars gradually fuse, and at 8 to 10 mm. a median band forms. Cod 10 to 20 mm. long may easily be distinguished from pollock by the fact that the pigment extends to the tail, whereas it ends abruptly some distance in front of the tail in the pollock. Haddock of this size show much less pigment (p. 203). Cod fry of 15 to 30 mm. are made recognizable by the location of the vent under the second dorsal fin, combined with dense pigmentation. At 20 mm. the dorsal and anal fin rays have attained their final number and the separate fins are outlined, while at 30 mm. the fry begin to show the spotted color pattern so characteristic of the cod.

Rate of growth.—In 1898 a large number of newly hatched larvae were released in December at Woods Hole in the "eel pond" (a lagoon freely communicating with the harbor and with a temperature about paralleling that of the outside water), where they grew to an average length of 50 to 100 mm. by the following June.⁷⁸ The experiment was repeated in the winter of 1899⁷⁹ with similar results, as appears from the following table showing the growth of approximately 2 million freshly hatched larvae that were placed in the eel pond on January 11.

Date	Extreme lengths	Average length	Date	Extreme lengths	Average length
Apr. 8.....	mm. 29 to 38.....	mm. 32.9	May 25.....	mm. 28 to 68.....	mm. 64
Apr. 25.....	34 to 49.....	40	June 6.....	71 to 76.....	75.5
May 13.....	35 to 51.....	42.8	June 20.....	73 to 77.....	75

Captures of young fry 1½ to 3 inches long in the neighborhood of Cape Ann late in June (Earl 1880), and subsequently around Woods Hole and on Nantucket Shoals, show that cod hatched from January to March in the Gulf of Maine grow at about this same rate. But fish that are hatched in the rising temperatures of spring might be expected to grow faster during their first few months. European experience⁸⁰ is to the effect that young cod are 4¾ to 8 inches long by the end of their first autumn, which probably applies equally to the Gulf of Maine.

In later life cod grow at varying rates in different seas, and even fish that are caught in the same haul

⁷⁸ Bumpus, Science N. Ser., vol. 8, 1898, p. 852.

⁷⁹ Smith, Bull. U. S. Fish Comm., vol. 19, 1901, p. 307.

⁸⁰ Damas (Rapp. et Procès-Verb., Cons. Perm. Intern. Explor. Mer, vol. 10, No. 3, 1909) gives an account of the European investigations on the life history of the cod, up to that date.

may have grown at very different rates, as shown by the structure of their scales. Consequently, the length of a fish older than a yearling is no criterion to its age within 2 or 3 years. Wodehouse's⁸¹ studies on cod caught at the mouth of the Bay of Fundy and the Bureau of Fisheries investigations on Nantucket Shoals, suggest that cod grow more rapidly in the Gulf of Maine than in European waters, as follows:

Age, in years	Average length, in inches, Nantucket Shoals	Average length, in inches, Bay of Fundy	European (approximate average)
1	7-8	6	5
2	14-17	14	8
3	19-22	20	12
4	23-26	26	15
5	27-29	32	19
6	30-32	36	21
7	33-34	39	24
8		45	27
9		49	29

The fact that cod run much larger in the Gulf of Maine than in either the North Sea or the Norwegian Sea, and that those of 75 pounds and heavier, such as are brought in every year from our coastal waters are unusual on the other side of the Atlantic, tends to corroborate the American age estimates, but the desirability of further investigation along this line is self-evident.

Judging from the foregoing table the general run of mature shore cod caught in the Gulf of Maine (5 to 20 pounds) are 3 to 8 years old, but whether the very large fish have grown exceptionally rapidly or are many years old, remains to be learned.

The smallest ripe male recorded for American waters weighed about 3½ pounds; the smallest ripe female 4 pounds,⁸² that is, they were in their fourth winter. Probably a considerable proportion of our cod mature when they are 5 to 6 years old; and practically all of them do so by the time they are 9 years old, as Thompson found for the cod of Newfoundland.⁸³

General range.—Both sides of the North Atlantic, north to West Greenland, Davis Strait, Resolution Island, Hudson Strait in the west,^{83a} south

nearly if not quite to Cape Hatteras on the American coast; abundant from northern Labrador to Nantucket Shoals, and to New York and New Jersey in winter, when a few are annually caught as far south as the northern part of the North Carolina coast. The continental slope marks the offshore boundary for the cod off the North American coast. The range of the cod in the eastern Atlantic extends from Nova Zembla, Spitzbergen, and Bear Island in the north to the northern part of the Bay of Biscay in the south, and up the Baltic to Finland. The North Pacific cod, with smaller air bladder (*G. macrocephalus*) cannot be separated from the Atlantic cod by external appearance.

Occurrence in the Gulf of Maine.—The cod ranks with the herring, mackerel, rosefish, haddock, pollock, and silver hake as one of the most plentiful of the important food fishes in the Gulf of Maine. Cod were the mainstay of its commercial fisheries from earliest colonial times and until the market began to welcome the haddock. We fancy there is no patch of hard bottom, rock, gravel, or sand with broken shells, from Cape Sable in the east to Cape Cod on the west, but supports more or less cod at one time or another. Cod are even caught on soft mud bottoms, though they are not common there. And while the cod are essentially fish of the open sea, they appear regularly in various river mouths in Maine and Massachusetts during the late autumn and winter. One is taken in brackish water occasionally.

The eastern half of Georges Bank has always been a most productive cod ground and one of the most famous south of the Grand Banks of Newfoundland. The next largest Gulf of Maine fares are brought in from the South Channel-Nantucket Shoals region in the southwestern part of the Gulf, and from Browns Bank in the eastern part, the latter being especially productive in winter. The broken bottom off Seal Island, Nova Scotia, the ground near Lurcher Shoal, and Grand Manan Bank are all famous cod grounds. Other well-known inshore grounds are certain hard patches off Chatham (Cape Cod); between Provincetown and Plymouth and off the latter port; Jeffreys Ledge, Ipswich Bay, Cashes Ledge, Platts Bank, and Fippenies. Small vessels likewise make good catches on the succession of hard and rocky patches that border the coast

⁸¹ Contrib. Canadian Biol. (1914-15), 1916, p. 103.

⁸² Earll, Rept. U. S. Comm. Fish. (1878) 1880, p. 717.

⁸³ Research Bull. No. 14, Newfoundland Dept. Nat. Resources, 1943, p. 87.

^{83a} Dunbar (Kennedy, Natural History, Amer. Mus. Nat. Hist., vol. 62, No. 2, 1953, p. 78) has recently reported cod landlocked in southern Baffin Land in a so-called "lake" where the surface is fresh but the deeper water salt.

from the Isles of Shoals to the mouth of Casco Bay; on "Seguin" and "Kettle" bottoms off Seguin Island; on the "Matinicus ground" off Matinicus Island; on the "Grumpy" off Isle au Haut; in the neighborhood of Mount Desert Rock and of Mount Desert Island; and on sundry small ridges thence eastward to the mouth of the Bay of Fundy. Rich,⁸⁴ in fact, lists no less than 175 cod grounds around the inner parts of the Gulf, and many other smaller spots all up and down the coast yield a few cod to the small-boat fishermen.

The following summary of the landings of fresh cod from several of the more important Gulf of Maine grounds for 1935⁸⁵ illustrates their relative productivity at that time, and there is no reason to suppose that the situation has altered significantly since then, so far as the numbers of cod are concerned.

Locality	Pounds	Percentage of cod in total catch of ground fish
Georges Bank.....	21, 598, 594	28
Browns Bank.....	9, 288, 806	30
South Channel.....	2, 993, 580	18
Cashes Ledge.....	602, 901	18
Stellwagen Bank.....	284, 265	37
Fippenies Bank.....	48, 865	19
Jeffreys Ledge.....	42, 430	21
Nantucket Shoals.....	26, 075	14
Platts Bank.....	20, 060	18

Cod, for some reason not yet explained, become scarcer passing up the Bay of Fundy, and very few are caught near the head, though there are plenty about the mouth of the Bay.

Movements of cod in the Gulf of Maine.—The young cod that are hatched within our Gulf tend to follow around the general coastline from north-east to southwest, during the period while they are adrift, as has been shown by Fish⁸⁶ very clearly for the Cape Ann—Massachusetts Bay spawning grounds. Our few captures of pelagic cod fry have, in fact, all been in the southwestern part of the Gulf, in which they agree with those of haddock, silver hake, and most of the common flatfishes. As Fish⁸⁷ pointed out, the fry from eggs that are spawned north of Cape Ann and on the Massachusetts Bay grounds have ample time to become distributed over the offshore banks

before they seek the bottom (with 14 to 30 days' drift as eggs, and two months or more as pelagic larvae). They might even circle around to the coast of western Nova Scotia and so to the eastern Maine coast. And fry from the Georges Bank spawning grounds would have ample time to do this in years when they are neither held over the Bank by the local circulation nor carried out over the continental slope, to be lost, as happens in the case of the haddock in some years (p. 212). Our Gulf may also receive contributions of cod larvae and fry drifting past Cape Sable, from outer Nova Scotia waters farther east. On the other hand, the cod fry that are taken at Woods Hole in spring may have come from Nantucket Shoals. But those that we found as far south as the Capes of the Chesapeake in April 1930, probably were the product of the spawning that has long been known to take place in winter off New York and off New Jersey.

Little is known of the wanderings of the cod in the Gulf of Maine from the time they first seek the bottom when 1½ inches long or so, until they are large enough to be caught on hook and line, say 10 or 11 inches long, or 1½ to 2 years old. Young fry, however, from 2 to 4 or 5 inches long and upwards, have been trawled often enough offshore as well as inshore, and they have been found in the stomachs of older cod often enough to show that they soon become distributed all around the Gulf, including the outer part of the Bay of Fundy where it seems that none are hatched (p. 193). But they usually are much more plentiful on the rough inshore bottoms than on the smoother offshore banks. A reasonable explanation is that if young cod take to the bottom on rough, rocky grounds, or among algae, they have a fair chance of escaping their various enemies, but that they find no hiding places on the smooth bottoms that characterize extensive areas on Georges Bank and on Nantucket shoals, hence, are soon decimated.

Some of the larger Gulf of Maine cod probably travel very little out of the spawning season, except as they gradually exhaust the food supply in one spot and are therefore driven to move on over the bottom to fresh foraging grounds. Such fish usually are dark and dull colored, with large heads, a sign of scanty diet. Thus tagging experiments, involving many thousands of fish, have shown that a large percentage of the rather

⁸⁴ Rept. U. S. Comm. Fish. (1929), 1930, App. 3, table 2, pp. 85-86; table 3, p. 98.

⁸⁵ Most recent year for which catches for the smaller inshore grounds are listed separately in the published catch statistics.

⁸⁶ Bull. U. S. Bur. Fish., vol. 43, 1929, pp. 266-290.

⁸⁷ Bull. U. S. Bur. Fish., vol. 48, 1929, p. 289.

small cod that make up most of the population along the coast of Maine shift ground but little from season to season. The red fish that haunt the rocks also belong to this category, and red "rock" fish are sometimes caught as large as 10 or 20 pounds.

Other cod (and these compose the greater part of the Gulf of Maine stock), are always on the move over the bottoms of their chosen banks. Though cod can hardly be described as schooling in the same sense as herring or mackerel school, these traveling cod often hold together so closely that it is common enough for one-half of a long line to come in loaded with cod, but the other half to come in empty, and these bodies of fish often run very even in size, color, and shape, suggesting that they may hold together for considerable periods. But fishermen report them mixed as to sex, sometimes males predominating, sometimes females. It is these "school" fish, as they are called, that most often prey on fish and on squid, though they feed chiefly on shellfish as all cod do. They run slenderer and lighter colored than ground cod and have smaller heads, but it is probable that such differences are only temporary reflections of the surroundings of the individual fish, and that a cod that is a ground fish this month, may start on its travels next, turning brighter and becoming more shapely as it goes, either from a change of diet, from a change of surroundings, or from more active exercise. Furthermore, cod may flee a given locality if harassed too much by the spiny dogfish (p. 48), and no doubt other enemies drive them at times.

When cod are on their travels they often rise to the middepths (a fact proved by the levels at which they are caught in nets); netted fish are so often empty, whereas those caught on hook and line are full of food, that they are popularly (and perhaps rightly) believed to fast while they are on a journey.

It is probable that the wanderings of these schools of fish are confined to rather small areas, in most instances. Very few cod, for example, that have been tagged on one of the major Gulf of Maine grounds north or east of Cape Cod have been recaptured on any other ground. But the experience of fishermen makes it probable that a certain amount of intermingling does take place between Browns Bank and Georges; also between the latter and Nantucket Shoals.

An interesting fact in this connection, and one for which we see no explanation, is that the majority of such cod as stray afield from the coast of Maine tend to travel to the eastward as a rule, as shown by tagging experiments. Thus 50 out of 76 cod that were marked near Mount Desert, and that are known to have journeyed more than a few miles afield went eastward to Petit Manan (5); to Grand Manan (6); to the west coast of Nova Scotia (20); to the outer coast of Nova Scotia as far as Scatari, Cape Breton (16); to Browns Bank (1); to La Have Bank (1); and to Sable Island Bank (1). But only 26 of them were recaptured to the southward and westward; i. e., Penobscot Bay to Cape Ann, including Cashes and Jeffreys Ledges (20); inner part of Massachusetts Bay (1); off Provincetown (1); South Channel (1); Nantucket Shoals (1) and Georges Bank (2).⁸⁸

Canadian tagging experiments have shown a similar state for Nova Scotian cod, most of them remaining nearly stationary for long periods, some straying eastward, very few moving westward.⁸⁹ And Thompson's very extensive tagging experiments have shown that the movements of most of the cod of Newfoundland waters are confined similarly within regions where physical conditions are comparatively uniform.

Some of the cod there make long journeys, discussions of which would carry us too far afield.⁹⁰ And in two different winters, (1877-1878 and 1892-1893) hooks of a kind that are used by French fishermen on the Grand Banks of Newfoundland have been found in cod that were caught near Cape Ann,⁹¹ evidence that cod sometimes carry out journeys from north and east to south and west along the American coast, comparable in length to the seasonal migrations that cod have long been known to make along the Norwegian coast, and between Iceland and the West Greenland Banks.⁹²

⁸⁸ About 12,000 cod were tagged by us near Mount Desert, on the U. S. Bureau of Fisheries vessels *Halcyon* and *Albatross II* and from other craft, from 1924 to 1931. Recaptures nearby totaled 1,754.

⁸⁹ For details as to tagging experiments in Nova Scotian waters, see McKenzie, *Contrib. Canadian Biol. and Fisheries*, N. Ser., vol. 8, No. 31, 1934.

⁹⁰ See Thompson (Research Bull. 14, Newfoundland Dept. Nat. Resources, 1943, pp. 20-45, charts 1-3) for detailed discussion in relation to spawning and to racial subdivisions of the local stock.

⁹¹ Earll, Rept. U. S. Comm. Fish. (1878) 1880, p. 706. Kendall, Rept. U. S. Comm. Fish (1896), 1898, p. 178.

⁹² See especially Hjort, *Journal du Conseil. Cons. Perm. Internat. Explor. Mer.*, vol. 1, No. 1, p. 9, 1926; also Schmidt, *Rapp. Proc-Verb. Conseil Perm. Intern. Explor. Mer.*, vol. 72, p. 37, 1931.

The only regular seasonal migrations that the cod within our Gulf are known to carry out are: (a) their concentrations on their spawning grounds, followed by their dispersal thence after they are spawned out; and (b) a tendency of the fish living closest in shore and shoalest to shift depth with the season, according to the temperature of the water. Thus the cod tend to work in shore, and shoaler, around Massachusetts Bay in autumn, to work out into deeper (hence cooler) water again for the summer. On the other hand, local fishermen report that the cod abandon the shoalest (7-10-fathom) parts of Nantucket Shoals, after the water there has been chilled by the first heavy snows, to congregate from January until April in the deeper (12-20-fathom) channels (warmer in this case.).

Spawning grounds and season.—Thanks to Earll's painstaking studies, and to the large scale on which the Bureau of Fisheries subsequently collected and hatched cod eggs at the Gloucester and Woods Hole hatcheries, the spawning season and the major spawning grounds of the cod are fairly well known for the coastal waters between Nantucket Shoals and the Bay of Fundy.

According to the reports of fishermen and to W. F. Clapp's first-hand experience, large bodies of cod spawn on the eastern part of Georges Bank east of Georges shoal, centering at about latitude $41^{\circ}21'$ to $41^{\circ}31'$, longitude $66^{\circ}50'$, to 67° F. in about 35 fathoms of water. Vague rumors are our only indication as to where and when cod spawn on other parts of Georges; they may do so there, wherever the water is shoaler than 35 to 40 fathoms. And there is every reason to suppose that they spawn regularly on Brown's Bank, though we have no definite record of it.

The broken bottom of Nantucket Shoals, east and south of Nantucket Island (fig. 94), has long been known as a center of abundance for ripe cod fish in late autumn and early winter.

So far as we can learn few cod, if any, spawn on the sandy bottom along the outer shores of Cape Cod. But great numbers of ripe fish congregate in Massachusetts Bay on well-defined grounds 3 to 10 miles offshore, extending from abreast of Sandwich (some 12 miles south of Plymouth) to Minots Light off Cohasset. Years ago many cod also spawned over a small area off Boston Lighthouse and thence northward toward Bakers Island. Few breeding fish have been reported

there of late, however, probably because this general locality has been used as the dumping ground for the refuse from Boston, but a few still spawn on various small rocky patches off Gloucester.

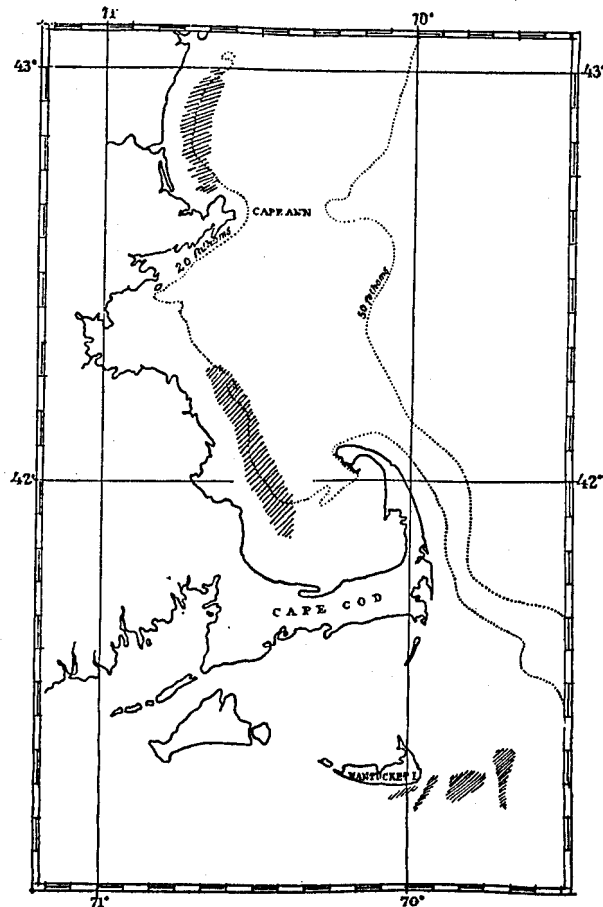


FIGURE 94.—Chief spawning grounds of cod in the western side of the Gulf of Maine.

The Ipswich Bay region, where large schools of ripe cod gather in winter and spring, is probably the most important center of production for the inner part of the Gulf of Maine north of Cape Ann, but this ground, like the Massachusetts Bay spawning ground, is limited to a rather small and well defined area extending only from a few miles south of the Isles of Shoals to abreast of the mouth of the Merrimac River and (less productively) to Cape Ann, chiefly within 4 to 6 miles of land. A glance at the chart (fig. 94) will show how limited the more important breeding grounds of the southwestern part of the Gulf of Maine are in extent (not more than 300 square miles in all)

compared to the whole peripheral zone of this part of the Gulf within the 50-fathom curve. And ripe fish are seldom found even close by, though the fishing for green or spent fish may be good there.

One consequence of the limited extent of these spawning grounds is that the cod congregate on them at the spawning season, in great numbers. During the spring of 1879, for example, when fishing was less intensive than it is at present, and when the cod may have been correspondingly more plentiful, more than 11,000,000 pounds of cod, mostly spawning fish, were taken on the Ipswich Bay ground alone by local fishermen.

Spawning cod are caught only in small numbers, and at scattered localities in the coastal zone north and east of the Isles of Shoals, the more productive of these minor grounds being near Cape Elizabeth; off Casco Bay; off the Sheepscott River; off Boothbay; and in the neighborhood of Mount Desert Island. Very few ripe cod are reported along the Maine coast farther east. And the egg-collecting activities of the several hatcheries have been carried on over so many years that important centers of production there could hardly have been missed. Cod eggs have been taken in the Bay of Fundy but the larvae are unknown there. Neither has any definite evidence been obtained that cod breed in any abundance off the west coast of Nova Scotia. And we should emphasize that the small ledges in the western part of the Gulf, e. g., Jeffreys and Platts, are not breeding centers though they are important feeding grounds. We cannot speak for Grand Manan Bank or for German Bank. Cod, in short, are quite as local in their choice of spawning grounds in the Gulf of Maine as they are in Norwegian waters.⁹⁵

Cod spawn at least as far south and west as New Jersey,⁹⁶ and captures, in 1930, of a considerable number of fry 1½ to 2½ inches long off New Jersey and off Virginia in April are evidence that spawning is successful at least as far south as the offing of Chesapeake Bay. But the fate of these southern-spawned cod is yet to be learned.

Following the cod eastward and northward, we learn that eggs are produced in profusion as far north as the Gulf of St. Lawrence and the Grand

Banks. But it is not known how much spawning takes place along the eastern coast of Labrador, although eggs have been taken in some numbers along the west coast of Greenland as far north as latitude 66°56' N.⁹⁵

Cod spawn in shoaler water than haddock on the whole. In fact, we can find no record of ripe cod deeper than 50 fathoms in our waters, and most of the Gulf of Maine spawning takes place on considerably shoaler bottoms. The Georges Bank ground, for example, is about 25 to 35 fathoms deep; the Nantucket grounds are hardly anywhere deeper than 20 fathoms, and as shoal as 7 fathoms in places; the Massachusetts Bay grounds are about 12 to 25 fathoms; and the Ipswich Bay ground is only 5 to 25 fathoms deep according to the precise locality.

It has long been known that while cod spawn chiefly in winter, both in American and in European waters, the breeding season lasts much longer and is less definitely limited at either end for cod than it is for the haddock or for the pollock. And experience has shown that the season when the production of eggs is most active differs widely even within the comparatively small area now under discussion. On Nantucket Shoals, ripening fish are caught from late October on, with the cod spawning there in early November to mid-February, and occasionally until April. Corresponding to this, the brood fish taken off Nantucket that were formerly brought in to the Woods Hole pool spawned there from about the first of December until well into February and occasionally as late as March, with the major production usually from December 20 to January 7.⁹⁶ And the spawning season is about the same as this off Plymouth in Massachusetts Bay, where ripe cod of both sexes are common from November until as late as April.⁹⁷ On the north side of Cape Ann, however, only 50 miles distant, ripe fish seldom appear in any numbers until January and not until February in some years, though odd ones may be expected from November on.

Earll, for example, found that not one female in ten had commenced to throw her eggs by February, in Ipswich Bay, though spawning was then

⁹⁵ Jensen (Rapp. et Proc. Verb., Conseil Internat. Explor. Mer., vol. 39, 1926, p. 85.

⁹⁶ Information from W. H. Thomas, former superintendent of the Woods Hole hatchery.

⁹⁷ Information from C. G. Corliss, former superintendent of the Gloucester hatchery.

⁹⁸ See Hjort (Rapp. Proc.-Verb., Cons. Perm. Internat. Explor. Mer., vol. 20, 1914).

⁹⁹ Smith, Rept. U. S. Comm. Fish. (1901) 1902, p. 208; Schroeder, Bull. U. S. Bur. Fish; vol 46, 1930, p. 70.

at its height in Massachusetts Bay, nor were as many as 50 percent of the Ipswich Bay fish ripe before mid-March. Commencing to spawn later there and near Cape Ann than they do off Plymouth, they also continue later, i. e., until the end of April or even into the first part of May, as appears from the following table of cod-egg collections supplied by the Gloucester hatchery:

Season	Collecting field	Number of eggs taken	Spawning season
1911-12	Plymouth	67,032,000	Nov. 24 to Jan. 3.
1912-13	Off Rockport (Ipswich Bay).	170,840,000	Feb. 16 to Apr. 7.
1913-14	Off Gloucester	91,980,000	Feb. 1 to Apr. 15.
1914-15		82,460,000	
1915-16	In Ipswich Bay and off the New Hampshire coast.	145,630,000	Feb. 9 to Apr. 13.
1916-17		92,540,000	Feb. 27 to Apr. 13.
1917-18	Off Gloucester	119,020,000	Feb. 25 to Apr. 27.
1918-19	do.	249,510,000	Feb. 27 to Apr. 30.
1919-20	do.	570,740,000	Dec. 28 to Apr. 30.
1920-21	do.	210,040,000	Jan. 15 to Apr. 29.

Off the western coast of Maine, according to Capt. E. E. Hahn, former superintendent of the Boothbay Harbor hatchery, cod spawn from late February or early March until the last of May, with the production of eggs at its peak in March; they spawn from March through May off the eastern Maine coast, and cod eggs (and hence spawning cod) have been recorded in spring in the Bay of Fundy.

On Georges Bank cod spawn in abundance in February,⁹⁸ March, and April.

The records of the hatcheries just summarized tell when eggs are produced in maximum abundance, but they throw little light on the limits of the spawning season, for it was only during the period when there were enough ripe fish to warrant the effort and expense that spawn taking was carried on. And occasional ripe cod of both sexes are seen long before the bulk of the fish breed, and long after. Thus Earll⁹⁹ reports the first ripe female as taken near Cape Ann on September 2 during the season of 1878-79, while we have taken cod eggs, far enough advanced in incubation for positive identification as such, off Shelburne (Nova Scotia) on September 6; near Mount Desert on September 15; and off Penobscot Bay on October 6 (all in 1915).

On the other hand Earll saw ripe fish about Cape Ann as late as June. And our tow-nettings make it likely that some may even spawn in midsummer in the coastal zone east of Cape Elizabeth, for we have occasionally found eggs identifiable as either cod or haddock by their black pigment, and probably the former, near Mount Desert Island on July 19; near Wooden Bell Island at the mouth of Penobscot Bay on August 6 and near Cape Elizabeth on September 30.

This sporadic summer breeding of cod in our Gulf is hardly comparable to the so-called "after-spawning" that has been observed off the north coast of Iceland by Schmidt,¹ in the North Sea, and in the Baltic.² But it is not unusual for cod to breed in summer off the outer coast of Nova Scotia where ripe fish are reported by local fishermen in June and July. Similarly, spawning cod were caught from the deck of the *Grampus* (Capt. E. E. Hahn in command) on Bradelle Bank in the Gulf of St. Lawrence late in August many years ago, while gadoid eggs (probably cod) were towed at various localities there during June, July, and August of 1915 by the Canadian Fisheries Expedition.³

Cod spawn chiefly if not altogether in summer on the Grand Banks where Arctic temperatures prevail during the spring.

Corresponding to the prolonged period of reproduction, spawning takes place over rather a wide range both of temperature and of salinity in our Gulf. On the Ipswich Bay grounds, for example, some are spawning late in November when the bottom water at the depth in question (p. 193) is at its warmest for the year (near 48°); they ripen regularly in temperatures of 41°-43° F. (January); spawning is at its height in the minimum temperatures of the year (35°-37.5°), and some spawning continues until the bottom water has once more warmed to 38°-41° (mid-May).

On the Massachusetts Bay ground, spawning fish appear in numbers (late November) when the bottom water is still as warm as 47°-48°; the chief production taking place in temperatures of 36°-42° (December through January), hence in warmer water than in Ipswich Bay. And the peak of the

⁹⁸ This fact has long been common knowledge, and W. F. Clapp, formerly of the Museum of Comparative Zoology, has seen many cod with eggs running, caught on Georges Bank in February and March.

⁹⁹ Rept. U. S. Comm. Fish. (1878) 1880, p. 713.

¹ Rapp. et Proc. Verb., Cons. Perm. Internat. Explor. Mer., vol. 10, 1909, pp. 21, 123.

² Ehrenbaum (Nordisches Plankton, vol. 1, 1905-1909, p. 225) and Fulton (Cons. Perm. l'Explor. Mer. Pub. de Circonstance, No. 8, 1904).

³ Dannevig, Canadian Fish. Exped. (1914-15) 1919, p. 22.

spawning season has passed before the temperature drops to its winter minimum, although some cod spawn there through the coldest season (minimum temperature 33°–37°). The temperature range through which the cod breed on the offshore grounds cannot be stated so precisely, for want of data for autumn and for early winter.

In the Gulf of St. Lawrence, cod are known to spawn in water as cold as 32° F. or even slightly colder,⁴ though the eggs develop at higher temperatures for they rise to the upper water layers. Around Newfoundland, the cod appear to seek temperatures of 35°–40° F. (1.5–4.4° C.) for spawning, with the chief production of eggs taking place at 37°–41° F. (3–5° C.).⁵

Cod spawn in rather colder water on the whole in the Gulf of Maine (still more so in the Gulf of St. Lawrence and on the Newfoundland Banks) than they do in the other side of the North Atlantic, or about Iceland, where the chief production of eggs takes place at temperatures of 40°–45° F.

Probably no cod spawn in water fresher than about 32 per mille nor saltier than about 32.8 per mille, either on the Ipswich Bay grounds or on the Massachusetts Bay grounds. And our records (as far as they go) point to a salinity of about 32.6 per mille as typical for the spawning of the cod on Georges Bank. This is water much less saline than ripe cod seek in European seas, and necessarily so, the Gulf of Maine being decidedly fresher at all times of the year than the Norwegian Sea or the waters around Iceland.

On the Massachusetts Bay spawning ground the specific gravity of the water is high enough to insure that the eggs shall float throughout the breeding season, but in Ipswich Bay the spring freshets often so lighten the surface that late-spawned cod eggs and haddock eggs may fail to rise to the uppermost water layers, a phenomenon which hinders the operations of the hatchery but which does not militate against the successful incubation of the eggs in nature, since the eggs merely float suspended at some deeper level. This subject is discussed at greater length in connection with the haddock (p. 208).

We have yet to learn what proportion of the cod larvae that are hatched in the Gulf of Maine (doubtless a very small one) survive to grow to

market size. And what few bits of evidence we have in this regard are contradictory.⁶

Importance.—In 1945, the most recent year for which detailed statistics of the catch are available for the coastlines of Massachusetts and Maine, as well as for the offshore Banks, the Gulf of Maine yielded about 62,500,000 pounds of cod to United States fishermen;⁷ some 8,000,000–9,000,000 to Canadian fishermen;⁸ or a grand total of some 70–71 million pounds, plus an indeterminate amount landed in small Nova Scotian harbors between the Yarmouth County line and Cape Sable. This is about the same amount as the Gulf had yielded in 1919 (about 67,000,000 pounds); nor is there anything in the catches of intervening years to suggest that any very pronounced fluctuations had taken place meantime in the abundance of cod within our Gulf.

A representative yield, in round numbers, broken down into the statistical areas now employed by the U. S. Fish and Wildlife Service, would be about 7,000,000 pounds along the western coast of Nova Scotia and along the lower Nova Scotian shore of the Bay of Fundy; about 380,000 pounds for the upper Nova Scotian shore of the Bay; about 1,600,000 pounds for the New Brunswick shore of the Bay near its mouth;⁹ about 500,000 pounds for eastern Maine; about 4,500,000 pounds for central Maine; about 3,350,000 pounds along western Maine; about 600,000 pounds from the small fishing grounds in the inner-central part of the Gulf; about 5,000,000 pounds off eastern Massachusetts: a little less than 5,000,000 pounds for the grounds from Cape Cod out to the so-called South Channel; about 17,000,000 pounds for Georges Bank as a whole; about 2,000,000 pounds for the western part of Browns Bank; and about 2,200,000 pounds for Nantucket Shoals.

During the early days of the fishery, the entire Gulf of Maine catch of cod was made on hook and line; on hand lines at first, but with long or

⁶ Fish (Bull. U. S. Bur. Fish., vol. 43, 1929, p. 286) caught no cod larvae in Massachusetts Bay, though eggs were abundant there, but the *Albatross II* towed several hundred little cod (4 to 9¼ mm.) off the tip of Cape Cod nearby, on May 28, 1927. The paucity of our other catches of cod larvae (80 to 90 all told) for other parts of the Gulf of Maine may have been accidental.

⁷ Total landings in New England ports were about 139,700,000 pounds, but something over 77,000,000 of this was taken on the grounds along outer Nova Scotia.

⁸ About 9,259,900 pounds in 1944, about 8,226,000 pounds in 1945, and about 8,174,800 pounds in 1946.

⁹ No cod are mentioned for the head of the Bay on the New Brunswick side in the Canadian statistics of late years.

⁴ Hjort, Canadian Fish. Exped. (1914–1915) 1919, p. XXVII.

⁵ Thompson, Research Bull. 14, Newfoundland Dept. Nat. Resources, 1943, p. 89.

trawl lines coming into general use about the middle of the 19th century. And it is not astonishing that a fish so nearly omnivorous as the cod should be caught on various baits. Those most in use in the Gulf of Maine are clams (*Mya arenaria*), cockles (*Polynices*), herring (fresh, frozen, or salt), and squid. General experience suggests that there is little to choose between the first two of these, while the razor clam (*Ensis directus*) is equally attractive though limited by the small supply. And tests made in the Gulf of St. Lawrence¹⁰ proved that fresh herring and fresh squid are about as good as clams, but that frozen and salt herring are less attractive. Other kinds of fish are also used as cod bait in other parts of the world; capelin, especially, in more northern seas, and lancee.

The earliest important addition to fishing methods came during the winter of 1880-1881, when gill nets, based on the Norwegian system, were introduced in the Ipswich Bay region, yielding unexpectedly large catches.¹¹ Since about 1908, when otter trawls came into general use in our waters, an increasing proportion of the catch has been taken by this method. Today about 80 to 85 percent of the Gulf of Maine catch is made in otter trawls; only about 10 percent on long lines; about 1 percent in gill nets; less than 1 percent in pound nets, and less than 1 percent on hand lines.

Cod still bite as greedily, however, as they ever did on clams, cockles (*Polynices*), or on pieces

of squid or herring. We have even caught fair-sized cod on a pickerel spinner tipped with a bit of pork rind, over ledges in shallow water; we have heard of small cod caught on bucktail lures, also on tin-clad lures cast in the surf. And anglers fishing from small craft for pleasure or for home use catch large numbers all along the coast, though these are mostly of the smaller sizes. So far as we can learn, cod have never been jigged successfully in the Gulf of Maine, as they are in abundance in northern Labrador waters.

Tomcod *Microgadus tomcod* (Walbaum) 1792

FROSTFISH

Jordan and Evermann, 1896-1900, p. 2540.

Description.—The tomcod resembles a small cod so closely in its fins, in the projection of its upper jaw beyond the lower, in the presence of a barbel on its chin; and in its pale lateral line, that the one might easily be taken for the other. But the outlines of the ventral fins offer a field mark by which the two fish may be separated, for while their second rays are filamentous at the tip in both species, the ventrals of the cod are moderately broad, rounded, and with the filament occupying less than one-fourth the total length of the fin, whereas the ventrals of a tomcod are so narrow, so tapering, and with so long a filament (as long as the rest of the fin) that the whole suggests a feeler rather than a conventional fin. Furthermore, the margin of the caudal fin of a tomcod is noticeably rounded, while that of the cod is square or slightly concave; the eye of the

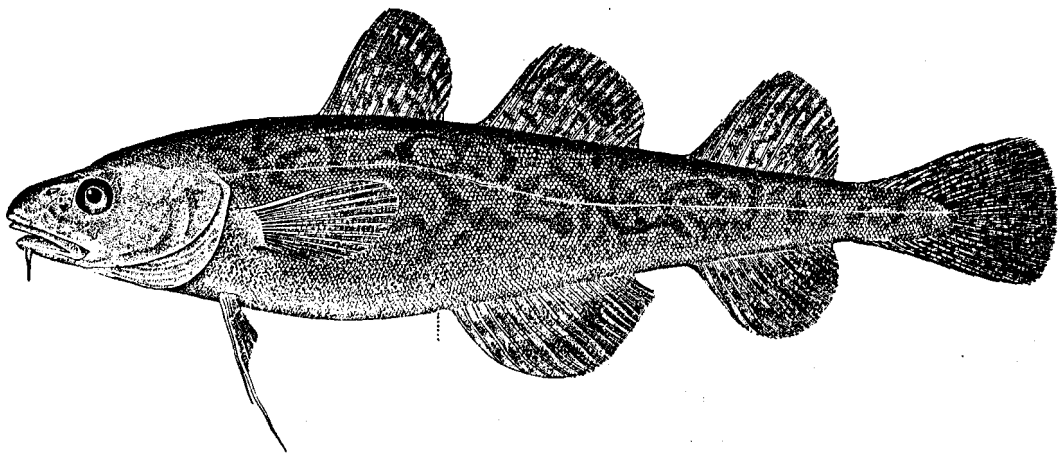


FIGURE 95.—Tomcod (*Microgadus tomcod*), Woods Hole. From Goode. Drawing by H. L. Todd.

¹⁰ Knight, Contrib. to Canad. Biol. (1906-1910) 1912, pp. 23-32.

¹¹ For account of cod fishing methods in North American waters before the introduction of the otter trawl, see Goode and Collins, Fish. Industries U. S., Sect. 5, vol. 1, 1887, pp. 123-198.

tomcod is decidedly smaller than that of a cod (about one-fifth to one-sixth as long as the head in the tomcod, about one-fourth in the cod, in fish 7 to 10 inches long); and the general form of its body is more slender. A less obvious difference is that the first dorsal fin of the tomcod originates over the middle of the pectoral fins or farther back still, farther forward in the cod; and the pectoral fins reach back only a little beyond the middle of the first dorsal fin in the tomcod, but nearly to the rear end of the first dorsal on a cod.

Unfortunately, the number of fin rays varies so widely in both these fish that it is not diagnostic, there being from 11 to 15 in the first dorsal, 15 to 19 in the second dorsal, and 16 to 21 in the third dorsal of the tomcod; 12 to 21 in its first anal fin and 16 to 20 in its second anal fin. Most of the recent accounts list the position of the vent as the chief external distinction between tomcod and cod, describing it as in front of the origin of the second dorsal fin in the former and back of it in the latter. But we must caution the reader that it is only for adults of the two species (which no one could confuse in any case, cod being so very much the larger) that this distinction holds; cod as small as tomcod (that is, up to a foot long) often have the vent well in front of the second dorsal, while it may hardly be further forward than that in adult tomcod in breeding condition.

Color.—Tomcod are not so variable in color as cod. Those we have seen (a considerable number) have been olive or muddy green above, with a yellowish tinge, darkest on the back, paling on the sides, and mottled with indefinite dark spots or blotches. The lower parts of the sides usually show a decided yellowish cast in large fish; the belly is grayish or yellowish white; the dorsal and caudal fins are of the same color as the back; the anals are pale at the base but olive at the margin; and all of the fins are more or less dark mottled. The tomcod has often been described (following Storer) as thickly speckled with black dots, but we have never seen one marked in that way.

Size.—The maximum size is about 15 inches and 1¼ pounds, but few of them are more than 9 to 12 inches long.

Habits.—The tomcod is strictly an inshore fish; probably few ever descend more than two or three fathoms, or stray as much as a mile outside the outer headlands. In our Gulf they chiefly frequent the mouths of streams and the estuaries into

which these empty, as well as shoal, muddy harbors like Duxbury Bay. As often as not they are in brackish water, and they run up into fresh water in winter. Dr. Huntsman, for example, writes us that they are caught in the Petit Codiac River 12 miles above the head of tide. Tomcod are less plentiful in harbors where there is no stream drainage, but now and then they are caught off open shores, off Nahant, for instance, and such fish are usually large ones. South of Cape Cod, most of them move out from the shore into slightly deeper (hence cooler) water in spring, coming in again in autumn to winter in the estuaries. But a year comes from time to time (such as 1925) when they are plentiful close inshore all summer, as far south even as New York.¹² And they do not carry out any inshore-offshore migrations of a regular sort in the cooler Gulf of Maine, so far as is known. Indeed, they are so resistant to cold that we find no record of them killed by winter chilling, a fate that sometimes overtakes other fishes that live in shoal water. And they are equally hardy toward sudden changes of salinity.

Tomcod feed chiefly on small crustaceans, especially on shrimps and amphipods, a great variety of which have been found in their stomachs; also on worms; small mollusks; squids; and fish fry, such as alewives, anchovies, cunners, mummichogs, herring, menhaden, launce, sculpins, silversides, smelt, and sticklebacks.

According to Herrick¹³ tomcod are not so keensighted as pollock nor so active as hake, but spend most of their time quietly on the bottom in the aquarium. His experiments also proved that they are able to recognize concealed baits by the sense of smell if they chance to swim near and that they search the bottom by dragging the chin barbel and the sensitive tips of the ventral fins as they swim to and fro, either for food, or to stir up shrimps and other food items.

Tomcod spawn in the shoal waters of estuaries, in stream mouths and such places, either in salt water or in brackish, and their eggs have been hatched artificially in fresh water. The season lasts from November to February, inclusive, with the height of production in January. The eggs are about 1.5 mm. in diameter with a conspicuous oil

¹² Nichols and Breder (Zoologica, N. Y. Zool. Soc., vol. 9, 1927, p. 160) state that tomcod up to 10¾ inches long were common throughout that summer in Sandy Hook Bay.

¹³ Bull. U. S. Fish Comm., vol. 22, 1904, p. 262.

globule, and (unlike those of its larger relative) they sink to the bottom where they stick together in masses, or to seaweeds, stones, or any available support. Incubation occupies about 24 days at an average temperature of 43°; 30 days at 40°. The larvae are not only somewhat larger (5 mm.) at hatching than those of the cod, but are farther advanced in development, the mouth being formed. And they differ from all other Gulf of Maine gadoids at a corresponding stage by the presence of the oil globule and by the fact that the vent opens at the margin of the ventral fin fold and not at its base at one side.¹⁴ Although great numbers of tomcod have been hatched artificially by the State of New York, its later larval stages have not been described, nor have we seen them ourselves. The fry, which are said to remain through their first summer in the waters where they are hatched, grow to a length of 2½–3 inches by the following autumn. But nothing is known of the rate of growth of older fish.

General range.—North American coastal waters from the Gulf of St. Lawrence and northern Newfoundland to Virginia, running up into fresh water.

Occurrence in the Gulf of Maine.—The tomcod is locally common around the entire coastline of the Gulf. It is reported at Pubnico and in St. Mary Bay, for example, on the west coast of Nova Scotia; at various localities on both shores of the Bay of Fundy (e. g., Annapolis Basin and River, Minas Basin, St. John Harbor, and the St. Andrews region); at Eastport; from almost every river mouth along the Maine coast; in the vicinity of Boothbay Harbor; at sundry stations in Casco Bay; and in Portland Harbor in Maine. And it is to be found in practically every estuary around the Massachusetts Bay region.

Tomcod are caught from docks and bridges and in salt creeks in mid-summer as well as in winter. Tomcod are in the inner parts of Duxbury bay, for example, in midsummer; there are also plenty of them in a certain salt marsh creek at Cohasset at all seasons; and this applies to many similar locations all up and down the coast, including the Bay of Fundy, where tomcod are in and near the estuaries the year round, as Huntsman¹⁵ remarks.

¹⁴ Ryder (Rept. U. S. Comm. Fish., (1885) 1887, p. 523, pl. 13, fig. 67) describes and pictures the newly hatched larva of the tomcod.

¹⁵ Contrib. Canadian Biol., (1921) 1922, p. 67.

Westward and southward from Cape Cod, the tomcod is plentiful in suitable situations all along the coast to New Jersey, where Abbott¹⁶ described them many years ago as a "very common" little fish, and we have often caught them while fishing from docks in lower New York Harbor.

In the opposite direction, they are common along the outer shores of Nova Scotia. They are plentiful enough around the shores of the Gulf of St. Lawrence for catches of 684,000 pounds to be reported from the New Brunswick coastline of the Gulf in 1947, 20,400 pounds from the southern shore of the estuary of the St. Lawrence River, 152,900 pounds from the north shore of the estuary and Gulf, while Jeffers¹⁷ reports them as taken in considerable numbers through the ice in winter, on the Newfoundland side of the Strait of Belle Isle. And they are to be expected along the southern and eastern coasts of Newfoundland, though they seem not to have been reported there as yet.

Importance.—The tomcod is a delicious little fish. But it seems to have been more highly considered a century ago, when between 5,000 and 10,000 pounds were caught annually in the Charles River tributary to Boston Harbor; today, it is unusual to see any for sale in a Massachusetts fish market. And, in any case, tomcod are not plentiful enough anywhere around our Gulf to support a regular commercial fishery of any magnitude. In 1929 the reported catch was about 6,000 pounds for Massachusetts, about 16,500 pounds for Maine, and about 6,100 pounds for the Canadian shores of the Gulf. In 1942,¹⁸ 27,500 pounds were reported for Maine, none for Massachusetts, about 10,000 pounds for the Nova Scotian shore of the Bay of Fundy. Since that time a few thousand pounds have been reported yearly from the Nova Scotia shores of the open Gulf and of the Bay of Fundy;¹⁹ none at all, however, from its New Brunswick shore.

Most of the tomcod marketed in Maine (also most of those formerly marketed in New Brunswick) are taken in bag nets or in pocket nets set

¹⁶ Geol. New Jersey, 1868, p. 818.

¹⁷ Contrib. Canadian Biol., N. Ser., vol. 7, No. 16 (Ser. A, general, No. 13), 1922, p. 7.

¹⁸ Most recent year when tomcod were mentioned in the United States catch statistics for the Gulf of Maine coast.

¹⁹ 35,000 pounds of tomcod were reported for Digby County in 1944, but this amount is so much larger than for preceding years, or for 1946, as to suggest some error.

in the courses of the larger rivers, a few in weirs. In the days when the commercial catch for Massachusetts was large enough to be worth reporting, most of it was taken on hook and line north of Plymouth, in weirs and traps south of Plymouth.

Besides the fish reported in catch statistics, a considerable number are caught in autumn on hook and line by smelt fishermen and by anglers fishing especially for "frost fish," all along the shores of northern New England and used for home consumption. Hence they are not reported or included in the fishery statistics.

Tomcod bite any bait greedily. Clams, shrimp, sea worms, or cut fish will serve, and they afford amusement to a larger number of anglers in harbors and stream mouths than the meager commercial catch might suggest.

Haddock *Melanogrammus aeglefinus* (Linnaeus)
1758

Jordan and Evermann, 1896-1900, p. 2542.

Description.—The most obvious ways in which the haddock differs from the cod are in its black

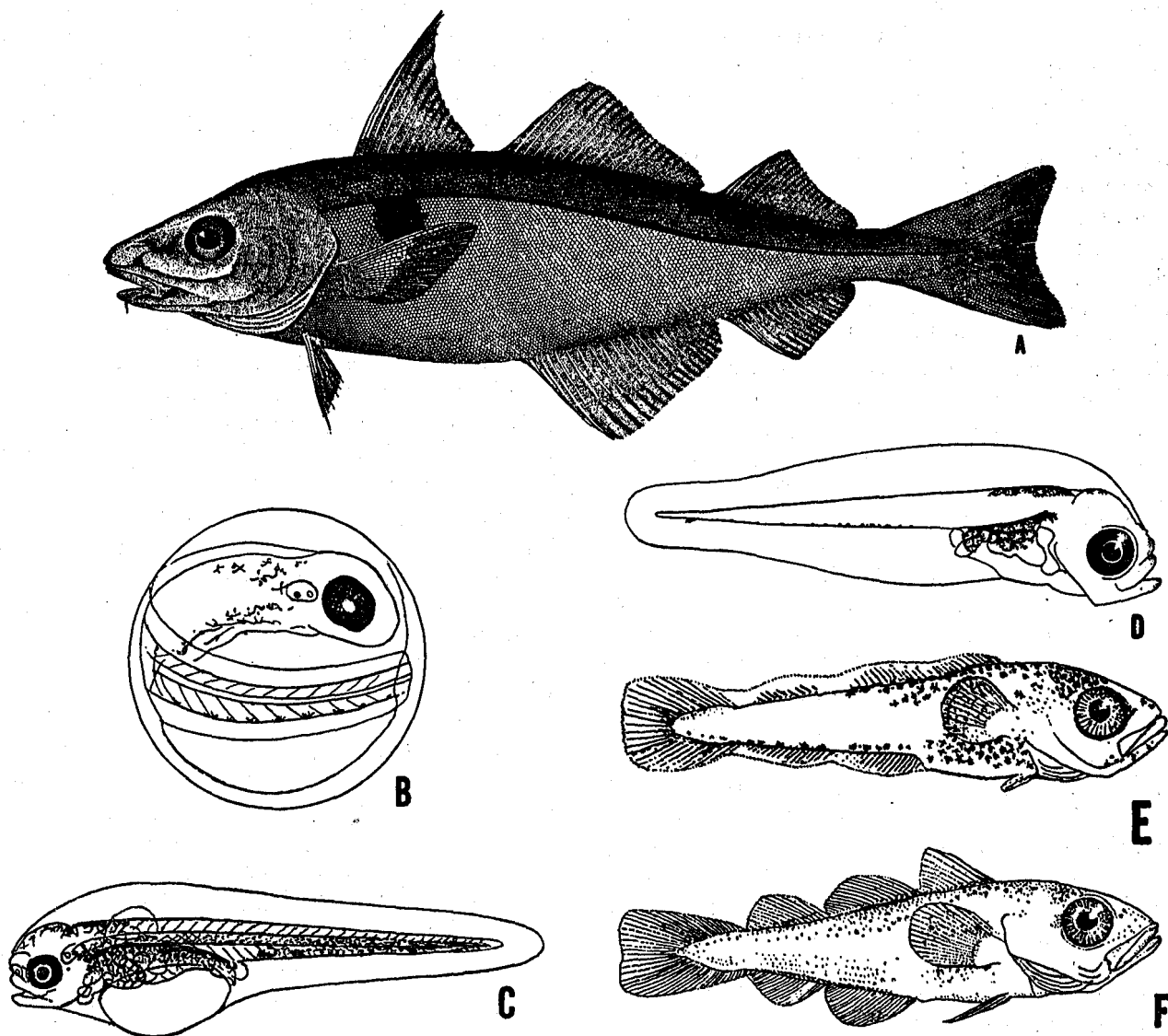


FIGURE 96.—Haddock (*Melanogrammus aeglefinus*). A, adult, Eastport, Maine, from Goode, drawing by H. L. Todd; B, egg (European); C, larva (European) just hatched; D, larva (European), 4.2 mm.; E, larva (European), 15 mm.; F, young fry (European), 25 mm. B and C, after Heineke and Ehrenbaum; D, after Ehrenbaum; E and F, after Schmidt.

lateral line (that of cod and of pollock is paler than the general ground tint) and in the presence of a dusky blotch on each side over the middle of the pectoral fin, and close below the lateral line. Furthermore the first dorsal fin of a haddock (higher than that of a cod, relatively) is considerably higher than either the second or third dorsal, more acutely triangular in outline, and with slightly concave margin. The margin of the haddock's tail is more concave than that of the cod; and its second and third dorsal fins are more angular than is usually the case with the cod, though they are similarly rhomboidal in outline.

The haddock's mouth is relatively the smaller, not gaping back to below the eye, and the lower profile of its face is straight, with the upper profile only slightly rounded, giving the nose a characteristic wedge-shaped outline in side view. The upper jaw projects further beyond the lower in the haddock than in the cod, and the snout is usually more pointed and the body more flattened sidewise. But the general arrangement of the fins is the same; there are about the same number of dorsal fin rays in haddock as in cod (14 to 17, 20 to 24, and 19 to 22, in the first, second, and third fins, respectively); and while the anal fins average one or two more rays each (21 to 25 and 20 to 24), individual cod may have more anal rays than individual haddock. Finally, the haddock is a slimmer fish than the cod and although its scales (which clothe it from nose to tail) are of about the same size relatively (about 160 rows along the side), they are scarcely visible through the mucus with which the skin is coated.²⁰

Color.—When a live haddock is first taken from the water, the top of its head, back, and sides down to the lateral line are dark purplish gray, paling below the lateral line to a beautiful silvery gray with pinkish reflections, and with the black lateral line and the sooty shoulder patch (just mentioned) standing out vividly. This patch, the "devil's mark," is indefinitely outlined and varies in size and in distinctness, but only very rarely does a haddock fail to show it. The belly and lower sides of the head are white. The dorsal, pectoral, and caudal fins are dark gray; the anal fins pale like the lower part of the sides and black specked at the base; and the ventrals are white, more or less dotted with black. Haddock usually

run very uniform in color, but occasionally one shows from one to four dark transverse bars or splotches in addition to the black shoulder blotch. Several of these serially striped haddock have been taken in Passamaquoddy Bay²¹ and we have seen such near Mount Desert. Occasionally a haddock may be decidedly golden on the back and sides, with the lateral line golden, and such fish may lack the dark blotches.

Size.—The haddock is a smaller fish than the cod, the largest on record having been only 44 inches long, weighing about 37 pounds.²² One of 30 pounds, caught on La Have Bank in the autumn of 1949²³ is said to have been the heaviest ever landed at the Boston Fish Pier. The largest among 1,300 fish that were measured and weighed by Welsh near Gloucester during the spring of 1913 was 35½ inches long, weighing about 16½ pounds. Only 4 or 5 out of the more than ten thousand haddock that we have helped to tag were as long as 32 to 34 inches. And the great majority of the fish that are brought in measure from 14 to 23 inches long, and weigh from 1½ to 4¾ pounds. The largest among 627,996 fish measured during the period 1931–1948 was 34½ inches long.²⁴ The relationship between length and weight averages as follows, according to Shuck;²⁵ 10 inches, 7 ounces; 12 inches, 12 ounces; 14 inches, 1 pound 2 ounces; 16 inches, 1 pound 11 ounces; 18 inches, 2 pounds, 6 ounces; 20 inches, 3 pounds 3 ounces; 22 inches, 4 pounds 3 ounces; 24 inches, 5 pounds 5 ounces; 26 inches, 6 pounds 9 ounces; 28 inches, 8 pounds 3 ounces; 30 inches, 9 pounds 15 ounces.

Habits.—Haddock live deeper than cod on the whole; few are caught in less than 5 to 10 fathoms of water and most of them in 25 to 75 fathoms. In fact, they so seldom come into shoal water where young cod are so plentiful that the pound nets of Massachusetts reported only about 5,000 pounds of haddock in 1919, as compared with almost 300,000 pounds of cod. Neither do we remember hearing of a haddock of any size in any of the shoal harbors where little pollock so abound. And the difference in habitat between these closely related species holds from the time the young fry

²¹ Prince, *Contrib. Canadian Biol.*, (1915–1916) 1917, p. 86.

²² This giant was an Icelandic fish, reported by Thompson (*Rapp. et Proc. Verbaux, Conseil Internat. Perm. Explor. Mer*, vol. 57, 1920, p. 29).

²³ Received by O'Hara Bros., and reported by Moore, *Boston Herald*, Nov. 29, 1949.

²⁴ Information from Howard W. Schuck.

²⁵ Fishery leaflet No. 198, U. S. Fish and Wildlife Service, 1947.

²⁰ Vladykov (*Canadian Field Natural.*, vol. 49, No. 4, 1935, p. 64) describes a haddock with 3 eyes, and includes a photograph of it.