first seek bottom, for haddock usually do so in 20 to 50 fathoms or deeper, seldom close to the shore, and perhaps never in the littoral zone.[26] On the other hand, comparatively few haddock, are caught deeper than 100 fathoms in American waters,[27] though they have been taken as deep as 120 fathoms (220 m.) on the slopes of the Faroe Bank, and as deep as 164 fathoms (300 m.) off Iceland.[28]

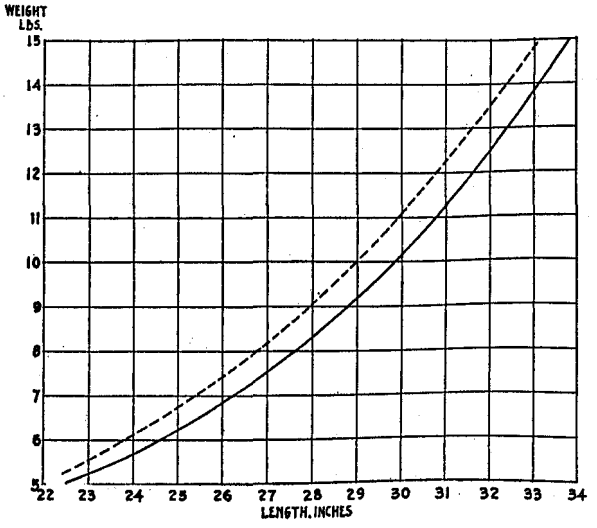

FIGURE 97.—Average weight of ripe haddock of different lengths; male (—) and female (- -) at Gloucester, Mass., March to May 1913.

The haddock, like the cod, is a cold-water fish, though it is not at home in temperatures quite as low. Thus it is almost wholly absent off Newfoundland, in the Gulf of St. Lawrence, and off Nova Scotia when the bottom water is as cold as 32° F.; few are caught there, generally speaking, where the bottom water is colder than about 35–36° F. (2° C.) though good catches are sometimes made in temperatures as low as 34°. At the opposite extreme, haddock appear to avoid water warmer than about 50–52° F. Thus Vladykov [29] reports that young haddock withdraw from Halifax Harbor if the temperature near the bottom rises above about 52°, though they can survive considerably higher temperatures for limited periods.[30] It is evident from this that the entire Gulf of Maine, at the depths frequented by the haddock, is suitable for them so far as temperature is concerned, but that the upermost stratum may be too warm from late summer through early autumn, and too cold from late winter through early spring. In exceptional years, too, such as 1926, the whole column of water may chill to a temperature too low for their comfort in the Bay of Fundy (p. 210).

The salinities at the localities and depths where haddock live in our Gulf range from about 31.5 per mille inshore to a maximum of about 34.5 per mille on the offshore edge of Georges Bank, with most of the catch made in water more saline than about 32 per mille. And while they enter the bays and reaches between the islands along the coast of Maine in some numbers (p. 210), they never run up estuaries into brackish water. Thus, haddock seem to require somewhat higher salinities than cod, which are sometimes caught in considerable numbers where the water is below 31 per mille (as in the Bras d'Or Lakes, Nova Scotia).[31]

In general, the haddock live in rather cooler and less saline waters in the American side of the Atlantic than in the European, as Thompson [32] has emphasized.

The haddock is more exclusively a ground fish than the cod and though they sometimes pursue herring and other small fish, as cod do more often, we have never heard of haddock coming to the surface when so engaged, events by no means unusual with cod, and a characteristic phase in the life of the American pollock (p. 214).

Haddock are more selective than cod in the type of bottom they frequent, being rarely caught over ledges, rocks, or kelp (where cod are so plentiful), or on the soft oozy mud to which hake resort. They are chiefly taken on broken ground, gravel, pebbles, clay, smooth hard sand, sticky sand of gritty consistency, and where there are broken shells; they are especially partial to the smooth areas between rocky patches.

Food.—During their first few months, while living pelagic near the surface, haddock fry probably depend on copepods as cod do. After

[26] The fact that haddock fry less than 1 year old have never been reported in shoal water in the Gulf or at Woods Hole corroborates European fishing experiments summarized by Damas (Rapp. et Proc.-Verb., Cons. Internat. Explor. Mer, vol. 10, 1909) and by Schmidt (*ibid.*).

[27] Thompson, Research Bull. No. 6, Newfoundland Dept. Nat. Res., 1939, p. 9.

[28] Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895, p. 354) list a haddock from 499 fathoms but with suspicion as to the accuracy of its label.

[29] Contrib. Canadian Biol., N. Ser., vol. 8, No. 29, 1934, p. 418.

[30] At the St. Andrews Laboratory, haddock kept at a temperature varying between about 57° and about 68° F. survived for 3 to 4 months.

[31] Needler, Contrib. Canadian Biol., N. Ser., vol. 4, No. 20, 1929, p. 10.

[32] Research Bull., No. 6, Newfoundland Dept. Nat. Resources, 1939, p. 12.

they take to the bottom they become bottom feeders like cod, devouring all kinds of invertebrates so indiscriminately that, as Baird [33] remarked long ago, "a complete list of the animals devoured by the haddock would doubtless include nearly all the species belonging to the fauna" of the particular ground on which the fish in question were living. And they begin to depend on this adult diet when they are small. Thus we have found 7- to 9-inch fish full ot brittle stars, bivalve mollusks, small worms, and amphipods. The larger Crustacea, such as hermit, spider, and common crabs, shrimps, and amphipods, with gastropods and bivalve mollusks in great variety, worms, starfish, sea urchins, sand dollars, brittle stars, and sea cucumbers all enter regularly into the dietary of the haddock, according to locality.

W. F. Clapp, for instance, listed no less than 68 species of mollusks, both bivalves and gastropods, from 1,500 haddock that were caught on the northwest part of Georges Bank in 40 to 60 fathoms, and he has called our attention to the fact that haddock usually contain smaller shells than do cod, and never the very large sea clams (*Mactra*) which are so important a constituent of the diet of the latter. Neither do haddock eat crabs larger than about 2 inches across, as cod so greedily do. On the other hand, haddock depend more on worms than cod do, and they are often packed full of worm tubes when they are caught on bottoms covered with the latter (the "spaghetti bottom") as in the locality known as "Cove Clark" on the northwest face of Georges Bank (about lat. 41° 08′, long. 68° 40′). Haddock caught near Eastport, Maine, contained 8 species of annelid worms, and they must root out much of their food from the mud and sand of the sea bottom; in no other way could they obtain the burrowing worms and mollusks that their stomachs contain so often.

Haddock take squid when opportunity offers; they are said to prey on herring in Norwegian waters; on launce around Iceland; on fish, mostly launce, on the Nova Scotian banks; [34] on young eels off Cape Breton, Nova Scotia; [35] on herring near Woods Hole and, in 1931, we received reports of haddock having eaten small mackerel on Georges Bank in January. And many baby haddock about 8 inches (20 cm.) long, trawled on the southwest part of Georges Bank, August 13, 1945, were not only seen by John R. Clark of the U. S. Fish and Wildlife Service, to disgorge large numbers of small fish (apparently young silver hake) on the deck of the vessel, but had been feeding chiefly on them. They have also been accused of feeding greedily on herring spawn, perhaps without much justice. But fish ordinarily form so small a part of the diet of the haddock of our Gulf that none of those examined by Welsh near Cape Ann in 1913, nor the Georges Bank haddock opened by Clapp (about 5,000 altogether), and only two of the many that we have ourselves opened, contained fish of any kind, nor have any of the fishermen of whom we have inquired (and their practical experience is of course vastly wider than ours) described Gulf of Maine haddock as feeding to any great extent on fish. And none of the Eastport haddock that were opened by Doctor Kendall had risen to take the large pelagic shrimps (euphausiids) that are so abundant there and which are the chief food of the local pollock.

Welsh's experience with the haddock near Cape Ann during April 1913 was that they are apt to fast at spawning time; more than 95 percent of the hundreds of fish caught there in the gill nets were totally empty, while long lines set nearby were bringing in very few haddock though they were taking hake in fair numbers. But spawning haddock elsewhere "both male and female, have been found with well filled stomachs, and many spawners have been observed in the catches of line fishermen," [36] so the rule is not universal. It also seems that they feed less actively, or at least they take the hook less freely, at temperatures lower than about 36°, as it is in the coldest parts of the Gulf in winter, and the best hook and line catches are made at about 45°–50° F.

The haddock, like the cod, is a prolific fish for its size. Earll [37] estimated the number of eggs in a female weighing 2⅝ pounds and 19¼ inches long at 169,050; 634,380 in one of 4¾ pounds and 24 inches long; 1,839,581 in one 9 pounds 9 ounces and 28½ inches long. Incubation occupies 15 days at a temperature of 37°; 13 days at 41°, a fair average for the eggs that are spawned in the Gulf of Maine. The eggs are buoyant, without oil

[33] Rept. U. S. Comm. Fish (1886) 1889, p. 37.

[34] See Homans and Needler (Proc. Nova Scotian Inst. Sci., vol. 21, 1946, pp. 15–49) for a study of the haddock.

[35] Needler, Copeia, No. 171, 1929, p. 41.

[36] Needler, Contrib. Canadian Biol. and Fish., N. Ser., vol. 6, 1930, No. 10, p. 7.

[37] Rept. U. S. Comm. Fish. (1878) 1880, p. 733.

globule, and from 1.19 to 1.72 mm. in diameter; eggs taken at Gloucester in March 1913 averaged 1.57 mm., varying from 1.47 to 1.72 mm. Thus they average slightly larger than those of the cod. The haddock egg cannot be distinguished from that of the cod in early stages in its development, hence the term "cod-haddock," and when they are newly spawned there is even danger of confusing them with the eggs of one of our commonest flounders, the "witch" (p. 287), whose breeding season immediately follows that of the haddock. But the formation of black pigment soon identifies the cod-haddock egg as such (the embryonic pigment of the "witch" is yellow).

The newly hatched larva is about 4 mm. long, with the vent close behind the yolk sac and at the base of the ventral fin fold, not at the margin, so that it seems to end blind. It resembles a cod so closely that the two would be indistinguishable one from the other, were it not that the post-anal pigment granules of the haddock are arranged in a row along the ventral surface of the trunk from vent to tip of tail, and not in bands as they are in the cod (p. 188) and in the pollock (p. 216), while the dorsal wall of the body cavity of the haddock is densely pigmented. In water of 41° F. the yolk sac is absorbed in about 10 days when the little fish is about 5.5 mm. long; the dorsal and anal fins are fully formed at 16 to 20 mm.; and the young haddock begin to take on the general aspect of the adult by the time it is 30 to 40 mm. long. The arrangement of the larval pigment serves to differentiate the little haddock until it is about 12 mm. long. Larger fry are distinguishable from both cod and pollock by their pale pigmentation, and by the greater height of their first dorsal fin.

Gulf of Maine haddock average about 6 inches long (extremes, 5 to 7 inches) at the end of their first year, and investigations show that the relationship between length and age averages about as follows for larger haddock in different seas:

Age, years	Gulf of Maine	North Sea	Norway
	Length, inches	Length, inches	Length, inches
2	12	10	10.5
3	17.5	12	13
4	19	15	15.5
5	21	17.5	17.5
6	22.5	20	19.5
7	24	22	21.5
8	25	24.5	23

Thus, American haddock grow more rapidly on the whole than European haddock while they are young, but more slowly when older, so that haddock on both sides of the Atlantic appear to be of about the same size by the time they reach 7 or 8 years of age. Needler [38] has found too, that haddock also differ considerably in their rate of growth in different parts of the Gulf of Maine, St. Andrews fish growing faster than those of Browns Bank, with Nantucket Shoals fish intermediate in this respect, as is illustrated in the following table:

Age, years	Average length, inches			
	St. Andrews	Nantucket Shoals	Browns Bank	Eastern Nova Scotia
3¼	18½	18¼	16¾	16¼
4¼	20¼	20¼	18¼	19¼
5¼	22½	22	19¾	21
6¼	24	23½	20¾	22½
7¼	25½	25	21¾	24
8¼	26¾	25¾	22¾	25¼

According to Thompson [39] haddock on the Grand Banks grow more slowly than the Nova Scotian fish, averaging about 23 to 26 inches when 8 to 10 years old, while in the vicinity of Halifax Vladykov [40] gave about 12¼ inches as the length of 2+-year-old haddock and 13¼ inches for 3+-year-old, a rate of growth slower than for other parts of the western Atlantic and perhaps not typical for all years. But individual fish grow at such different rates (probably due to food supply) that a haddock of a given length may differ by 1 or 2 years in age, or even by 3 years in the case of the larger fish. Thus a Gulf of Maine haddock, 14 inches long, may be 2 to 2½ years old; one of 20 inches, 3 to 4 years; one of 28 inches, 8, 9, or 10 years old.

An illustration of this variability is that 6 out of 10 fish that were tagged by the vessels of the U. S. Bureau of Fisheries and were recaptured later had gained ¼- to ½-inch in 2 months though another had not grown at all in that period; one grew 2 inches in 9 months, but two others grew only ½- to ¾-inch in 11 months.[41] And Vladykov's

[38] Contrib. Canadian Biol. and Fish., N. Ser., vol. 4, No. 20, 1929, pp. 11-20, 275-284; N. Ser., vol. 6, No. 10, 1930, p. 54 [295], fig. 17, p. 55 [296].

[39] Research Bull. No. 6, Newfoundland Dept. Nat. Resources, 1939, p. 15, fig. 3 and table 3.

[40] Vladykov (Contrib. Canad. Biol., vol. 8 (29), 1934, p. 7) gave his lengths to the last vertebra, but we have converted these into total lengths to middle of caudal fin.

[41] Schroeder, Jour. Marine Res., vol. 5, No. 19, 1942, p. 16.

studies of the age-length relationship among young haddock of different sizes near Halifax, Nova Scotia, have shown, similarly, that their average rate of growth may differ considerably within short distances in Nova Scotia waters.[42]

The oldest haddock noted by Needler, one about 28¼ inches (72 cm.) long, taken off Ingonish, Nova Scotia, was in its 14th year. But the largest, about 30¾ inches (78 cm.) long, taken off Campobello Island at the mouth of the Bay of Fundy, was in its tenth year, only.

In general, Gulf of Maine haddock grow most rapidly in late summer and early autumn, when the temperature of the water is highest at the depths in which they live, but there is much variation in this respect from place to place and from year to year, as various authors have noted.

Shuck [43] describes the haddock of New England waters as maturing sexually at 3 or 4 years, when they weigh 2 or 3 pounds. And the smallest sexually active specimens found by Welsh among 1,300 haddock were 2 females of about 20 inches long each; i. e., about 4 years old. Most of the Nova Scotia haddock also spawn first in their fourth or fifth year, according to Needler, as some do in Icelandic waters, also. This supports Duff's [44] view that the slackening of the rate of growth at 4 or 5 years of age, which she observed, reflects the first ripening of the sexual organs. In the eastern Atlantic, mature haddock have been reported as small as 9 inches. And almost all the fish spawn there by the end of their third year.

General range.—Both sides of the North Atlantic. On the American coast haddock are the most abundant from the southern part of the Grand Bank and from the more easterly of the Nova Scotian Banks to Cape Cod. In winter they are taken southward to New York and New Jersey, and they have been recorded in deep water as far southward as the latitude of Cape Hatteras. But the species as a whole is so much more closely confined to waters east of Marthas Vineyard than is the cod, that in 1947, for example, only 158,992 pounds of haddock were caught off New York and New Jersey, contrasting with 2,962,559 pounds of cod for that part of the coast.[45] Neither does the range of the haddock extend as far north as that of the cod. Small catches are made in the southern side of the Gulf of St. Lawrence; also along its north shore both in the St. Lawrence estuary and nearing the Strait of Belle Isle, and a scattering are taken among the cod along the west coast of Newfoundland.[46] And while the experimental trawling campaigns of the Newfoundland Fishery Research Laboratory have shown that there is a distinct and extensive stock of haddock on the southern part of the Grand Banks region [47] very few are caught farther north along Newfoundland, though some fish have been reported from the Strait of Belle Isle, likewise from West Greenland.[48] And haddock are unknown in the icy waters along the outer coast of Labrador, where great quantities of cod are caught every summer.

Occurrence in the Gulf of Maine.—Haddock are very plentiful all around the open Gulf, as well as on all the offshore banks, especially on Georges where they greatly out-number the cod. This is, in fact, one of the two species that now rank at the top among Gulf of Maine fishes, from the commercial standpoint; the rosefish is the other (p. 430). Good haddock grounds, it is true, are less extensive close inshore and more scattered there than good cod grounds, haddock being confined for the most part to depths greater than 5 to 10 fathoms (p. 200), and being more selective in types of bottoms they frequent (p. 201). But the number of individual haddock that inhabit the coastal belt of the Gulf within 15 to 20 miles of the land may be as great as the number of individual cod, for while the yield of the inshore small boat fisheries has run only one-third to one-half as great in pounds for haddock as for cod, in Maine and Massachusetts, in years for which data are readily available,[49] and one-half to three-fourths as great for haddock as for cod in the Bay of Fundy,[50] this discrepancy may

[42] Contrib. Canadian Biol. Fish., N. Ser., vol. 8, No. 29, 1934, p. 415, fig. 2.

[43] Unpublished manuscript.

[44] Contr. Canadian Biol. (1914–1915) 1916, p. 39.

[45] This is exclusive of 4,110,508 pounds of haddock and 739,759 pounds of cod landed at New York City, most if not all of which were caught in waters to the east of Marthas Vineyard.

[46] For locations, see Needler, Contrib. Canadian Biol., N. Ser., vol. 6, No. 10, 1930, p. 5 [245], fig. 1.

[47] Thompson, Research Bull. No. 6, Dept. Nat. Resources Newfoundland, 1939, p. 7.

[48] Jensen and Hansen (Undersøgelser over den Grønlandske Torsk, p. 52, 1930).

[49] Between 14 and 15 million pounds of cod and about 5 million pounds of haddock in 1919; between 6 and 7 million pounds of cod and about 3 million pounds of haddock in 1924, these being the only two recent years when the yield of the small boat inshore fishery was listed separately in the published statistics of the catch.

[50] Bay of Fundy catch, about 7 million pounds of cod and about 5 million pounds of haddock in 1919; about 6 million pounds of cod and about 4 million pounds of haddock in 1946, years that seem to have been fairly representative. The inshore catches for western Nova Scotia are not separated from the offshore catches in the published statistics.

not be greater than can be accounted for by the considerably greater weights of individual cod than of individual haddock. And haddock certainly are far more numerous than cod on Georges Bank as a whole, especially on its western half.

Haddock, for example, large and small, made up 60 to 70 percent by number of all the fish caught on various parts of the bank, spring to autumn, by certain otter trawlers in 1913, cod less than 10 percent; similarly, in 1948, 1949, and 1950 haddock formed about 21 percent by number, cod less than 1 percent of the fish trawled there by the *Albatross III*.[51]

In 1945 (most recent year for which detailed statistics are available both for the New England fishery and for the Canadian), the landings were as follows, for different parts of the Gulf, to the nearest 100,000 pounds: western part of Browns Bank, 6,000,000; grounds along the Nova Scotian shore of the open Gulf, 1,000,000; Nova Scotian side of the Bay of Fundy, 3,400,000; New Brunswick side of the Bay of Fundy near the mouth, 1,100,000;[52] off eastern Maine, 200,000; off central Maine, 2,100,000; off western Maine, 900,000; off eastern Massachusetts, 5,400,000; small grounds in the inner central part of the Gulf, 400,000 to 500,000; northern part of the Gulf, not classified, 1,700,000; Cape Cod out to the so-called South Channel, 3,900,000; Nantucket Shoals, 2,200,000; Georges Bank as a whole, 53,200,000. If this proportional relationship is roughly representative, as seems likely on various grounds, the Georges Bank-South Channel area as a whole harbors perhaps two-thirds to three-fourths of the total haddock population of our Gulf, with an average yearly yield of about 94,000,000 pounds, for the period 1931–1948, equivalent to something like 37 million fish.[53] This indeed, is perhaps the greatest haddock ground for its size in the world, or has been in the past.[54]

According to the combined landings for the years 1942–1947, the northwestern[55]–northern parts of the Bank, and its central-southeastern part, are two to three times as productive each, as is the southwestern part, which agrees with fishermen's reports in general.[56] Browns Bank, much smaller in area than Georges, is perhaps equally densely populated.

The following table shows the percentages of the total catch of haddock taken on Georges Bank in each of the major statistical areas, in different years:

Year	Northwestern part	Northern edge	Central and southeastern part	Southwestern part
1942	19	39	36	6
1943	17	27	45	11
1944	20	37	35	9
1945	31	24	24	22
1946	26	35	29	11
1947	19	40	33	9
Average	22	34	34	11

Proceeding next to a more detailed survey of the inshore grounds we find that considerable numbers of haddock are caught on German Bank, and on the broken grounds off Lurcher Shoal. And while haddock are less plentiful than other ground fish on Grand Manan Bank at the mouth of the Bay of Fundy, perhaps because of the type of bottom, yearly landings of something like 3 million pounds along Digby Neck, Nova Scotia,[57] reflect a rich center of population at the mouth of the Bay of Fundy on the Nova Scotia side.[58] Haddock, like cod, diminish in numbers inward into the Bay, so much so that the counties at its head (Hants, Colchester, Cumberland, Westmoreland) report a few hundred pounds, at most, in some years, none at all in others. But they are plentiful enough on the New Brunswick side of the Bay near its mouth and within Passamaquoddy Bay to yield yearly catches about one-third as great as on the Nova Scotia side.

The most productive of the small grounds in the western side of the Gulf[59] are Cashes Ledge,

[51] Information contributed by Clyde C. Taylor of the U. S. Fish and Wildlife Service.

[52] Few haddock are landed near the head of the bay on the Nova Scotian side; none there on the New Brunswick side.

[53] Estimate by Howard W. Schuck, from Fish. Bull. 66, 1951.

[54] Herrington (Fishery Circular No. 23, U. S. Bur. Fish., 1936) so classed it.

[55] During recent years this part of the Bank has been classified as "eastern side South Channel" in the catch statistics published by the U. S. Fish and Wildlife Service.

[56] Needler's chart of haddock catches, 1917–1925 (Contrib. Canadian Biol., N. Ser., vol. 6, No. 10, 1930, p. 5 [245], fig. 1) would suggest that haddock were concentrated on the western edge of the Bank chiefly and on the neighboring parts of Nantucket Shoals. But it is probable, as he points out, that "an exaggerated impression is given of the abundance on the grounds nearest Boston, which is the most important market center."

[57] Classified in Canadian Fisheries statistics as "Digby County, from Sissiboo River to Annapolis County line."

[58] This appears clearly on Needler's (Contrib. Canadian Biol., N. Ser., vol. 6, No. 10, 1930, p. 5, fig. 1) chart of the distribution of the haddock catch, 1917–1925.

[59] Rich (Rept. U. S. Fish Comm. (1929) 1930, App. 3, pp. 51–117) gives a detailed account of the fishing grounds of the Gulf of Maine. In table 2, pp. 85–86, and table 3, p. 96, he lists 130 grounds in the inner parts of the Gulf where haddock are taken regularly.

Jeffreys Ledge north of Cape Ann, Stellwagen Bank at the mouth of Massachusetts Bay, and the several areas of "haddock bottom" off Chatham, Cape Cod. Small isolated rocky banks, such as Cashes and Platts, usually yield fewer haddock than cod, but in recent years of intensive fishing, haddock have been taken in numbers even on these so-called "cod grounds," as appears from the following table (landings to the nearest 1,000 pounds):

Locality	1919	1929	1934	1935
Platts Bank	68,000	193,000	75,000	18,000
Fippenies Bank	34,000	83,000	85,000	26,000
Cashes Ledge	[1] 320	494,000	423,000	384,000
Jeffreys Ledge	1,094,000	1,705,000	226,000	27,000
Stellwagen Bank	736,000	790,000	682,000	236,000
Off Chatham	1,373,000	1,044,000	678,000	339,000

[1] The reported landings from Cashes Ledge for 1919 were so small as to suggest some error.

Spawning grounds.—One part or another of Georges Bank appears to be the most productive spawning ground for haddock off the American coast, one of the most productive anywhere, for that matter. And Walford's detailed studies [60] have shown that haddock may spawn anywhere on the Bank eastward from Nantucket Shoals, except on Georges Shoals where the water is not deep enough. In most years there is a definite spawning center on the northeastern part of the bank, just east of Georges Shoals; Walford found this to be the case in 1931 and in 1932, corroborating our experiences on the *Albatross I* in 1920, when we found haddock eggs in great abundance [61] over an area there of at least 1,600 square miles. In 1932, there was a second spawning center in the so-called South Channel, where there seems to have been little spawning the year before. That Browns Bank, also, is a productive spawning center is proved both by Walford's studies, and by the fact that a fair proportion of the many gadoid eggs we towed there on the *Albatross I* in April 1920 were far enough advanced in development to show a haddock parentage.

Our own egg records, added to reports from the hatcheries and from local fishermen, show that haddock also spawn here and there, along the coastal belt from the entrance to the Bay of Fundy to Cape Cod, though in much smaller numbers than on Georges and Browns.

[60] Bull. U. S. Bur. Fish., vol. 49, Bull. 29, 1938, pp. 3-12.

[61] Captures of ripe fish, male and female, in the trawl established the identity of these eggs as haddock, not cod.

The more productive of the inshore spawning grounds which are neither as sharply circumscribed as those of the cod, nor as regularly occupied, are along the outer (eastern) and northern slopes of Stellwagen Bank, whence many eggs have been obtained for the Gloucester hatchery; the coastal belt between Cape Ann and Cape Elizabeth, especially off Ipswich Bay; the vicinity of the Isles of Shoals; about Boon Island; and off Wood Island, Maine.

Breeding haddock are plentiful east of Cape Elizabeth in some years and scarce or altogether absent there in other years, or for terms of years. Thus, Captain Hahn, former superintendent of the Boothbay hatchery, has informed us that spawning haddock came into Boothbay Harbor in abundance and into Linekin Bay in April and May of 1912, while gill-netters made large catches in the general vicinity, but that spawning haddock did not approach this part of the coast at any time during the next 12 years in numbers large enough either to support any extensive fishery there, or to provide the hatchery with more than a few eggs.

Spawning haddock have also been reported to us from the neighborhood of Mount Desert Island and off Cutler, Maine, while we found a few cod-haddock eggs near Petit Manan Island on April 12, 1920.[62] But there is no reason to suppose that any considerable body of haddock spawn along the Maine coast east of Mount Desert, nor on the northern side of the Bay of Fundy, where neither eggs, larvae, nor young fry have ever been seen. However, our capture of a few haddock eggs [63] and others in the younger "cod-haddock" stage (p. 203) in Petit Passage on June 10, 1915, proves that some spawn on the Nova Scotian side of the bay near its entrance; a few do so on the coastal banks along the western shores of Nova Scotia southward to Cape Sable according to general report, and we have taken a few cod or haddock eggs on German Bank in our tow nets in May.

Turning, now, southward and westward, we learn that gill-netters sometimes get good fares of ripe fish off Boston Harbor, though no great body spawns in the inner part of Massachusetts Bay, and few if any on the cod-spawning grounds off

[62] In a previous report (Bulletin, Museum of Comparative Zoology at Harvard College, vol. 59, 1917, p. 258) we recorded eggs taken along this part of the coast in June as "cod-haddock", but fresh examination of the material shows that they might equally have belonged to the witch flounder, none being sufficiently advanced in incubation to show the pigment.

[63] Far enough advanced to show the pigment in its distinctive arrangement.

Plymouth (p. 192). Some ripe haddock are caught on the shelving-sandy bottom along Cape Cod as far south as Nauset; spawning fish, too, are caught off southern New England every winter. Nearly 800 baby haddock less than 1 year old were taken off Fire Island Inlet, Long Island, and 10 miles off Ambrose Lightship, in November 1948.[64] But their presence there does not necessarily mean that they were spawned so far west, as Dr. Howard A. Shuck of the Fish and Wildlife Service has pointed out to us. Haddock may at times deposit their eggs within a couple of fathoms of the surface in our Gulf, as, for instance, in Boothbay Harbor on the occasion just noted (p. 206). But this is most unusual, 15 to 20 fathoms being the upper limit to regular spawning with the depths of the more productive Gulf of Maine spawning grounds as follows: Browns Bank, 30 to 50 fathoms and probably deeper; Georges Bank, from about 30 fathoms; Cape Cod grounds, about 40 to 70 fathoms; Stellwagen ground, 20 to 40 fathoms; grounds between Cape Ann and Cape Elizabeth, 20 to 65 fathoms.

The presence of newly spawned eggs out to the 100-fathom contour on the southeastern slope of Georges Bank at the height of the breeding season (late March 1931)[65] is evidence that the fish were spawning down nearly or to that depth. But about 100 fathoms appears to be the lower limit to any regular spawning. When eggs are found over greater depths they have drifted from shallower regions, as Walford has emphasized. The few eggs, for example, that we found over the deep basin of the Gulf, and in the Eastern Channel, in April 1920, were flotsam from the neighboring slopes or banks.

The haddock spawn rather shoaler in the Gulf of Maine on the whole than they do in the North Sea region, where the maximum production of eggs takes place at 50 to 100 fathoms. Consequently, there is less difference in this respect between haddock and cod in the western North Atlantic than in the eastern. Neither do haddock confine their spawning so definitely to smooth bottom in American seas as they do in European waters. Welsh found ripe fish chiefly on broken ground "wherever sand, gravel, mud and rocks alternate—if anything, more are taken on the mud in such localities," between Cape Ann and Cape Elizabeth.

The Gulf of Maine haddock spawn chiefly from late February until May and the following record, supplied by C. G. Corliss, former superintendent of the local hatchery, illustrates how brief the peak period of reproduction is near Cape Ann:

Year	First eggs taken	Last eggs taken	Period of greatest abundance	Total eggs collected
1917	Apr. 16	May 3		10,820,000
1918	Mar. 22	Apr. 24	Apr. 9 to Apr. 23	32,380,000
1919	Feb. 12	Apr. 30	Feb. 20 to Apr. 23	332,740,000
1920	Jan. 20	Apr. 29	Mar. 25 to Apr. 25	303,380,000
1921	Jan. 22	Apr. 25	Jan. 27 to Apr. 14	629,130,000

It appears from the hatchery records, corroborated by Welsh's experience in 1913, that the commencement of spawning varies considerably in date from year to year, with the fish breeding freely as early as the end of January in early seasons, but not until the end of March or even until the first part of April in late. But most of them are spawned out invariably by the middle or end of May at the latest.

In normal years the spawning season is about the same on Georges Bank as it is near Cape Ann. In 1920, for example, we found cod-haddock eggs in moderate numbers across its western end late in February; great numbers of them (and took ripe haddock in the trawl) on the eastern end of the Bank on March 11 and 12; and they were still plentiful there on April 16 and 17, but we found none on the western part of the bank on May 17. Similarly, Douthart, of the Bureau of Fisheries, towed haddock eggs over the north-central portion of the bank on April 14 and again on the 26 and 27th in 1913, while Walford found that spawning commenced in February, was at its peak in March and April, and had about come to an end by late May in 1931. Spawning is likewise at its height in mid-April on Browns Bank (large egg catches were observed in our tow-nets April 16, 1920).

Occasional haddock, however, may spawn long after the majority are spawned out. Thus we have towed eggs off Petit Passage, Nova Scotia, on June 10, and have caught a ripe female and a ripe male on Nantucket shoals on June 13 (in 1927). Ripe haddock have even been taken as late as the first part of July near Gloucester,[66] but this is exceptional.

The spawning season continues well into the summer in the colder water along the outer shores

[64] As reported by Arnold, Copeia, 1949, p. 239.

[65] Walford, Bull. U. S. Bur. Fish., vol. 49, Bull. 29, 1938, p. 16, fig. 7.

[66] Earll, Rept. U. S. Comm. Fish., (1878) 1880, p. 730.

of Nova Scotia and south of Newfoundland. Thus we took several unmistakable haddock eggs among numerous newly spawned cod or haddock eggs a few miles off Shelburne on June 23, 1915, while Dannevig [67] records occasional haddock larvae off Halifax on July 23; near Sable Island on July 25 and 26; and on St. Pierre Bank off Newfoundland on July 27 and 28 for that same summer.

The breeding season is about the same in European as in American seas, that is, end of January until June, with the peak of production falling as early as March and April in the North Sea region but not until June around Iceland.[68]

The Georges and Browns Bank haddock spawn in temperatures ranging from about 36.5° to about 42°–43° F., and spawning is likewise completed on the coastwise grounds between Cape Cod and Cape Elizabeth before the stratum of water in which the fish are living has warmed more than a few degrees from its coldest for the year; i. e., in temperatures of about 35° to 40°–42°. Allowing for annual variations, this gives an extreme range of from about 35° to about 44° F. for the most active spawning over the Gulf of Maine as a whole, temperatures averaging considerably lower than those in which haddock spawn the most freely in European waters (41° to 50°).

The Gulf of Maine haddock likewise spawn in less saline water than does its European congener; and necessarily so, for the more important Gulf of Maine spawning grounds are considerably less saline at all depths and seasons (about 31.5 to 33.5 per mille, mostly).

The specific gravity of the water at the temperature *in situ* (the factor that determines whether buoyant fish eggs float suspended, and develop, or sink to the bottom and die) is usually between 1.0255 and 1.0270 in our Gulf in spawning season, at the depths where the fish spawn, both along shore and on the offshore Banks. Experiments by us and by Walford have shown that these values are high enough for the flotation of the eggs. And while the water at the surface often is so light, near shore, as to interfere with the operation of the hatcheries, this layer of low specific gravity is so thin there is no reason to suppose that any of the haddock eggs produced in the Gulf fail to rise from the bottom.[69]

Populations and migrations within the Gulf of Maine.—Needler's [70] analysis of the results of tagging experiments, and of the differences in rate of growth between fish caught in different regions, and Vladykov's [71] studies of the number of vertebrae, confirmed by comparison between the growth rates of the haddock of Georges Bank and of Browns Bank by Schuck and Arnold,[72] have shown that the haddock of North American waters include three more or less self-contained populations; one (Needler's "New England population") inhabiting the Georges Bank–Nantucket shoals region and the inner waters of our Gulf from Cape Cod around to the New Brunswick shore of the Bay of Fundy; a second (Needler's "Nova Scotian") in the Nova Scotian side of the Bay of Fundy, and around Nova Scotia (including Browns Bank) to the Laurentian Channel; and a third in Newfoundland waters.

The geographic ranges of the New England and Nova Scotian populations are separated by the deep so-called "Eastern Channel" between Georges Bank and Browns, which extends inward as the "Fundian Channel" more than 100 fathoms deep, to the mouth of the Bay of Fundy. And it is probable that the depth is an actual barrier in this case, there being no evidence that haddock normally cross channels that are deeper than about 100 fathoms (at least in American waters), once they have taken to the bottom. Only within the Bay of Fundy, where there is no intervening water as deep as 100 fathoms, have tagging experiments given any evidence of a mixture between these two adult populations.[73] And the still greater depth of the Laurentian Channel probably makes it an even more effective barrier between the Nova Scotian and the Newfoundland populations.

The movements of individual fish within each of these populations fall in three groups: (a) those of the eggs and larvae while they are still adrift in the intermediate and upper water layers; (b) those of the young fry from the time they take

[67] Canadian Fish. Exped. (1914–15) 1919, p. 21.

[68] Damas, Rapp. et Proc.-Verb. Cons. Internat. Explor. Mer, vol. 10, 1909; Schmidt, *ibid.*

[69] For a discussion of the relationship between flotation of haddock eggs and the specific gravity of the water, with references to European studies, see Walford, Bull. U. S. Bureau of Fisheries, vol. 49, Bull. 29, 1938, pp. 13–15.

[70] Contrib. Canadian Biol. and Fish., N. Ser., vol. 6, No. 10, 1930.

[71] Progress Rept. Atlantic Biol. Sta. Biol. Board, Canada, No. 14, 1935.

[72] Fish. Bull. No. 67, U. S. Fish and Wildlife Service, 1951.

[73] One fish that was tagged by us near Mount Desert Island was recaptured in the Nova Scotian side of the Bay of Fundy off Digby.

to bottom until they are large enough to figure in the commercial catches, and (c) those of the larger fish.

It may be assumed that the pelagic life of the haddock lasts about as long in American waters as in European; i. e., for three months or so (we have no first-hand information) before the fry seek the bottom. Meantime the eggs and larvae, like those of many other fishes may drift for considerable distances from where they were spawned. And these involuntary drifts may be greatly extended by a habit that the very young haddock have (like those of other gadoids) of living under the bells of the larger kinds of jellyfishes. Welsh, for instance found many small haddock of 2¼ to 3 inches (60 to 77 mm.) in company with the common red jellyfish (*Cyanea*) on Georges Bank and off Nantucket Island, in late July of 1916, while Willey and Huntsman[74] found young haddock about 2 inches long under *Cyanea* in the Bay of Fundy. In fact, it is in company with *Cyanea* that young haddock in the late larval stage have been taken most often in the other side of the Atlantic.

Our few records for the pelagic larvae in the inner parts of the Gulf all have been in the southwestern part. Thus the coastal zone east of Cape Elizabeth, and the whole deep basin of the Gulf, seems to be as barren of larval haddock (so far as our catches go) as of larval cod, of larval silver hake, of larval flatfishes, and, in fact, of most other larval fishes except rosefish (p. 433) and herring. It appears from Walford's studies that in normal years, as represented by 1931, the haddock population of Georges Bank is recruited by a good supply of larvae hatched from eggs that have been spawned on the bank itself. But a large proportion of the Georges Bank eggs and larvae drift off the bank in other years, as in 1932, either to the westward and southward past Nantucket Shoals, where their mortality is too great for them to support a population of any importance, or southward out over the continental slope, to even more certain destruction,[75] with results disastrous to the ensuing brood of young fry (p. 212).

It is during their pelagic stage (whether drifting independently or with Medusae) that intermingling is the most likely to take place in significant amount between the New England and the Nova Scotian populations of haddock. All that is known in this respect is that Georges Bank seems not to have received any important recruitment from elsewhere, either in 1931 or in 1932.

In any case, hosts of young fry settle on the bottom on the offshore banks generally. Thus we have repeatedly found 10 or more little haddock 3 or 4 inches long, in the stomachs of pollock caught on Georges, while we have trawled numbers of equally small ones there as well as on the other offshore grounds. And 1- to 2-year-old fish, 6 to 12 inches long (too small to market) sometimes make up as much as 35 to 40 percent of the total catch of haddock on Georges as well as in the South Channel, while many more of them doubtless escape through the meshes of the trawls. On the other hand, very young haddock are seldom seen inshore for they are too small to be caught either on long lines or in gill nets. But it is probable that they are plentiful there, also, for yearlings are reported in the Bay of Fundy, by Huntsman.

Nothing is known about the movements of the young haddock during the first year or two after they take to the bottom. But our fishermen have long realized that the larger haddock, like the larger cod, are so constantly on the move in search of food that the fishing may be poor tomorrow where it was good today, or vice versa. And analysis of the catches that we made on Nantucket Shoals during the tagging campaigns of the U. S. Bureau of Fisheries, 1923–1931, shows that considerable changes took place in the abundance of fish within periods of a few days or weeks at the spots fished, also with occasional brief periods of unusual abundance that are most reasonably interpreted as reflecting the passage of large bodies of fish from elsewhere.[76]

The extensive tagging experiments that we have made within the Gulf of Maine on vessels of the U. S. Bureau of Fisheries,[77] and that have been made in Nova Scotian waters[78] by the Biological Board of Canada have now proved

[74] Canadian Field Natural, vol. 35, 1921, p. 2.

[75] For further details we refer the reader to Walford's very interesting study (Bull. U. S. Bur. Fish., vol. 49, Bull. No. 29, 1938).

[76] For details, see Schroeder, Jour. Marine Research, vol. 5, No. 1, 1942, p. 9, table 2.

[77] Schroeder, Jour. Marine Research, vol. 5, No. 1, 1942.

[78] Needler, Contrib. Canadian Biol. and Fish., vol. 6, No. 10, 1930.

(as was previously suspected) that most of the wanderings of the Gulf of Maine haddock are of short extent. Thus 34 fish that had been tagged on Nantucket Shoals were recaptured nearby, 16 after periods longer than 200 days; only 10 were captured at a distance. And the preponderance of relatively stationary fish is even more impressive for the vicinity of Mount Desert Island, where 114 tagged fish were recaptured within a few miles of the tagging stations after an average period of 224 days, contrasting with recaptures of only 25 of them at a distance.

The haddock of the coasts of Massachusetts and of western Maine, with the offlying banks, may be less stationary, for only two of the fish that were tagged on Stellwagen Bank and between Boone Island and Boothbay were recaptured locally; 13 of them far afield.

The tagging experiments do not suggest that such of the Gulf of Maine haddock as do wander follow any regular migratory routes. Thus some of the few Nantucket Shoals fish that are known to have strayed were recaptured to the eastward (eastern part of Georges Bank, 2); some of them to the northward (western side of Gulf and Platts Bank, 6); and some to the northeastward (northern entrance to Bay of Fundy, 2). Conversely, it was in the opposite direction, i. e., to Platts Bank, to the coasts of western Maine and of Massachusetts, to the South Channel, and to Georges Bank that wanderers are known to have strayed from the Mount Desert tagging ground. And the few fish that were recaught from those tagged at localities intermediate between Nantucket Shoals and Mount Desert, have fanned out in various directions.

An obvious reason why haddock of the New England population, that commence their adult journeyings in the northeastern part of the Gulf, should tend to stray southwestward, southward, and perhaps then eastward along Georges Bank, whereas others, commencing in the southwest should tend either eastward, or northward and then northeastward, is that these are the only routes left wide open to them within the Gulf, between the coastline on the one side and the barrier that is set for them by the 100-fathom depth line on the other side. How effective is this barrier is emphasized by the fact that only one fish, among 9,416 that we tagged off the coasts of Massachusetts and of Maine was recaptured in Nova Scotian waters (it had gone from Mount Desert to the southern side of the Bay of Fundy); and that none of the haddock that were tagged in Nova Scotian waters by the Biological Board were recaptured west of the Fundian Channel.

Very little is known as to the shifts in location and in depth that haddock may make between winter and summer, the difficulty lying in the interpretation of the differences from season to season in the amounts of haddock that are caught on neighboring grounds in the inner parts of the Gulf.[79]

In general, it appears that when the temperature of the upper 15–20 fathoms of water rises above about 50° to 52° F., as happens along the coasts of Maine and Massachusetts in July or August, the haddock tend to withdraw from the shallower grounds where they are plentiful in spring and early summer. But certain bodies of fish may linger all summer in the deeper channels among the islands of Maine, on patches of suitable bottom. In 1923, for instance, haddock were caught throughout July, August, and September, between Suttons Island and Bear Island, near Mount Desert Island, as well as at other inshore localities near by. Fishermen report them as working inshore again in autumn or early winter, as the water cools, but those that come closest inshore then are supposed to work out again, in mid and late winter, to avoid extreme chilling. Thus few or none are caught at that season in the Bay of Fundy, where the temperature may fall as low as 32° in occasional winters,[80] though it does not drop below 34° to 36° in most years.

We must caution the reader, however, that these supposed disappearances in winter from inshore localities are based on failure to catch haddock then on hook and line, which may actually result more from a reluctance on their part to bite at low temperatures (p. 202) than from seasonal scarcity of fish. Experimental trawlings at different seasons are needed to clarify this matter. At any rate, the temperatures of the open Gulf of Maine at the depths where haddock are the most plentiful never fall too low for their comfort in the winter, nor rise too high in the summer.

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[79] Rich (Rept. U. S. Fish Comm. for 1929, 1930, App. 3) gives information in this respect.

[80] As happened in 1926 (Needler, Contrib. Canadian Biol. and Fish., N Ser., vol. 6, No. 10, 1930, p. 19 [259]).

Accordingly, haddock are caught on all the major grounds the year around.

Except for shifts in depth, apparently associated with temperature, the haddock as a whole are year-round residents as far east as the offing of southeastern Nova Scotia (Roseway, La Have, and Sambro Banks); many of them as far east as Halifax and Sable Island Bank. But they appear only as late spring to early winter visitors farther to the east and north where they are wholly absent (as indicated by the catches) in late winter and early spring. Large catches, for example, are made in traps near Ingonish on the northeastern coast of Cape Breton Island in late May and in June. The first haddock are caught within the Gulf of St. Lawrence in June, whether on the Cape Breton shore, or westward, the largest catches are made there from July through the late autumn, and very few are taken as late as December. But catches are made again near Ingonish in December and January, of haddock, seemingly en route out of the Gulf of St. Lawrence. And it now seems established that these visitors to the Gulf of St. Lawrence pass the late winter and early spring on Sable Island Bank and farther to the westward in Nova Scotian waters.[81]

Part of the haddock in the southern part of the Grand Banks region, which form a distinct population separated from that of Nova Scotia by the deep Laurentian Channel, are described by Thompson [82] as making a summer inshore migration to the southwest coast of Newfoundland, and as clearly avoiding regions where the bottom water is colder than about 34° F.

Abundance.—The haddock and the rosefish rank next after herring in numbers, among the fishes of our Gulf that are important commercially. In good years it has not been unusual for a trawler to take 10,000 to 20,000 haddock in 5 or 6 days' fishing on the Georges Bank and South Channel grounds; a catch of 240,000 pounds of haddock (something like 70,000 fish) brought in by the trawler *Fabia* in March 1926 is one of the largest of which we have chanced to hear. One must remember, too, that this represents only the fish that are large enough to be worth saving, and that multitudes of baby haddock too small to be marketable, caught on Georges, are thrown back dying or dead; in 1947, for example, the number so wasted was estimated at almost 17 million on Georges Bank alone.[83] Howard W. Schuck informs us that the average weight of the haddock landed from Georges Bank during 1928 was about 3¼ pounds.

Fishermen have long been aware that the haddock vary widely in abundance from year to year and over periods of years, on one ground or another, independent of any effects the fishery may have had on the numbers of fish. It has been amply proved by investigations both in Europe and in North America, that these fluctuations result chiefly from differences, from year to year, in the number of young that survive and take to the bottom on the grounds in question; the Gulf of Maine is no exception. The production, for example, of young haddock at the mouth of the Bay of Fundy, on the New Brunswick side was low from 1915 to 1919, very much higher in 1920, but somewhat lower again in 1921–1923 though somewhat better than it had been in the 5 years preceding 1920.[84] But a larger number of haddock (by report) were produced near Digby, on the Nova Scotian side of the Bay in 1921 than had been in 1920.[85]

Similarly, two exceptionally successful year classes that were spawned in the Georges Bank–South Channel region during the period 1921–1924 were followed by poor year classes from 1925–1928, but then by an abundant class that was spawned in 1929.[86] Since then Georges Bank has been abundantly recruited with haddock fry in 1936, 1937, 1939, 1940, and 1945.[87] On the other hand, the crop, so to speak, was unusually scanty on the Bank in 1930, 1931, 1932, 1942, and 1947.

Perhaps a good crop comes a little more often for the Nova Scotia population, and every 3 years or so in the North Sea, "where the fry have a much better chance of being retained in the area owing to the prevailing currents." [88]

[81] For further discussion, see A. W. H. Needler, Contrib. Canadian Biol. and Fish., vol. 6, No. 10, 1930, and A. B. Needler, Bull. 25, Biol. Bd. Canada, 1931.

[82] Research Bull. No. 6, Newfoundland Dept. Nat. Resources, 1939, p. 7.

[83] Schuck, Commercial Fish. Review, vol. 10, No. 10, October 1948, p. 5.

[84] Huntsman and Needler, Contrib. Canadian Biol. and Fish., N. Ser., vol. 3, No. 18, 1927, see summary on p. 14 [436].

[85] Needler, Contrib. Canadian Biol. and Fish., N. Ser., vol. 6, 1930, No. 10, p. 44 [284].

[86] The data for 1921-1929 are summarized in the Proc. No. 2, for 1931-1933, N. Am. Council on Fishery Investigation, Ottawa, 1935, p. 18.

[87] From data supplied by Howard A. Schuck of the U. S. Fish and Wildlife Service.

[88] Thompson, Res. Bull. No. 6, Newfoundland Dept. Nat. Resources, 1939, p. 22.

Analyses from year to year of the relative proportions of fish of different ages in the catch [89] show, too, that our offshore banks may receive as much as 30 times as many fry in a good year as in the average for a run of years, and as much as 60 times as many as in the poorest years.

One essential for a good year class of haddock, perhaps the chief essential, is that large numbers of larvae shall not only be hatched and survive until old enough to take to bottom, but shall remain in the area in general, to take to bottom there, as happened in 1931, and not drift elsewhere. Conversely, a poor brood automatically ensues if the circulation of the water is such that a large proportion of the larvae drifts away, as happened in 1932, when so many of them drifted off Georges Bank altogether, to be lost permanently to the local population, that the success of that year class was seriously affected.[90] Herrington has also suggested that in years when large fish are the most plentiful the resulting competition for the supply of available food makes conditions difficult for the survival and growth of the young fry. Evidence is that the "largest spawning stocks have almost invariably yielded the leanest year classes 3 years later, and the poorer spawning stocks have done much better." [91] No doubt a combination of various other factors helps to determine whether any particular year class shall be plentiful or the reverse. But the relative importance of these factors has not yet been evaluated for our haddock.

The incidence of a good brood in any particular year, or the reverse, shows up in the commercial catch 2 years later; i. e., when the young fish first reach market size in significant numbers. And it is now well established, for both sides of the Atlantic,[92] that the differences in the numbers of fry reared in different years are the chief cause for the short term fluctuations in the catches that are so characteristic of the haddock fishery.

Our reason for emphasizing the qualification "short term" in this connection is that the situation is complicated by the unhappy fact that the haddock populations of Georges and Browns Banks have been seriously reduced by the fishery.

Commercial importance and effects of the fishery.—The haddock was once much less in favor than the cod. But the expansion of the fresh-fish trade[93] brought an increasing acceptance of haddock on the market because of their good keeping qualities and convenient size for the table. In 1919 the Gulf of Maine, inshore and offshore combined, yielded something like 85 million pounds of haddock to United States and Canadian fishermen. And the development of the filleting and packaging of fresh and frozen haddock soon brought so great an increase, both in the demand and in the intensity of the fishery, that some 206 million pounds were caught in 1929 from the New England population, with some 17 million pounds more from the Nova Scotian population on Browns Bank, off western Nova Scotia, and in the Nova Scotian side of the Bay of Fundy, making a total of at least 223–224 million pounds from the Gulf of Maine as a whole, corresponding to perhaps 60 to 70 million individual fish.

This, however, was the high point, for trawlers working on Georges during the five years, 1930–1934, "averaged scarcely one-third as much haddock per day as during the previous five years," [94] while the Gulf of Maine catch as a whole had fallen by 1934 and 1935 to only about one-quarter of what it had been in 1929.[95]

Since then, down to 1947 (most recent market year for which we have seen the returns), the yearly yield of market-size haddock from the New England population has varied between about one-third to one-half as great, and about two-thirds as great as it was in 1929, to judge from the landings in the major New England ports, which form at least 90 percent of the total take from this population.[96]

A recent estimate is that there were only about one third as many haddock on Georges Bank in

[89] From unpublished data for Georges Bank and the South Channel area supplied by Howard A. Schuck.

[90] For details, see Walford's (Bull. U. S. Bur. Fish., vol. 49, Bull. 29, 1938) very interesting study of the drift of the Georges Bank eggs and larvae in these two years.

[91] Trans. 9th North American Wildlife Conference, 1944, p. 260.

[92] See especially Thompson's studies for Iceland (Fisheries Scotland, Sci. Invest. [1928], No. 5, 1929), and Raitt's for the North Sea (Journal du Conseil, Cons. Internat. Explor. Mer, vol. 11, No. 2, 1936, p. 211).

[93] Fish that are iced at sea, not salted.

[94] Herrington, Fishery Circular No. 23, U. S. Bur. Fish., 1936, p. 9.

[95] About 78 million to 80 million pounds in 1934, judging from the landings at Portland, Boston, and Gloucester from within the Gulf (which usually run about ¾-⅘ of the total catch in the Gulf by United States and Canadian vessels combined) plus perhaps 4 million to 5 million pounds taken by Canadian fishermen off western Nova Scotia and in the Bay of Fundy.

[96] For tabulations of the total catches of haddock in the western Atlantic by Canadian and United States vessels, 1880–1927, see Needler, Contrib. No. 2, North American Council on Fish. Investigations, Ottawa, 1929, 13 pp., also Rept. U. S. Comm. Fish. (1930) 1930, App. 2, pp. 27–40.

1931 as there had been there a year or two earlier.[97] This conclusion is based on the assumption that yearly changes in the average yearly catches, per day's fishing of a standard group of the large otter trawlers, fishing consistently for haddock, over the period in question, have been proportional to the relative changes in the number of haddock on the banks. In 1939–1947 the catch statistics suggest that the total population on the banks had, on the average, increased somewhat from the relatively small population of 1931.[98]

Landings of haddock

Year	Landings by United States vessels in the major New England ports, to nearest 100,000 pounds		Canadian landings to nearest 100,000 pounds	Total Gulf of Maine
	Georges Bank, Nantucket shoals, and inner parts of Gulf of Maine	Browns Bank and off western Nova Scotia	Western Nova Scotia and southern side of Bay of Fundy	
1929	174,700,000	8,200,000	11,500,000	194,400,000
1934	45,300,000	14,800,000	6,500,000	66,600,000
1935	66,200,000	18,000,000	5,500,000	89,700,000
1936	78,500,000	13,600,000	5,100,000	97,200,000
1937	87,500,000	14,900,000	4,700,000	107,100,000
1938	83,200,000	22,500,000	8,200,000	113,900,000
1939	95,600,000	11,300,000	7,200,000	114,100,000
1940	88,800,000	8,200,000	7,100,000	104,100,000
1941	116,400,000	6,100,000	5,600,000	128,100,000
1942	101,400,000	5,100,000	5,900,000	112,400,000
1943	89,700,000	2,800,000	4,600,000	97,100,000
1944	86,800,000	4,400,000	5,200,000	96,400,000
1945	72,500,000	6,000,000	5,400,000	83,900,000
1946	99,300,000	5,200,000	5,200,000	109,700,000
1947	107,400,000	4,900,000	----------	----------

The yield from Browns Bank and the Nova Scotian side of the Gulf has also been significantly smaller since 1939 than it was during the few years previous, when American vessels began to fish Browns Bank more intensively than they had previously.

The persistence of poorer catches through so long a term of years in the face of sustained demand, added to continued improvement in the gear and in the general efficiency of the fishing fleet, is only too clear evidence of overfishing.

The decrease in the yield of haddock from within the Gulf of Maine has been partially offset by increased catches from the Banks along outer Nova Scotia eastward to Banquereau Bank. The landings, for example, were about 8 times as great, from east of Cape Sable in 1947 (about 26,400,000 pounds) as had been the case back in 1929 (about 3,300,000 pounds). Further discussion, however, of the fishery aspects of the matter would lead us too far from our main theme.

Previous to the general adoption of the otter trawl in American waters, haddock were caught mostly on hand lines or on long lines; some in gill nets, especially in spawning time inshore between Cape Ann and southern Maine. Today all but a very small part of the catch is made in otter trawls. In 1947, for example, nearly 97 percent of the haddock that were landed in Maine and Massachusetts had been taken in otter trawls; only 3 percent of them on long lines; and only a small fraction of 1 percent on hand lines and in gill nets.

While the haddock is of primary interest from the commercial standpoint, it deserves a word from the angler's viewpoint also, for it bites as freely as the cod does, on almost any bait, and, being a much more active fish, a haddock of fair size is likely to prove an astonishment to anybody who is lucky enough to hook one while fishing with a light sinker. A new-caught haddock is also a very beautiful object.

American pollock *Pollachius virens* (Linnaeus) 1758

POLLOCK; BOSTON BLUEFISH; COALFISH (IN GREAT BRITAIN); GREEN COD (IN GREAT BRITAIN)

Jordan and Evermann, 1896–1900, p. 2534.

Description.—The American pollock[99] has a deep, plump body (about four and one-fourth times as long as it is deep) tapering to a pointed nose and to a slender caudal peduncle. Its mouth is of moderate size. Its projecting lower jaw (giving it an undershot facial aspect); its forked, sharp-cornered tail, small ventral fins, small chin barbel (as a rule the latter is lacking altogether in large fish), and its beautiful olive green color, are ready field marks when it is caught with cod and haddock.

Its first dorsal fin (13 or 14 rays), originating slightly behind the pectoral, is triangular, and is a little the highest of the three dorsals. The second dorsal, also triangular, is the longest of the

[97] Herrington, Trans. 9th North American Wildlife Conf., 1944, p. 259. Schuck, Commercial Fish. Rev., vol. 10, Oct. 1948, p. 1.

[98] See Schuck (Biometrics, Amer. Statistical Assoc., vol. 5, No. 3, 1949, p. 215, table 1, and p. 216, fig. 2).

[99] This is the "coalfish, green cod, or saithe" of British, Scotch, and Irish fishermen. The European "pollack" is a different species (*Gadus pollachius*)

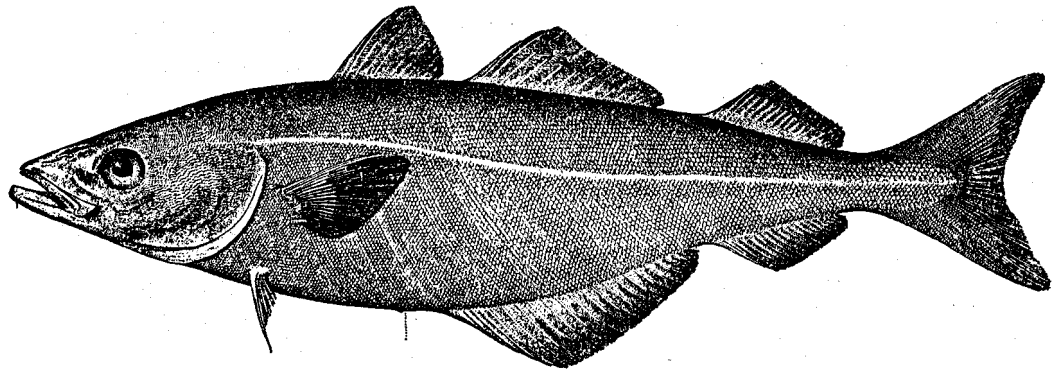

FIGURE 98.—American pollock (*Pollachius virens*), Eastport, Maine. From Goode. Drawing by H. L. Todd.

three (21 or 22 rays) and is separated by a considerable space from the third dorsal fin (19 or 20 rays) which is more rhomboid in outline. The second anal fin (20 or 21 rays) corresponds in shape and size to the third dorsal, under which it stands, but the first anal (24 to 28 rays) is considerably longer than the second dorsal though similar to the latter in shape. The ventral fins are a little in front of the pectorals, and are only about half as long as the latter. The pectorals are set high on the sides, and are longer than the first dorsal, but shorter than the second dorsal; they have rounded lower corners and bluntly pointed tips. The caudal fin is noticeably forked, with angular corners, unless it is spread to its widest when its margin becomes nearly straight.

Color.—Pollock are always of a greenish hue, usually deep rich olive green or brownish green above, paling to yellowish or to smoky gray on the sides below the lateral line, and to silvery gray on the belly. The lateral line is white or very pale gray, contrasting strongly with the dark sides. The dorsal, caudal, pectoral, and anal fins are olive, the latter pale at the base. The ventral fins are white with a reddish tinge. Young fish are darker than large ones, and many of them are more tinged with yellow on their sides.

Size.—Pollock reach a maximum length of about 3½ feet and a weight of about 35 pounds. But fish of this size are exceptional, few growing larger than 40 inches or 30 pounds, with about 2 to 3 feet and 4 to 15 pounds as the average for adults. The proportion of length to weight was as follows among fat fish measured by Welsh off Boon Island on April 22 to 25, 1913:

Length, in inches	Weight, in pounds	Length, in inches	Weight in pounds
24½	4–5½	30	8½–9½
26	4	31	10
27	7½	31½	10
27½	8½	32	10–12
28½	8	33	12
29	8–9	35	14
29½	8½–9		

Large pollock, however, of a given length vary widely in weight; for example, we have found 40-inch fish to weigh from 25 to 35 pounds; 35-inch fish, from 14 pounds to 21 pounds.

Habits.—The pollock is an active fish, living at any level between bottom and surface according to the food supply and on the season, often schooling, and sometimes gathering in bodies so large that it is on record that a purse seiner once took 60,000 fish from one school at a single set. In our Gulf their depth range is from the surface down to 100 fathoms at least,[1] while they may descend somewhat deeper in the deepest troughs. And it is the local presence or absence of prey that governs the movements of the larger pollock.

Pollock feed chiefly on small fish, and on pelagic crustaceans; among the latter most often on the large pelagic shrimp-like euphausiids. It is commonplace that pollock destroy great quantities of small herring, launce, young cod, young haddock, young hake, silver hake, and other small fish in the Gulf of Maine just as they do on the other side of the Atlantic. Pollock chasing schools of herring are a familiar sight;[2] pollock of 1 to 1½ pounds commonly run up estuaries in pursuit of smelt in autumn; and newly hatched haddock or other

[1] We have seen them trawled as deep as this on the northern slopes of Georges Bank.

[2] Sars (Rept. U. S. Comm. Fish., (1877) 1879, p. 619–620) has given a graphic account of pollock rounding up schools of launce and of young cod in Norwegian waters.

larvae that are liberated in harbors from the hatcheries are always in danger of being snapped up by the young pollock that are plentiful in such situations. When a pollock only 9 inches long is capable of eating 77 herring up to 2½ inches long at one meal,[3] "ravenous" is only mildly descriptive. However, pollock so seldom strand in pursuit of prey that we have never seen one on the beach though schools often come close in and are caught in the traps.

In the Gulf of Maine, pollock depend perhaps as much on pelagic shrimps as on fish. At Eastport, for example, where these shrimps (genera *Meganyctiphanes* and *Thysanoessa*) are very abundant all summer, Kendall [4] reports pollock of all sizes not only fattening on them but so evidently preferring them to young herring that he did not find a single "sardine" in a pollock stomach, though these were plentiful enough at the time. He adds that "if at any time the crustaceans disappeared from a place the large pollock disappeared also." And pollock, breaking the surface in pursuit of shrimp are familiar sights there, as we can bear witness with many others.

Similarly, Welsh found large pollock in schools feeding on the surface on shrimp (*Thysanoessa raschii*) off the Isles of Shoals and off Boon Island in April 1913, remarking in his field notes for the 25th that "in the last few days pollock have begun to appear in small schools of 400 to 500 fish with the appearance of large schools of feed (shrimp, 'all eyes'), the feed (shrimp) breaking water trying to get away from the pollock which are after them." He described the fish themselves as "rising and sinking at intervals; when at the surface swimming like porpoises, leaping up and over with open mouths, the feed being in dense streaks 6 inches to 1 foot down." These feeding fish were "very sluggish and tame on this feed and easily taken in the purse seines." All were "stuffed to capacity" with shrimps, and only a few contained herring.

Large pollock take morsels as small as copepods. Willey [5] for example, speaks of a fish caught near Campobello Island which contained proportionately as many of these as of euphausiid shrimps, and it is probable that the little pollock depend chiefly on copepods. Glass worms (*Sagitta*), too, have been found in pollock stomachs. Sometimes they consume considerable quantities of ctenophores; we found many pollock full of them on Cashes Ledge and on Platts Bank in August 1928; one had 105 of these watery organisms in its stomach. They also feed to a small extent on bottom-dwelling crustaceans on both sides of the Atlantic, thus crabs, and bottom-dwelling shrimp have been found in fish caught at Woods Hole and in the Gulf of Maine. They have also been reported as gorging themselves on herring spawn. They never take shelled mollusks, so far as we are aware. But they bite on clams as greedily as on fish baits. And fishermen speak of them as one of the few species that will bite, that is, feed, during the spawning period.

Experiments on fish kept in captivity at Woods Hole [6] have shown that the pollock captures its food more by its keen sight than by scent.

The pollock is a cool-water fish. We have never seen any large ones caught at the surface when the temperature there was higher than about 52° F., though there may be plenty of them a few fathoms deeper down where the water was cooler. Even the little "harbor pollock" of 8 inches or so do not appear in any great numbers at times or places where the water is warmer than perhaps 60° F. At the other extreme, pollock of all sizes from the 1 year-old fish upward must experience temperatures as low as 32° F. on the fishing grounds in the southern side of the Gulf of St. Lawrence, and on the more easterly of the Nova Scotian banks during the late winter or early spring, unless they descend then to considerably greater depths, a possible shift of which we have no direct evidence. But it is probable that the pollock's need of water as warm as about 38° F. for the incubation of its eggs (p. 216) and perhaps of temperatures a little higher than that for the maturation of its sex organs (p. 216) is the factor that sets the northern boundary to the maintenance of a permanent resident population (p. 218).

The pollock is a late autumn and early winter spawner, and the shortness of the spawning season (p. 220), with the fact that the vertical temperature gradient covers a range no greater than 3° to 5° F. down to 50 fathoms at that season, makes it easy to establish the physical conditions under which the eggs are produced

[3] Smitt, Scandinavian Fishes, vol. 1, 1892, p. 503.
[4] Rept. U. S. Comm. Fish., (1896) 1898, p. 180.
[5] Proc. Amer. Acad. Arts, Sci., vol. 56, 1921, p. 192.
[6] Herrick, Bull. U. S. Comm. Fish., vol. 22, 1904, p. 258.

and in which they develop. On the Massachusetts Bay grounds breeding commences when the whole column of water has cooled to about 47° to 49°, and is at its climax (late in December) in temperatures of 40° to 43°, while the major production of eggs takes place long before the water has cooled to its winter minimum of 35° to 36° F. at the level at which the fish lie. Thus the pollock spawns on a falling temperature, with most of the eggs produced within a comparatively narrow range and in water several degrees warmer than that in which haddock spawn most actively (p. 208). This agrees closely with the European pollock which spawns only in temperatures near 44.5°, so far as is known.

As the successful propagation of any fish depends as much upon the incubation of its eggs as on its spawning, we should note that incubation proceeds normally, and that the resultant larvae are strong and active over the whole range of temperature just outlined, that is, from about 38° to about 48° as proved by experience in the Gloucester hatchery.

The Massachusetts Bay spawning takes place in salinities ranging from as low as 32 per mille to as high as 32.8 per mille, according to precise locality, depth, and season, salinities much lower than those in which pollock breed on the other side of the Atlantic (35.14 to 35.26 per mille).

The number of eggs produced by a female pollock averages about 225,000, but more than 4 million eggs were reported in one fish of 23½ pounds. The egg is buoyant, has no oil globule, and averages about 1.15 mm. in diameter. Thus it is decidedly smaller than the egg of the cod or of the haddock. Incubation occupies 9 days at a temperature of 43°; 6 days at 49°.

The larvae are about 3.4 to 3.8 mm. long at hatching, slender, with large yolk sac, and with the vent situated on one side of the body at the base of the ventral fin fold as it is in other larval gadoids; they are sprinkled with black pigment cells. About 5 days' time is required for the entire absorption of the yolk sac and for the formation of the mouth; meantime the pigment of the post-anal section of the trunk becomes grouped in longitudinal bars, two dorsal and two ventral, the former longer than the latter. At this stage pollock closely resemble cod of the same size, but the ventral bars are longer than the dorsal bars opposite them in the cod, and usually three in number in the cod instead of two as in the pollock. These bars persist until the pollock grows to a length of about 15 mm., when the pigment becomes more scattered. The caudal fin rays appear at about 9 mm., all the dorsal and anal rays and the ventral fin rays at about 15 mm., the dorsal fins are separate from one another and also the anal fins at 20 mm. (at about 2 months), and fry of 25 to 30 mm. show most of the characters of the adult.

In European seas the young pollock lives near the surface for its first 3 months. The young fry have been taken similarly, in the tow nets near the surface at Woods Hole from January to May, and they are to be expected in Massachusetts Bay then, though we have no actual record of them there.

Rate of growth.—Thanks to the shortness of its breeding season and to the readiness with which its scales can be "read" European students [7] have found it easy to trace the rate of growth of these "saithe" or "coal fish"; and this has been done for the American pollock by Mavor,[8] also by us. Judging from scale studies and from the sizes of the fry that are caught near Woods Hole in the spring, pollock hatched in mid-winter are about 1 to 2 inches long by the following spring, growing to 3–5 inches by late summer; to 5–7 inches in their first winter, when a year old; to 12–13 inches at two years of age; to 17–18 inches at three years; to 21–22 inches at four years; to an average of about 23 inches at 4½ years; of 25 inches at 5½ years; and of about 27 inches at 6½ years. Thus the 11–12 inch and 15–16 inch pollock that appear in such numbers along the New England coast late in summer are about 1¾ and 2¾ years old, respectively. The annual rate of growth thus is about 5 or 6 inches for the first three years, 2–4 inches for the next three years, and 1–2 inches for the next few years, after which they grow still more slowly.

These sizes are somewhat larger than the averages given by Damas for European fish of corresponding ages, but the difference is so small that it is safe to apply the European figures to older Gulf of Maine fish, for which we have no data. On this basis we may expect the American pollock to average about 28 inches at 7½ years; about 29

[7] For résumé see Damas (Rapp. et Proc. Verb., Conseil Perm. Internat. Explor. Mer, vol. 10, No. 8, 1900, p. 107).

[8] Contr. Canad. Biol., (1917–1918) 1918, No. 6.

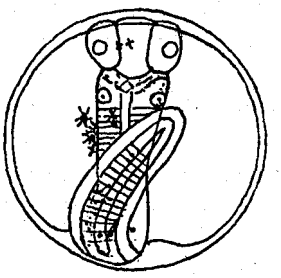

FIGURE 99.—Egg (European). After McIntosh.

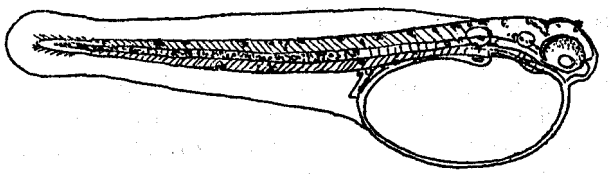

FIGURE 100.—Larva (European), 5 days old, 4.3 mm. After McIntosh.

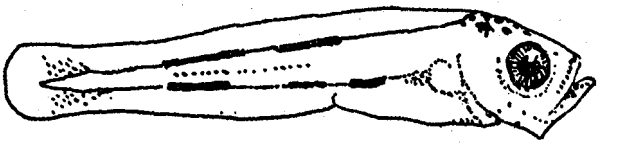

FIGURE 101.—Larva (European), 6.75 mm. After Schmidt.

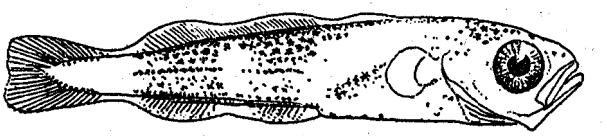

FIGURE 102.—Larva (European), 12.5 mm. After Schmidt.

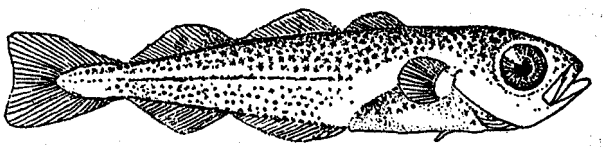

FIGURE 103.—Fry (European), 23 mm. After Schmidt.

AMERICAN POLLOCK (*Pollachius virens*).

inches at 8½ years, and about 30 inches at 9½ years. Fish of 3 feet and upward are therefore of considerable age. The oldest recorded by Damas among the thousands he examined was in its nineteenth year. In European seas pollock grow faster in the southern part of their range than in the northern, but we have yet to learn whether this applies to the American fish.

The age at which Gulf of Maine pollock first mature is not known, but this is probably at a somewhat greater size than in Norwegian waters, where most of them mature by the time they are 1½ feet long; i. e., 3 years old. All of them that are 2 feet long, or longer, in summer have spawned at least once.

General range.—Continental waters on both sides of the North Atlantic in cool temperate and boreal latitudes; regularly in the west from the southeastern part of the Gulf of St. Lawrence [9] and northeastern Nova Scotia to New Jersey; southward occasionally to Chesapeake Bay and to Cape Lookout,[10] N. C., and northward in small numbers to the southern part of the Grand Banks, to the southeastern coast of Newfoundland, and to Sandwich Bay on the southeastern coast of Atlantic Labrador;[11] West Greenland; Spitzbergen; Iceland; and the coasts of northwestern Europe south to the North Sea, English Channel, and Brittany coast of the Bay of Biscay in the eastern Atlantic; occasionally to the Gulf of Gascony (Arcachon).

Occurrence in the Gulf of Maine.—In our side of the Atlantic the pollock has its chief center of abundance in the Gulf of Maine, where it is caught in large numbers both on the offshore banks, and all around the coast line, from Nantucket Shoals and Cape Cod to Cape Sable. The only regional exception is in the inner part of the Bay of Fundy along the New Brunswick shore, where so few pollock are taken that they do not appear at all in the landings reported thence (Albert County).

The following statistics of the United States catch for 1945, combined with the Canadian catches for 1944 and 1946,[12] give a general idea of the regional abundance of pollock, on a broad scale, also of how universal they are, with the one exception just noted.

Browns Bank, about 965,000 pounds; western coast of Nova Scotia to the Annapolis County

[9] Pollock appear not to be known anywhere farther within the Gulf or in its northern side.

[10] Reported from Chesapeake Bay by Hildebrand and Schroeder (Bull. U. S. Bur. Fish., vol. 43, pt. 1, 1928, p. 156) and from Cape Lookout by Coles (Copeia, No 151, 1926, p. [105]).

[11] The pollock is listed in the Reports of the Newfoundland Fisheries Research Commission for 2 stations on the southern edge of the Grand Bank, from Bay Bulls, Newfoundland, and from Sandwich Bay, Labrador.

[12] We have not yet seen the Canadian statistics for 1945.

line, at least 7,300,000 pounds;[13] Nova Scotian shore of Bay of Fundy, about 500,000 to 1,000,000 pounds;[14] inner part of Bay of Fundy on New Brunswick side (Albert County), 0; mouth of the Bay of Fundy on New Brunswick side, about 2,000,000 to 3,500,000 pounds;[15] off eastern Maine, about 1,045,000 pounds; off central Maine, about 2,573,000 pounds; small fishing banks in west-central part of the Gulf, about 516,000 pounds; off western Maine, about 1,861.000 pounds; off eastern Massachusetts and off northern Cape Cod, about 7,347,000 pounds; Cape Cod out to the so-called South Channel, about 1,518,000 pounds; Georges Bank as a whole, about 3,184,000 pounds.

In general, pollock are more abundant around the coastal belt of the Gulf, out about to the 75 to 80 fathom line, on the isolated fishing grounds enclosed within that depth limit, and over the offshore banks than they are over the deeper central basin of the Gulf; though some are taken there also. And this has always been one of the principal fishes to be caught with hook and line on the various small banks and ledges in the inner part of the Gulf; near Lurcher Shoal for instance; on Grand Manan Bank; on Jeffreys Ledge, and on Stellwagen Bank at the entrance to Massachusetts Bay, while the neighborhoods of Boon Island and of the Isles of Shoals long have been famous pollock grounds.

Pollock are decidedly less plentiful on the Nantucket grounds in general (only about 56,000 pounds landed thence in 1947) and west of Cape Cod than they are either farther within the Gulf to the northward or on Georges Bank to the eastward. But commercial quantities are caught yearly (in season) along southern New England and New York. The landings for Rhode Island, Connecticut, and New York, combined, ranged, for example, between 787,000 pounds and 883,000 pounds for the years 1930 to 1933. And though the landings ran less than one-half as great (between 135,000 pounds and 452,000 pounds) for 1935 to 1947 we suspect that this decrease resulted from market conditions, rather than from any decrease in the numbers of pollock that are available there. A few hundreds or thousands of pounds of pollock are landed yearly[16] in New Jersey ports also. But this is the extreme southern limit for the pollock as a market fish.

To the eastward and northward, we find pollock caught in abundance all along the outer Nova Scotian coast and banks. In 1946, for example, 840,000 pounds were landed in Guysborough County, Nova Scotia, and 277,200 pounds along the Atlantic coast of Cape Breton Island, east of the Gut of Canso.[17] This, however, is the northeastern limit of our pollock as a market fish of any importance. True, a few thousand pounds were reported yearly from the southeastern side of the Gulf of St. Lawrence near the Gut of Canso during the early nineteen hundreds.[18] But the catch is so small that pollock have not been mentioned in the catch statistics for more recent years, nor anywhere else within the Gulf of St. Lawrence.

Small pollock, 8 to 10 inches long and weighing less than half a pound (1 or 2 years old) swarm inshore after early April, when we have seen thousands of them taken from the traps at Gloucester and Magnolia. In the southern part of Massachusetts Bay these "harbor pollock," as they are called locally, move out in June, probably to avoid the rising temperature, to return again in autumn. But they continue abundant all summer and autumn in the harbors and bays and among the islands along the coast northward from Cape Ann and eastward to Nova Scotia. Most of them seek slightly deeper water in winter, however, probably to avoid the cold.

The larger fish tend to keep farther offshore than the small ones; they live deeper on the whole, except when they are pursuing some particular feed (p. 214), and they are caught in more definite localities, not everywhere and anywhere along the coast as are the little fish. In the southwestern part of the Gulf, as exemplified by Massachusetts Bay and by the belt from Cape Ann to the Isles

[13] U. S. catch, 492,400 pounds, 1945; Canadian catches 7,017,000 pounds in 1944 and 6,642,000 pounds in 1946, besides an indeterminate amount landed along this part of the Shelburne County coast line.

[14] 1944, 513,000 pounds; 1946, 983,000 pounds.

[15] Charlotte and St. Johns Counties, about 2,000,000 pounds in 1944, about 3,507,000 in 1946.

[16] Maximum, 10,700 pounds, minimum 600 pounds for the years 1930–1937 and 1939–1947, 101,200 pounds were credited to New Jersey in 1938; an amount so much larger than usual as to suggest that it was because of economic reasons that the fish were landed in New Jersey rather than in New York.

[17] Richmond County, Nova Scotia, 223,600 pounds; Cape Breton County, 53,600 pounds.

[18] Yearly catch, 1,600–4,000 pounds; for 1902 to 1906 and 1909 to 1915–1916, 61,500 pounds were credited to Inverness County in 1901, but this amount is so much larger than usual as to suggest some error.

of Shoals, large pollock are taken in greatest number in late autumn and early winter when the gillnet fishery taps the spawning fish (fig. 220). Few are caught there later in the winter after they finish spawning, showing that the spent fish do not winter on particular grounds, but scatter to and fro in search of food.

Along this part of the coast they often reappear in abundance at the surface near land during April and May and even into June. In 1951, for example, we heard of schools of large pollock at various points off the tip of Cape Cod, in the northern side of Massachusetts Bay, and off the Merrimac River during the first week of that month. They tend to move out again, and deeper, as the surface warms with the advance of the season, and very few large ones are taken inshore in the Massachusetts Bay region during July and August. But it is not likely that they travel far, or sink very deep, for good fares of fish 2 to 3 feet long are brought in by line fishermen from Jeffreys Ledge throughout the summer, most of them caught some distance above bottom.

North of the Isles of Shoals, pollock are more commonly seen on the surface during the hot months. Thus, we remember one year (1922) when small boats from Cape Porpoise and from neighboring ports were doing well trolling during July and early August; in 1951 schools were reported off Baileys Island, Casco Bay, during the first week of July. And great numbers of good sized pollock are caught all summer in the tide rips at the mouth of the Bay of Fundy; in Passamaquoddy Bay; in Digby Gut on the Nova Scotian side of the Bay of Fundy; and along outer Nova Scotia.[19]

No information is available as to the relative frequency with which pollock appear at the surface over Georges Bank and other offshore fishing grounds, though they are caught all through the year at deeper levels, with no greater seasonal fluctuation in the landings than might result from the various vicissitudes of fishermen's luck, the weather, and the market.

Pollock spawn in great numbers at the mouth of Massachusetts Bay, especially on the broken bottom southeast of Gloucester and along the seaward (eastern) slope of Stellwagen Bank, where most of the eggs were taken during the years when pollock were hatched in great numbers at the Gloucester hatchery of the U. S. Bureau of Fisheries.[20]

In some years many pollock spawn (and large quantities of their eggs have been collected for the hatchery) right up to Boston Lightship in the inner part of Massachusetts Bay, though this is not a regular annual event. And gill-netters also catch an abundance of ripe fish between Cape Ann and the Isles of Shoals, where breeding pollock congregate in such abundance that they have supported a lucrative fishery in some years.

This in general seems to cover the most productive spawning area so far as the inner parts of the Gulf are concerned. Few spawning pollock are caught in the Gulf south of the Massachusetts Bay region, while we find no report of them as breeding anywhere west of Cape Cod, although fry of the winter's hatch appear at Woods Hole in spring (p. 220). On the other hand only a fewripe fish are seen along the coast of Maine, though the Boothbay hatchery has made diligent search for them east of Casco Bay; neither have we found pollock eggs anywhere north of the Isles of Shoals in our autumn or winter towings. And it seems that very few larvae are hatched at the mouth of the Bay of Fundy on the New Brunswick side, for none of their young fry have been found in the Passamaquoddy–Grand Manan region, though yearlings, half-grown fish, and adults are there in great numbers. Thus it is safe to say that no production of any importance takes place anywhere in the Gulf of Maine east of Cape Elizabeth.

We cannot offer any explanation for this regional contrast in pollock productivity. Temperature seems not the cause, for this differs by only a couple of degrees between Massachusetts Bay and Passamaquoddy Bay at the commencement of the spawning season. And while the coastal water as a whole is slightly cooler east than west of Cape Elizabeth at the height of the season, the differences from station to station have been small; and all the readings we have taken there during late December and early January have fallen well within the range at which pollock spawn freely in

[19] Near Canso good-sized fish are caught on hook and line at the surface from June to December, according to Cornish, Contributions Canadian Biology (1902–1905) 1907, p. 189.

[20] Information supplied by C. G. Corliss, former Superintendent of the Gloucester Hatchery.

Massachusetts Bay, as appears in the following table:

Water temperatures, Massachusetts Bay to Lurcher Shoal, 1920–1921

Depth in fathoms	Off Gloucester, Dec. 29, station 10489	Off Cape Elizabeth Dec. 30, station 10494	Off Mount Desert I., Jan. 1, station 10497	Off Machias, Jan. 4, station 10498	Fundy Deep, Jan. 4, station 10499	Off Lurcher Shoal, Jan. 4, station 10500
0	42	42	40.5	42	42	42.5
10	43.7	42.5	41.4	42	42.4	42.7
20	44.4	43.1	41.8	42.1	42.6	43.1
40	44.4	44.9	42.3	42.1	42.9	43.9
75	44.6				43.5	

Presumably the pollock of Georges and Browns Banks and of outer Nova Scotian waters to the eastward reproduce themselves there. But we have no definite information in this regard.

A few ripe fish are caught in the Massachusetts Bay region as early as the last week in October, and the first of November to the middle of January covers the most active production there, as illustrated by the following table supplied by C. G. Corliss, former Superintendent of the hatchery, where many millions of pollock eggs were once hatched yearly.

Year	First eggs taken	Last eggs taken	Eggs most plentiful	Total eggs collected
1911–12	Nov. 10	Jan. 22		499,875,000
1912–13	Nov. 1	Jan. 31		856,680,000
1913–14	do	Feb. 6		974,240,000
1914–15	do	Feb. 9		855,020,000
1915–16	do	Feb. 17		1,713,730,000
1916–17	Nov. 7	Jan. 27	Nov. 16 to Jan. 20	2,081,400,000
1918–19	Nov. 6	Jan. 23	Nov. 20 to Jan. 8	1,110,470,000
1919–20	Nov. 10	Jan. 16	Nov. 17 to Jan. 16	954,800,000
1920–21	Nov. 15	Jan. 21	Nov. 21 to Jan. 16	650,850,000

The first week of March is the latest that the gill netters have reported any spawning fish.

The pollock spawns considerably earlier in the Gulf of Maine than in European waters, where spawning does not begin until January, is at its height in March, and continues into April.

The Gulf of Maine pollock, like the cod and haddock, spawn in comparatively shoal waters. Thus we have towed a considerable number of pollock eggs over Stellwagen Bank where the water was only 16 fathoms deep (on November 8, 1916) and most of the ripe fish that supplied the Gloucester hatchery with eggs were netted in depths of 25 to 50 fathoms. Probably few spawn deeper than 50 to 60 fathoms, and there is no evidence in egg records, in captures of ripe fish, or in fishermen's reports, that any pollock eggs are produced in the deep basins of the Gulf. In European waters, however, this fish is described as breeding only in depths greater than 75 fathoms.

The gill netters have described it to us as spawning over hard bottom chiefly, though the pollock is not a ground fish at other seasons.

The migrations of the young pollock in our Gulf, from hatching until they appear on the coast as yearlings, are of special interest because of the probability that the great majority of all the pollock that frequent the eastern coast of Maine and the Bay of Fundy region are produced elsewhere. Some of them may come from spawning grounds (as yet unmapped) off southern or western Nova Scotia; our own observations throw no direct light on this point. But what is known of the general circulation of the Gulf in spring and early summer suggests, rather, that the bulk of them come from the spawning grounds on the western side, south of Cape Elizabeth, having circled around first southward, then eastward and northeastward, and so finally to the Bay of Fundy and to the east part of the Maine coast. Others, hugging the coast more closely in their involuntary journeyings, may follow past Cape Cod and so westward, evidence of which is the presence of an abundance of pollock fry in spring at Woods Hole, for pollock are not known to spawn in quantity anywhere west of the Cape (p. 219).

Strangely enough, we have caught no pollock less than 8 or 9 inches long on the offshore banks either on hook and line or in our tow nets, nor have we seen any that had been trawled there. Whether this is because the young are too nimble to be taken in trawls, whether because they live well off bottom, or whether because they are scarce offshore, is not known.

The larger pollock of our Gulf seem to wander but little, for many that have been tagged by the U. S. Bureau of Fisheries have been recaptured within short distances of the localities where they were marked, and after long periods of time. And while a few of the marked fish are known to have made considerable journeys eastward, (one, for example, from Jeffreys Ledge to Sable Island), instances of this sort have not been numerous enough to suggest any mass movements.

Pollock appear to be similarly stationary all along the outer Nova Scotian coast, for they are caught there throughout the fishing season. But

we think it likely that the few pollock that are caught within the Gulf of St. Lawrence wander in via the Gut of Canso. On the other hand, pollock are seldom caught west of Rhode Island after June,[21] and it is chiefly as cold season visitors that they appear off the coasts of Connecticut, New York, or New Jersey; the commercial catches reported thence are made mostly in winter and in early spring.

Importance.—At the time the first edition of this book appeared (1925) our Gulf was yielding about 35 million to 40 million pounds yearly. In 1946, most recent year for which we have seen the Canadian catch statistics as well as those for the United States, the total catch for the Gulf was close to 48 million pounds,[22] say 5 million to 7 million fish.

A quarter of a century ago, the gill net was regarded as the most effective apparatus for catching pollock; hand and long lines ranking next; otter trawls yielding only a few,[23] while schools that were seen at the surface were often seined, especially the smaller sizes. But the relative proportions have been reversed with the great development of the otter trawl fishery. In 1946, for example, a representative year, a little less than ¾ of the pollock landed from the Gulf of Maine by United States fishermen were caught in otter trawls; a little less than ⅛ in gill nets; with hand and long lines, traps of one sort or another, and purse seines accounting for the remainder in the order named.[24]

Some of our readers will be more interested in the fact that pollock will take an artificial lure and put up a strong resistance. Small ones up to 4 or 5 pounds will take a bright artificial fly freely (silver body with white wings of hackle or hair is good, especially with a touch of red). We have caught many fly casting from the rocks in autumn when smallish pollock are inshore after smelt or other small fish. And a pollock rises so fiercely to the fly and makes so long and strong a run when it is hooked that a small one gives fully as good sport as a trout caught on a light fly rod; a medium-sized pollock provides nearly as good sport as a salmon of equal weight. When the larger pollock are schooling at the surface near shore in May and June, many of them are taken by anglers trolling with spoons or with feather lures of one kind or another, from party boats out of Plymouth, Gloucester, Ipswich, Newburyport, Hampton, York, Casco Bay, and various other places along our coasts; also off Gay Head, Marthas Vineyard, and still farther to the westward. And pollock of all sizes bite eagerly on clams, minnows, or on bait of cut fish.

WHITE HAKE AND SQUIRREL HAKE

We are forced to discuss these two hakes together, for they are so hard to tell apart that they are often confused, while they agree so closely in habits and distribution that what is said of one applies equally to the other, except as noted below.

White hake *Urophycis tenuis* (Mitchill) 1815 [25]

BOSTON HAKE; BLACK HAKE; MUD HAKE; HAKE; LING

Jordan and Evermann, 1896–1900, p. 2555.

Description.—Although the hakes of the genus *Urophycis* (true hakes in general parlance on this side of the Atlantic) are close relatives of the cod and of the haddock, they are not at all codlike in appearance, being more slender and softer-bodied fish, tapering backward from the shoulders to a slim caudal peduncle and to a small weak tail, with much larger eyes than the cod but with smaller chin barbels. Furthermore, they have only two dorsal fins, the second much longer than the first, and only one anal fin instead of the three dorsals and the two anals of the pollock, cod, and haddock. The ventral fins are long, narrow, and feelerlike.

The body of the white hake is rounded in front of the vent, flattened sidewise behind the vent, and is about five and one-half times as long as it is deep. The mouth is so large that it gapes back to below the eyes, the upper jaw projects beyond the lower, and the chin bears a small barbel. The first dorsal fin (9 to 10 rays) originates close behind the pectorals, and is shorter

[21] Two pollock tagged on Nantucked Shoals in June and October were caught off Block Island in the following May and July respectively.

[22] 47,670,776 pounds, plus an indeterminate amount for Shelburne County, Nova Scotia, that may have been caught on the Gulf of Maine side of Cape Sable.

[23] Bigelow and Welsh, Bull. U. S. Bureau of Fisheries, vol. 40, Pt. 1, 1925, p. 406.

[24] No statistics are available as to what proportions of the Canadian catch in the Gulf are made with the different kinds of gear.

[25] The European hake is a *Merluccius* (p. 177).

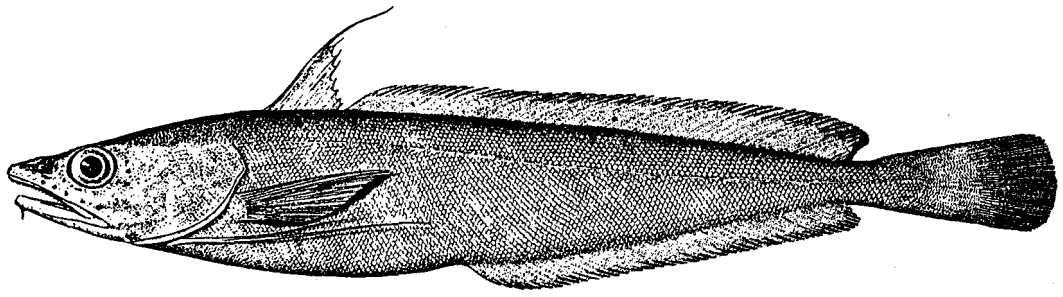

FIGURE 104.—White hake (*Urophycis tenuis*), Halifax, Nova Scotia. From Goode. Drawing by H. L. Todd.

than the latter, triangular, with the third ray prolonged as a filament that is longer than the fin proper is high. The second dorsal fin (about 54 to 57 rays) runs the whole length of the trunk from close behind the first dorsal fin to the caudal peduncle, is of about equal height from end to end, with rounded corners, and is only about half as high as the first dorsal. The anal fin is similar in outline to the second dorsal but is shorter (about 48 to 50 rays). The pectorals are rounded when spread; the ventral fins are situated considerably in front of the pectorals, and each is reduced to two very much prolonged rays (apparantly a single branched ray), with the lower (longer) ray of the two falling slightly short of the vent.

The length of the ventral fins has often been given as an alternative character separating the white hake from the squirrel hake (p. 223), in which the ventrals are usually described as reaching beyond the vent. This distinction is not to be relied on, however, for we have seen squirrel hakes in which the ventrals lacked something of reaching the vent.

The scales on both head and body are smaller than those of the closely allied squirrel hake, and their number is the most reliable distinction between the two species, there being about 140 oblique rows of scales along the lateral line between gill opening and base of tail fin in the white hake, but seldom, if ever, more than 110 rows of scales in the squirrel hake.

Another difference, which seems equally dependable, though it is less obvious, is that the upper jaw (maxillary) bone reaches as far back as the rear edge of the eye in the white hake, but only as far as the rear edge of the pupil in the squirrel hake.

Color.—Like most bottom fish, white hake vary in color. As a rule they are muddy or purple brown above, sometimes almost slaty (we saw one of this shade caught in Northeast Harbor, Maine), the sides sometimes bronzed, and the belly dirty white or yellowish white peppered with tiny black dots. The dorsal fins are of the same color as the back, the anal fin the same as the belly, and both the dorsals and the anal are edged with black. The ventral fins are pale, like the belly, but usually they are more tinged with yellow.

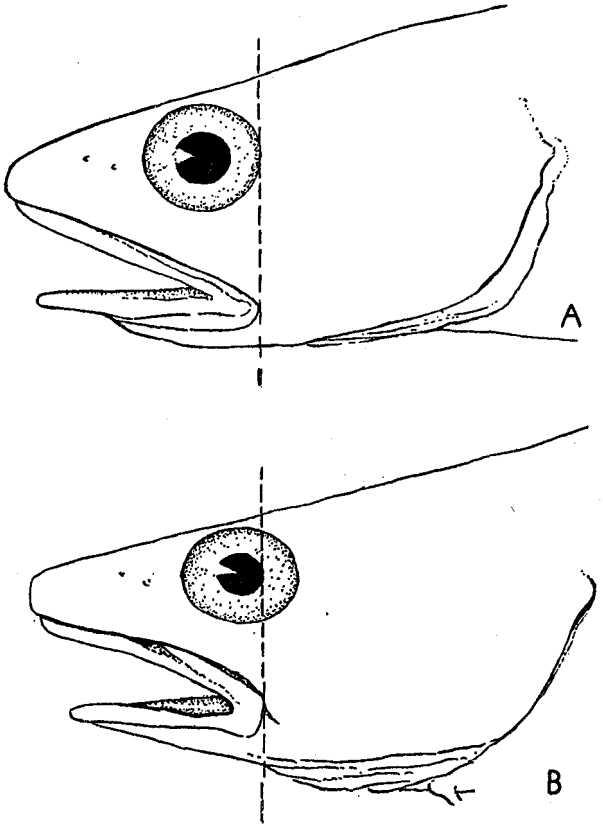

FIGURE 105.—Side view of heads of white hake, A, and of squirrel hake, B, to show the difference between the two in length of the upper jaw bone.

Size.—The maximum length is about 4 feet, the maximum weight about 40 pounds. But most

of the fish that are caught weigh between 1 and 20 pounds, averaging no more than 8 pounds. A hake 28 inches long will weigh about 8½ pounds if it is in good condition; one of 30 inches, about 9 pounds; 36 to 38 inches, 13 to 16 pounds; and about 18 pounds at 40 inches, according to Welsh's experience.

Squirrel hake *Urophycis chuss* (Walbaum) 1792

RED HAKE; LING

Jordan and Evermann, 1896–1900, p. 2555.

Description.—The squirrel hake resembles its larger relative, the white hake (p. 221) so closely that the one is often taken for the other. The number of scales affords the most reliable means of identification, those of the squirrel being much larger relatively than those of the white, and arranged in only about 100 to 110 oblique cross rows along the side from gill opening to base of caudal fin, and in about 9 longitudinal rows on the upper part of the sides between lateral line and dorsal fin, as against about 140 transverse rows and about 12 longitudinal rows in the white hake (p. 222). Also, the upper jaw (maxillary bone) reaches back only as far as the rear edges of the pupil in the squirrel hake, but as far as the rear edge of the eye in the white hake (p. 222), and this difference can be relied upon, even for very small fish.

The ventral fins of the squirrel hake overlap the vent as a rule, whereas those of the white hake fall short of it, but this is not invariably the case, as already remarked (p. 222), for we have seen squirrel hakes in which the ventrals did not reach to the vent. Furthermore, the filamentous part of the third ray of the first dorsal fin is much longer (if undamaged) in the squirrel than in the white hake, i. e., three to five times as long as the rest of the fin, and the nose is blunter. The color, too, is of some value in identifying these species, for while the squirrel hake is almost always reddish brown, the white hake has a decidedly purplish lustre when fresh caught.

Color.—The squirrel hake is reddish, muddy, or olive brown on sides and back, darkest above; sometimes almost black, sometimes more or less mottled, and sometimes plain, with pale lateral line. The lower part of its sides usually are washed with yellowish, and sometimes marked with dusky dots. Its belly and the lower parts of the sides of its head are pure white, grayish, or yellowish; its dorsal, caudal, and anal fins are of the same color as the back except that the anal is pale at the base. The ventral fins are very pale pinkish or yellowish.

Size.—The squirrel hake does not grow so large as the white hake, seldom reaching a greater length than 30 inches (the largest of 780 Bay of Fundy fish measured by Craigie was about 27 inches long), or a greater weight than 6 to 7 pounds, and the average of those caught will not run above 1 to 3 pounds. In fact, a fish as heavy as 5 pounds is exceptional. Females are both longer and heavier than males of the same age (p. 226).

Habits.—These two hakes,[26] like many other sea fishes, spend their first months drifting at or near the surface, and fry of ½ to 4 inches (among which both species are no doubt represented) are often taken in summer under floating eelgrass or rockweed. On calm days we have seen them darting to and fro on the surface on many occasions (p. 224). And it is evident that the duration of this pelagic stage varies, for we have towed fry as long as 4 inches on the surface although others seek the bottom while they still are only

[26] The youngest stages of the two species are so much alike that in most cases we have been forced to list them simply as "hake," awaiting more critical examination than we have been able to give them.

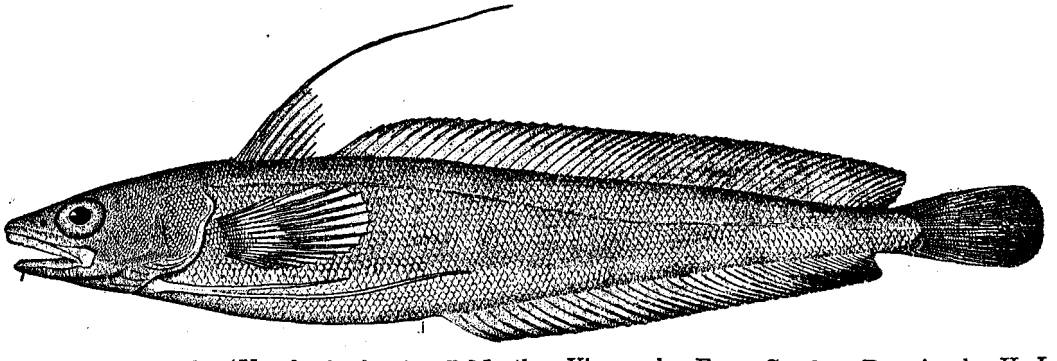

FIGURE 106.—Squirrel hake (*Urophycis chuss*), off Marthas Vineyard. From Goode Drawing by H. L. Todd.

about 2 inches long. But it is not known how far they may journey while they are at the mercy of currents. After they have taken to the bottom, they are ground fish for the remainder of their lives, only rising into the upper layers in pursuit of food. They are rather sluggish swimmers, as their body form suggests, and even a large one makes only a very feeble resistance when it is hooked.

When hake first take to bottom many of them do so in very shallow water, fry 2 to 6 inches long being common close below the tide mark among the eelgrass (*Zostera*); and fish a little larger are often caught by flounder fishermen in the harbors all around the Gulf of Maine. Others, however, seek the ground in somewhat deeper water, where they have an interesting habit of hiding within the living shells of the giant scallop (*Pecten magellanicus*). This has often been observed on the outer part of the Continental Shelf off southern New England; Nichols and Breder [27] have found little hake hiding in the mantle cavities of scallops in 20 fathoms off New York, and scallop fishermen have informed us that they often find little hake in the scallops that they dredge off the coast of Maine. Both of the common species of hake are known to use this curious refuge (they do not feed on the scallops but merely use their shells as hiding places), but most of the specimens so taken have proved to be squirrel hake. And the latter adopts this form of commensalism so commonly that Welsh records as many as 27 taken from 59 scallops in one haul of a scallop dredge, and 11 hake from 9 scallops in another haul, besides many others not counted off southern New England, New York, and New Jersey during the summer and autumn of 1913.

Slightly larger hake of both species, up to 8 to 12 inches long, are not only plentiful offshore, but are rather common close inshore in a fathom or two of water, in harbors, and even well up estuaries. The larger fish usually keep to deeper water, especially in summer, when hake of marketable sizes are most plentiful below 20 fathoms, and when only a few large ones are caught in less than 10 fathoms of water. But this rule, like most others, has its exceptions. For instance, we once saw a white hake of about 8 pounds caught from a float in Northeast Harbor, Maine, in about 10 feet of water, in July (in 1922). On the other hand, hake of both the species in question are to be caught in the deepest parts of the Gulf, and white hake have been taken down to 545 fathoms at least, on the offshore slope of Georges Bank.

Both of these hake haunt soft bottom chiefly, few being caught on the gravelly or shelly grounds that are so prolific of cod and haddock, or on rocky grounds. And it has been our experience that the whites are the more strictly mud fish of the pair.

The temperatures in which hakes of different ages are found cover the entire range proper to the Gulf except perhaps the very lowest. At the one extreme many of the youngest fry that are seen swimming at the surface in the west central part of the Gulf in summer are in water as warm as 68° to 70° F., while young hake are in still higher temperatures west and south from Cape Cod if they are at the surface. And the somewhat larger fry found on our beaches a little below tide mark may be in water as warm as 60° locally. But the great majority of the hakes living deeper are in water at least as cool as 50° throughout their later lives, most of them in temperatures lower than 45° F.

At the other extreme, all of the hakes living around the inner slopes of the Gulf at depths less than 50 fathoms experience temperatures as low as 35° to 37° F. in late winter and early spring; as low as 33° to 34° locally if they are living as shoal as 20 fathoms, which many of them do. But the fact that the bottom temperatures at the particular stations on the Grand Banks (all on the southern part) where white hake have been reported by the Newfoundland Fisheries Research Commission have all been between about 42° and about 33° F. (5.5° C. and 0.6 C.), and that they were not taken on other parts of the Bank where the bottom is colder, suggests that they tend to avoid regions where the temperature is as low as 32° F. or lower. And this finds some corroboration in the report (see p. 228) that hake tend to withdraw in autumn from Passamaquoddy Bay, where the water chills at least as low as 32° at some time during some winters.

Food.—Less is known of the diet of the hakes than of the cod, the haddock or the pollock. However, it is certain that they are not shell eaters to any extent, for it is seldom that their stomachs contain even the smaller univalve or

[27] Zoologica, N. Y. Zool. Soc., vol. 9, 1927, p. 172.

bivalve mollusks, and neither large mollusks nor echinoderms have ever been found in a hake, so far as we know. The stomach contents so far recorded [28] show that shrimps (*Pandalus*), amphipods, and other small crustacea which they find on the bottom are their chief dependence at most times and in most places. They also feed as greedily on squid as others of the cod tribe do, and a variety of small fish have been found in hake stomachs at Woods Hole,[29] such as alewives, butterfish, cunners, eels, flatfishes, tautog, herring, mackerel, menhaden, launce, silversides, silver hake, sculpins, sea robins, smelt, and tomcod.

Small white hake trawled some 75 miles south of Martha's Vineyard, in 56 fathoms, January 29, 1950, by the dragger *Eugene H* had fed on small squid, crabs (*Cancer*) and small butterfish (*Poronotus*); others trawled off Chesapeake Bay (lat. 38°13′ N., long. 73°49′ W.) in 52 fathoms by the *Albatross II*, March 2, 1931, had small mackerel, flounders, crabs, and squid in their stomachs. And we have seen squirrel hake caught off northern New Jersey with their bellies distended with launce, and with launce hanging from their mouths.

Hake of both species bite on fish bait such as herring readily; in fact, most of those that are caught on long lines (p. 230) are hooked on pieces of herring. But they also take clams on the hook greedily enough. In the northeastern part of the Gulf of Maine hake feed far enough off bottom to capture the pelagic euphausiid shrimps (*Meganyctiphanes* and *Thysanoessa*) that are so plentiful there, while the general character of their diet is sufficient evidence that they do not root in the ground like haddock.

Ever since 1616, when Capt. John Smith [30] wrote "Hake you may have when the cod failes in summer, if you will fish in the night," it has been common knowledge that they bite best after dark, from which it is fair to assume they do most of their foraging between sunset and sunrise.

Herrick [31] has given an interesting account of the perceptions of squirrel hake kept in a tank at Woods Hole, where they proved to have keen sight (though less so than pollock) and usually caught bits of meat before these had sunk. But it seems that it was only while food was in motion that the fish recognized it by sight, and that they depend chiefly on the sense of touch for their livelihood. They exercised this by swimming close to bottom with the sensitive tips of the ventral fins dragging the ground. When a hake touched a fragment of clam in this way it immediately snapped it up, but not otherwise. And they paid no attention whatever to live clams in their shells, though they often brushed over them. These observations, applied to the conditions under which hake actually live, suggests that they recognize shrimps, crabs, and other foods by their ventral feelers, and that they snap up their victims as these dart ahead, when the feelers drag over them.

No doubt the eggs of the white hake are bouyant like those of the squirrel hake (p. 225), but few wholly ripe females, no eggs naturally spawned, or young larvae have been seen yet.

We were equally ignorant of the spawning and early stages of the squirrel hake up to the summer of 1912. But we trawled squirrel hake with running spawn and milt in Ipswich Bay in that July, fertilized the eggs on board the *Grampus*, and thus identified the eggs. Since then large numbers of squirrel-hake eggs have been hatched artificially at the Gloucester hatchery.

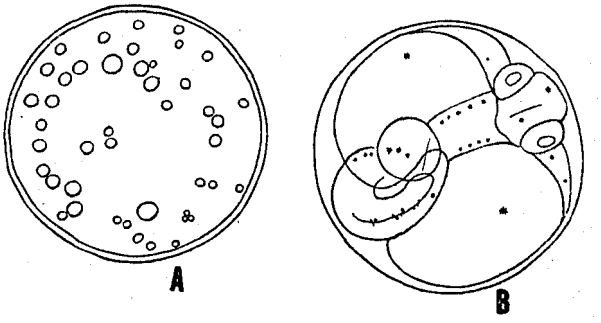

FIGURE 107.—Squirrel hake (*Urophycis chuss*), eggs, after 1 hour's incubation, A; and after 74 hours' incubation, B.

The eggs are buoyant, spherical, transparent, and 0.72 to 0.76 mm. in diameter. When first spawned they have variable numbers of small

[28] Goode, (Fish. Ind. U. S., Sect. 1, 1884, p. 235); Kendall, (Rept. U. S. Comm. Fish., (1896) 1898, p. 180); Linton, (Bull. U. S. Fish Comm., vol. 19, 1901, p. 478); Hansen, (Proc. U. S. Nat. Mus., vol. 48, 1915, p. 94); Broder (Zoologica, N. Y. Zool. Soc., vol. 2, No. 15, 1922, p. 350); and Vinal Edwards' notes.

[29] A large white hake taken at Woods Hole in May 1908 had a fish (*Lepophidium*) encysted in the wall of its body cavity, having no doubt penetrated the hake's stomach after it had been swallowed. (Sumner, Osburn, and Cole, Bull. U. S. Bur. of Fish., vol. 31, pt. 2, 1913, p. 768).

[30] General Historie of Virginia, New England, and the Summer Isles, 1616, ed. of 1819, vol. 2, p. 188.

[31] Bull. U. S. Fish Comm. ,vol.22 ,1904. p. 258.

colorless oil globules 0.02 to 0.07 mm. in diameter, scattered over the yolk, but most of these globules unite shortly after fertilization into one large one of 0.15 to 0.17 mm., which is sometimes single but which usually has two or three tiny ones close beside it. The embryo extends half way around the yolk sphere within two days after fertilization (at a temperature of 60° F.), and pigment has appeared, one of the most characteristic features of this species being the development of black chromatophores not only on the embryo, but over the yolk, and finally on the oil globule as well. In late stages of incubation this feature, combined with the small size of the egg and (usually) with a multiple oil globule, distinguishes eggs of the squirrel hake from all other buoyant fish eggs of known parentage that have been found in the Gulf, except for any rockling eggs that may have pigmented oil globules (p. 236). There is also some danger of confusing newly spawned eggs of the squirrel hake with those of the butterfish (of about the same diameter) for these sometimes have two oil globules (p. 364).

The newly hatched larvae have not been described. Older fry (identity established either as white hake or squirrel hake by comparison with young fry that have been reared in the hatchery by Louella E. Cable) already show the long, slender ventral fins, the short first dorsal but long second dorsal, and the tapering body form, characteristic of the adults. These little hakes, greenish blue on the back, with silvery sides, are separable from rockling fry by their more slender form, and by their scattered pigment. Older stages are separable from rocklings by their two well developed dorsal fins, while their silvery sides mark them at a glance from the dull colored fry of the cusk.[32]

Rate of growth.—The rate of growth during the first few months cannot be stated until many more young fry have been measured and identified as the one species or as the other. It is probable that two year classes are represented among the fry that are caught along shore in summer. Some of the smaller ones (2 to 3 inches long) may be from the earliest spawned eggs of that same season, but other squirrel hake of 2⅝ to 4⅛ inches (60–110 mm.) that were seined at Provincetown, on June 26, 1925, must have been about one year old, as they were taken too early in the season to have been the product of that year's spawning. And the larger ones of 6 or 7 inches are yearlings.

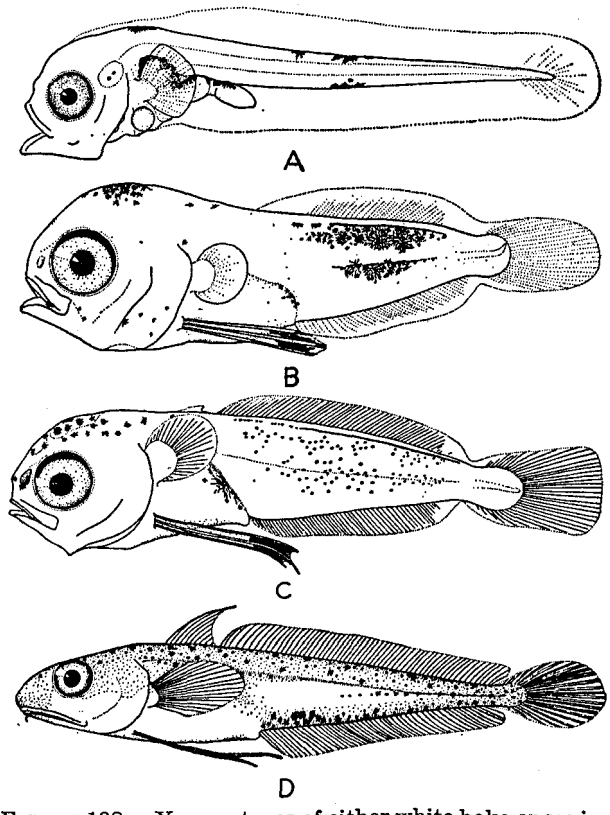

FIGURE 108.—Young stages of either white hake or squirrel hake. A, larva, 2.2 mm.; B, larva, 6.2 mm.; C, larva, 9 mm.; D, young fry, 40 mm. silvery still, and living at the surface of the water. Specimens collected off Woods Hole.

The growth of older squirrel hake in the Bay of Fundy has been studied by Craigie; his conclusions from scale studies,[33] combined with the relative abundance of fish of different size groups, being as follows.:

Age	Average length, inches	
	Male	Female
1 year-old	8	8
2 years-old	13	14
3 years-old	16	19

The indicated rate of growth is so uniform during the first three years of life as to suggest that spawning (an event so exhausting that it

[32] Fry figured by A. Agassiz (Proc. Amer. Acad. Arts, Sci., N. Ser., vol. 9, 1882, pl. 7, fig. 6; pl. 8, figs. 1–3), as *Motella argentata* undoubtedly were either white hake or squirrel hake. But the simple post anal pigment band, short, stocky bodies, and fan-like ventrals of the younger stages pictured by him under this same name (pl. 7, figs. 1–4) suggest that they were rockling.

[33] Contrib. Canadian Biol., (1914–1915) 1916, p. 87. Unfortunately, hake scales do not show the yearly growth zones as clearly as cod and haddock scales do.

slows the growth of any fish) probably does not take place until they have passed their third birthday. Nothing definite is known of the rate of growth of the white hake, but it is fair to assume that it grows faster than the squirrel, to attain its greater length and weight.

General range.—Both the white hake and the squirrel hake are exclusively American, occurring in continental waters from the Gulf of St. Lawrence and the southern part of the Grand Bank of Newfoundland southward to the Middle Atlantic States. The squirrel, though common as far south as Chesapeake Bay, has not been reported from farther south than Virginia. But the white hake is known off North Carolina (we have seen a 30 inch specimen that was trawled off Bodie I., North Carolina, lat. 35°52′ N., long. 74°51′ W. in 70 fathoms by the *Albatross II*, Feb. 24, 1931). And very likely the "squirrel" actually ranges as far south as the "white" does. Both of them occur from near tide mark, the squirrel down to about 175 fathoms, the white down to about 545 fathoms.

Occurrence in the Gulf of Maine.—Hake are very common fish in our Gulf, where the two species, white and squirrel, are caught side by side regularly. In the Bay of Fundy there are so few toward the head that stragglers are caught, or none at all, but they are plentiful enough toward the mouth where, for example, about 6,400,000 pounds were landed on the Nova Scotian side by Canadian fishermen in 1944, and about 8,200,000 pounds in 1946, while the yearly catch on the New Brunswick side is about 500,000 to 600,000 pounds. Other centers of abundance for them inshore are along the coast of Maine between Machias and Mount Desert Island, in Frenchman's Bay (formerly the site of an important hake fishery), the ground known locally as the "Grumpy" near Isle au Haut, and off Penobscot Bay.

Sundry small grounds outside the islands from Penobscot Bay to Cape Elizabeth and all along the western side of the Gulf, also yield good numbers of hakes, especially near Boon Island; the vicinity of the Isles of Shoals, a famous hake ground for small boat fishermen; Ipswich Bay; the lower slopes of Jeffreys and Stellwagen Banks; also the deeper parts of Massachusetts Bay, which yielded 750,000 pounds in 1919 when the demand for hake was better than it is now.

Hake, indeed, are so widespread on the lower slopes of all the banks and ledges in the inner parts of the Gulf, as well as on the mud floors between them, that Rich [34] listed 119 named grounds in the western side of the Gulf as good haking bottoms. Hake, with flounders, rosefish, and silver hake are practically the only commercially valuable fish one is likely to catch on the floors of the deep basins and channels of the Gulf; and a catch of 2,880 of them with 580 cusk, but no cod or haddock, by long-line fishing 15 miles southeast of Monhegan on June 24 to 25, 1913, will illustrate how completely they may monopolize suitable bottoms.

Hake are plentiful in the so-called South Channel also, and on the northwest slope of Georges Bank, whence about 2,000,000 pounds were landed in 1919, about 1,500,000 pounds in 1947. And it has long been known that there is an abundance of hake at depths greater than 60 to 70 fathoms all along the southern slope of Georges Bank. Long-line fishermen, too, have told us that while it was unusual to hook a hake on the shoaler parts of Georges, many were caught wherever the line was run off into deeper water on the northwest face of the bank; i. e., onto soft bottom. And this is borne out by the statistics of the catches, for the good trawling grounds on Georges Bank yield far fewer hake of marketable size than the inner parts of the Gulf do, if the year 1945 can be taken as representative.[35]

It has only been since 1944 that the landings of white hake and of red (i. e., squirrel) hake have been reported separately. Taken at their face value, these would point to the white hake as by far the more plentiful member of the pair throughout the inner parts of the Gulf as a whole, and on Georges Bank. In 1945, for example,[36] the reported landings were some 14 times as great for white as for red hake, for every one of the subdivisions into which the inner part of the Gulf is divided for statistical purposes, while only a few thousand pounds of red hake were reported from off eastern or central Maine, or from the northwestern part of Georges Bank; and none from the eastern or southwestern part of the

[34] Rept. U. S. Comm., Fish. (1929) 1930, App. 3, pp. 85–86, 96.

[35] Landings of hake in 1945 were about 414,000 pounds for Georges Bank; about 12,700,000 pounds for the inner parts of the Gulf by United States fishermen and about 9,140,000 pounds by Canadian fishermen.

[36] The only year when the landings of the two have been reported by counties for Maine and Massachusetts, besides the landings at the major ports.

Bank. But this would give a wholly false picture of the actual situation, because most of the red hake that are caught on these grounds are thrown overboard because they are too small to be worth gutting and icing under present market conditions.

Actually, we trawled 34 squirrel hake and only two other hake[37] in Ipswich Bay, in 22 fathoms on one occasion in July 1912; Welsh counted 5,450 squirrel hake to 652 white hake caught in otter trawling on the northwest slope of Georges Bank in June 1912; we counted 2,457 red hake to only 196 white hake from 29 trawl hauls at 22 to 150 fathoms on the southwestern part of Georges Bank and south of Nantucket Shoals on the *Albatross III*, May 11–18, 1950; and we saw 2,040 squirrel hake taken in 42 hauls by the *Eugene H* on the southwest part of Georges Bank, in late June 1951, but only 51 white hake. Reported landings also, in pounds, for 1945, were about 100 times as great for red as for white hake from the Nantucket grounds, whence all the little hake are brought in for the trash fish industry. And the discrepancy is greater still in numbers, for the white hake are much the heavier of the two, individually. Red hake also predominate over white among the hake landed in New York and to the southward, as is illustrated by the catch statistics for 1947.[38]

Landings, for 1947, to nearest 100,000 pounds:

	New York	New Jersey	Delaware
Red hake	1, 200, 000	5, 600, 000	200, 000
White hake	1, 000, 000	200, 000	100

On the other hand, inquiries of fishermen, corroborated by our own experience, point to the white hake as the more plentiful of the two in the basin of our Gulf at depths greater than 40 to 50 fathoms. The *Atlantis*, for example, trawled about 700 white hake in the deep basins off Cape Cod, west of Jeffreys Ledge and off Mount Desert, in August 1936, but only a scattering of squirrel hake. This appears to apply equally to the deeper holes in Massachusetts Bay at depths greater than 30 fathoms or so (both Storer and Goode and Bean spoke of the "white" as the more common of the two there), also to the Bay of Fundy region in general, including Passamaquoddy Bay, according to Huntsman. And nearly all of the hakes that have been listed by name from the more easterly of the Nova Scotian Banks, or from the southern part of the Grand Banks in the annual reports of the Newfoundland Department of Natural Resources, have been the white (*tenuis*). *Tenuis*, also, is the only member of the pair that was reported by Cornish[39] from Canso, but *chuss* alone is recorded from the Cape Breton shore of the Gulf of St. Lawrence by Cox,[40] who also records one from 205 fathoms on the Nova Scotian side of Cabot Strait.

The situation is made more confusing by Cornish's report of hake with 123 rows of scales from Prince Edward Island, and with 130 rows of scales from Canso, fish intermediate, that is, between *chuss* and *tenuis* in this regard, though favoring the latter. Perhaps the separation between the two species in number of scales, and also in other features, may not be so sharp toward the northern boundaries of their geographic ranges as we have found it farther south.

A more or less regular inshore movement of hakes of one or the other species, or of both of them, is said to take place in autumn, especially in the northeastern part of the Gulf, made evident by capture of considerable numbers in winter in the deeper, muddy harbors and bays east of Penobscot Bay, including St. John Harbor, and Kennebecasis Bay, which they reach by running up the St. John River, and where they are caught all winter through the ice. They also carry out corresponding movements in and offshore off southern New England, with goodly numbers appearing in shoal water at Woods Hole in autumn. But it is only in the spring and autumn that they are found close inshore off New York and off New Jersey. On the other hand, they are said to enter Passamaquoddy Bay in early summer, to withdraw in autumn.

Probably the explanation is that the adults, being cool water fish, are barred from the shallows in summer by high temperature along the coasts of Massachusetts and of west-central Maine, but that the low summer temperature of Passamaquoddy Bay allows large hake to summer there, as well as small. Their reported withdrawal from

[37] The latter were listed by Welsh as *U. regius*, but probably they were white hake.

[38] About 13,000 pounds of white hake were reported from Maryland in 1947, about 65,000 pounds from Virginia, and about 4,000 pounds from North Carolina, with no reds. But we suspect that reds were actually included as well as whites, and spotted hake also.

[39] Contrib. Canadian Biol. (1902-1905), 1907, p. 89.

[40] Contrib. Canadian Biol. (1918-1920), 1921, p. 113.

Passamaquoddy Bay in autumn may be in avoidance of extreme winter chilling. But we should remind the reader that failure to catch fish on hook and line in the cold season of the year (it is in this way that hakes are caught in the Passamaquoddy region) does not necessarily mean that they have departed. The hake may have stopped biting, as every fisherman knows by experience. The evidence of otter trawl catches is much more reliable in this respect, for ground fishes in general.

Except for in and offshore movements, hake are resident throughout the year in the open Gulf of Maine wherever they are found, once they have taken to the bottom. And they appear to be much more stationary than either cod or haddock.

The localities where we have found eggs, provisionally identified as squirrel hake (fig. 109), show that it spawns all around the Gulf from Cape Cod to Nova Scotia. And despite its rather deep-water habitat and preference for soft bottom, most of these egg stations have been in shoal water near the coast; a haul in the eastern basin which yielded both squirrel hake and silver hake eggs (p. 178) has been the only exception. This, of course, points to a movement from the basins into shoaler water for spawning.

It seems that the white hake spawns from late winter through spring to late summer, for we saw a

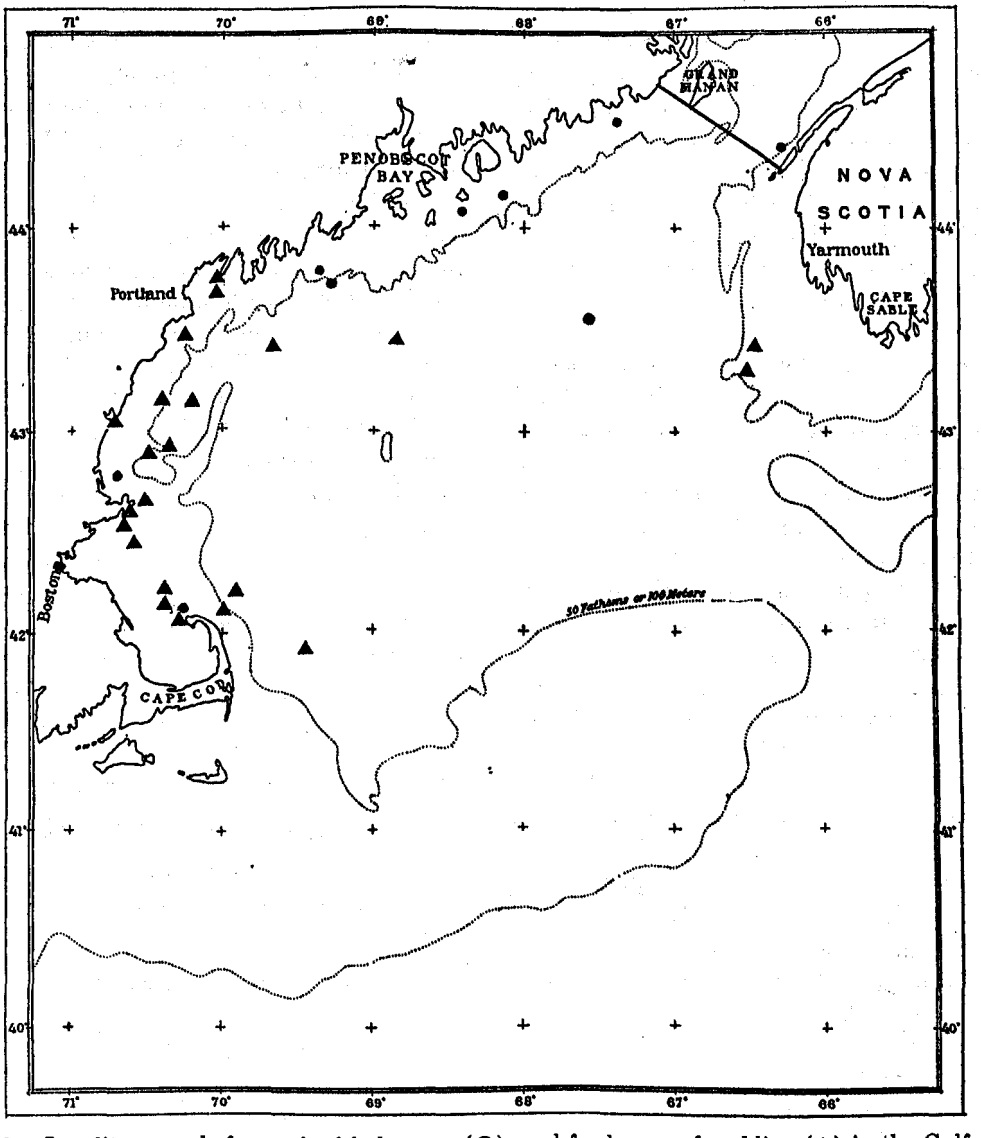

FIGURE 109.—Locality records for squirrel hake eggs (●), and for larvae of rockling (▲) in the Gulf of Maine.

30-inch female, with large roe, trawled off New Jersey (lat. 39°23′ N.) by the *Albatross II* at 88 fathoms, on February 27, 1929; Welsh saw a male with milt flowing, near Gloucester on April 22, 1913; we saw spent females, but also a male just ripening, trawled by the *Albatross III* on the southwestern part of Georges Bank on May 15, 1950; and Nichols and Breder [41] report a ripe female with ripe eggs at Woods Hole in July.

The height of the spawning season of the squirrel hake comes at least as early as June south of Cape Cod, and through early summer in the Massachusetts Bay region, judging from the size (27 to 70 mm.) of the fry mentioned above as found in scallop shells in late summer and autumn (p. 224). The extreme limits of the season are not known. But we have towed eggs of this species as early as June 10 in Petit Passage, Nova Scotia, and as late as September 20 in various parts of the Gulf, while captures of fry of 72 mm. as early as the last week in July (in Shelburne Harbor, Nova Scotia), and others as small as 36 mm. in the western part of the Gulf as late as November 1 (in 1916), point to a spawning season lasting from late spring until early autumn.

Abundance.—There is nothing in the statistical picture to suggest that hake of either species fluctuate very widely in abundance in our Gulf from year to year, for the ups and downs in the amounts caught are not greater than can be charged to market conditions. Neither has any attempt been made to estimate the periodic variations in the relative abundance of different year classes. Earlier characterizations of the numbers of the two hakes in our waters have been in relative terms, ranging from "common" to "in immense numbers." [42] More precise information is that the *Atlantis* caught an average of about 32 *tenuis* per hour's trawling, with an 82-foot trawl at 65 to 125 fathoms (120–228 meters) off Cape Cod, west of Jeffreys Ledge and off Mount Desert, in August 1936,[43] while the *Albatross III* trawled about 245 *chuss* and about 18 *tenuis* per hour's hauling on the southwestern part of Georges Bank and south of Nantucket Shoals in May 1950. And we find record of 145 *tenuis* taken per hour's trawling,[44] on Sable Island Bank, off outer Nova Scotia.

[41] Zoologica, N. Y. Zool. Soc., vol. 9, 1927, p. 172.
[42] Huntsman, Contrib. Canadian Biol., (1921) 1922, p. 68.
[43] Bigelow and Schroeder, Biol. Bull., vol. 76, 1939, p. 308.
[44] Report, Newfoundland Fish. Res. Comm., vol. 1, No. 4, 1932, p. 109.

Importance.—The hakes are soft-meated and have rather poor keeping qualities, but both the white and the squirrel hake are readily absorbed by the fish markets if they are large enough, and great numbers of small squirrel hake are now used for mink and poultry feed. A quarter of a century ago the yearly catch in the Gulf ran between 20 and 35 million pounds, and it has been much the same of late years (1941–1946), with yearly landings by Canadian and United States fishermen of between 19 and 30 million pounds. In 1946, which may serve as representative, Canadian fishermen landed about 2,100,000 pounds in outer Nova Scotian ports (Cape Sable to Cape North), about 4,800,000 pounds along the southern shore of the Gulf of St. Lawrence.

At the present time (as represented by 1946 and 1947) 4 to 5 times as much hake is marketed in Maine and Massachusetts in the form of fresh and frozen fillets as is marketed there salted, some are used for fish cakes, and a very small part [45] as smoked fillets. Hake sounds (swim bladders), especially of those that are caught off Nova Scotia in deep water, are also used to make isinglass,[46] and increasing amounts of small squirrel hake brought in from Nantucket Shoals, are utilized from year to year in the trash-fish industries.[47]

Roughly two-thirds of the poundage of hake that is landed in Maine and Massachusetts are caught in otter trawls nowadays, roughly one-fifth in gill nets, and only a little more than one-eighth on long lines.[48]

The hakes are such dull and inactive fish that they are of no special interest to the angler. But a good many fair-sized ones are caught hand-lining from party boats, for they bite readily, and small hake are caught from small boats in harbors and bays, along the Maine coast especially.

Spotted hake *Urophycis regius* (Walbaum) 1792

Jordan and Evermann, 1896–1900, p. 2553.

Description.—This species is distinguishable among the hakes of the Gulf of Maine by the fact

[45] About 39,000 pounds reported for 1946, none for 1947.
[46] For further information see Tressler, Marine Products of Commerce, 1949, pp. 489–491.
[47] Landings of red hake at New Bedford from the Nantucket Shoals region, mostly used in this way, were about 5,600,000 pounds in 1947.
[48] The amounts recorded for 1947 were:

	Pounds
Otter trawls	10,399,800
Gill nets	3,380,200
Long lines	2,097,200
Hand lines	102,200

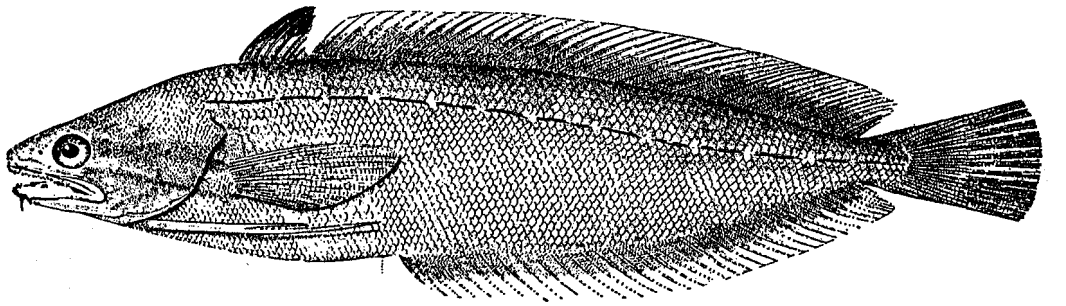

FIGURE 110.—Spotted hake (*Urophycis regius*). From Jordan and Evermann. Drawing by H. L. Todd.

that it has no prolonged rays in its first dorsal fin (which is hardly higher than the second dorsal, and has 8 or 9 rays); by the smaller number of rays in its second dorsal fin (46 to 51 as against 54 or more in the squirrel and white hakes); and by having only 90 to 95 oblique rows of scales along its sides from gill opening to caudal fin, instead of about 105 to 110 rows and about 140 rows, respectively, in the other two species. The anal fin has 43 to 49 rays, somewhat fewer, on the average, than the squirrel or the white hake (48 to 50).

Convenient field marks are that the outer half of its first dorsal fin is black with a whitish margin; that its pectoral fins reach back as far as the origin of the anal fin, whereas they fall considerably short of the latter in both the white and the squirrel hake; and that its lateral line is darker brown than the general body color, instead of paler, and is interrupted by a series of distinct whitish spots. Otherwise the spotted hake, like the commoner hakes, is dull brown, darker above than below, with dorsal and anal fins of the same color as the back. Its ventrals are whitish.

Size.—The largest of many measured by Welsh at Atlantic City, in August 1920, were about 16 inches long, and weighed between 1 and 1½ pounds; the usual length is less than 12 inches, and the longest, of about 600 taken by the *Albatross II* at 14 stations between the offing of Delaware Bay and Cape Hatteras, in late winter and spring (1930 and 1931) was 5⅛ inches (130 mm.).

Habits.—The spotted hake resembles the other hakes in its habits. It may be more of a fish eater, for Vinal Edwards noted that the few he examined at Woods Hole contained alewives, menhaden, launce, and squid. But it also feeds on the crustaceans on which the white and squirrel hakes subsist, for Hildebrand and Schroeder[49] found mysid-shrimps in most of those examined in Chesapeake Bay where small spotted hake are very common. The capture of spawning fish by the *Albatross*, off the coast of the Carolinas in December in 1919, recorded in Welsh's field notes, is evidence that it is a winter breeder.

General range.—Coast of the United States, regularly from southern New England and New York to Cape Hatteras (including Chesapeake Bay where it is plentiful), and ranging southward as far as the offing of northern Florida in deep water.[50]

Many were trawled as far northward as the offing of Delaware Bay by the *Albatross II*, in 1930 and 1931; it is reported as rather uncommon at New York;[51] it has been taken occasionally at Woods Hole; it has been known to reach the coast of Maine as a very rare stray; it was reported more than a century ago off Halifax, Nova Scotia, by Richardson;[52] and a single specimen was reported as taken, pelagic, near Sable Island (lat. 44°10′, long. 59°45′) in August 1931.[53]

Occurrence in the Gulf of Maine.—The spotted hake strays past Cape Cod so seldom that specimens taken off Seguin Island many years ago, and four, trawled on the southwestern part of Georges Bank, by the *Albatross III* in May 1950, are the only definite records of it for the Gulf of Maine.[54] But it may well have been overlooked among the hosts of young hake of the two common species (white and squirrel) that are caught in

[49] Bull. U. S. Bur. Fish., vol. 43, pt. 1, 1928, p. 161.

[50] The U. S. National Museum has specimens taken off Charleston, S. C., at 87 and 124 fathoms.

[51] Nichols and Breder, Zoologica, N. Y. Zool. Soc., vol. 9, 1927, p. 169.

[52] Fauna boreali Americana, vol. 3, 1836, p. 253. Richardson's wood cut of the specimen in question, from a sketch by Lt. Col. Hamilton Smith, shows the low first dorsal with black apex that is characteristic of the species *regius*.

[53] Report, Newfoundland Fishery Res. Comm., vol. 1, No. 4, 1932, p. 109.

[54] This species was also listed from Ipswich Bay, from Casco Bay, and off of Monhegen Island in the *Grampus* collections of 1912 (Bull. Mus. Comp. Zool. vol. 58, No. 2, 1914, p. 113), but it is probable that these specimens were white hake in reality.

the southwestern part of the Gulf every year, for 49 spotted hake were taken south of Block Island, in 47 to 67 fathoms, January 27 to February 3, 1950, by the dragger *Eugene H.*

Long-finned hake *Urophycis chesteri* (Goode and Bean) 1878

Jordan and Evermann, 1896–1900, p. 2556.

Description.—The most distinctive character of the long-finned hake is its very long ventral fins, the longest of the rays of which reach back nearly to the rear end of the anal fin (about to its fortieth ray), with the next longest ventral ray considerably overlapping the origin of the anal. The filamentous dorsal ray is longer also, than in the other Gulf of Maine hakes, reaching back to about the middle of the second dorsal fin or beyond. Furthermore, there are only about 90 rows of scales from gill opening to caudal fin along the lateral line, and the scales are relatively larger than in either the white hake or the squirrel hake; the eye is larger in the long-finned hake; the anal fin rays are more numerous (average about 56), the rear corners of the dorsal and anal fins are more rounded. The outline of the anal is slightly concave instead of straight (fig. 111); the pectoral fins are more slender and more pointed, and the caudal fin is narrower with more strongly convex margin; these differences are more clearly shown in the illustrations than verbally. The skin of the long-finned hake is curiously loose, like that of many deep-sea fishes.

Color.—Freshly preserved specimens are olive above and on the sides, with a silvery white belly. The fins are olive, with dusky markings on the dorsal filament, on the outer edge of the dorsal fins, on the caudal fin, and on the ventrals.

Size.—Specimens 14 to 15 inches (36 to 38 cm.) long, trawled by *Albatross III*, on the southwestern slope of Georges Bank and off Nantucket Shoals, in 105 to 240 fathoms, May 11–18, 1950, are the largest yet recorded.

Habits.—The long-finned hake is a bottom fish, living chiefly between 100 and 500 fathoms, the deepest record for it is from 538 fathoms. It is a summer and autumn spawner, judging from the fact that Goode and Bean saw specimens in breeding condition at that season. We have taken pelagic young of 8 to 35 mm. in our tows off Marthas Vineyard during the last week of August.[55] And captures of 3 fry, about 2¼ to 2¾ inches (57–71 mm.) long on April 26 (1931) and of 16 fish of about 3 to 4¼ inches (74–110 mm.) late that July suggests that a length of 4 to 5 inches is reached at 1 year of age.

General range.—This is a deep-water fish, occurring in great abundance on the continental slope off North America from the Laurentian Channel in Cabot Strait to abreast of Cape Lookout, N. C.

Occurrence in the Gulf of Maine.—This hake is plentiful all along the seaward slopes of Browns Bank, of Georges Bank and of Nantucket Shoals at depths greater than 100 fathoms, where it has been trawled at many stations.[56]

The *Albatross III*, for example, caught 861 in 63 half-hour trawl hauls, at 105 to 240 fathoms on the slope between the south-central part of Georges Bank (long. 67°14′ W.) and the offing of the eastern end of Long Island, New York (long. 71° 57′ W.) in May 1950. Up to 1931 the only

[55] Bigelow, Bull. Mus. Comp. Zool., vol. 59, No. 8, 1917, p. 275.

[56] For early locality records see Goode and Bean, Smithsonian Contrib. Knowl., vol. 30, p. 361.

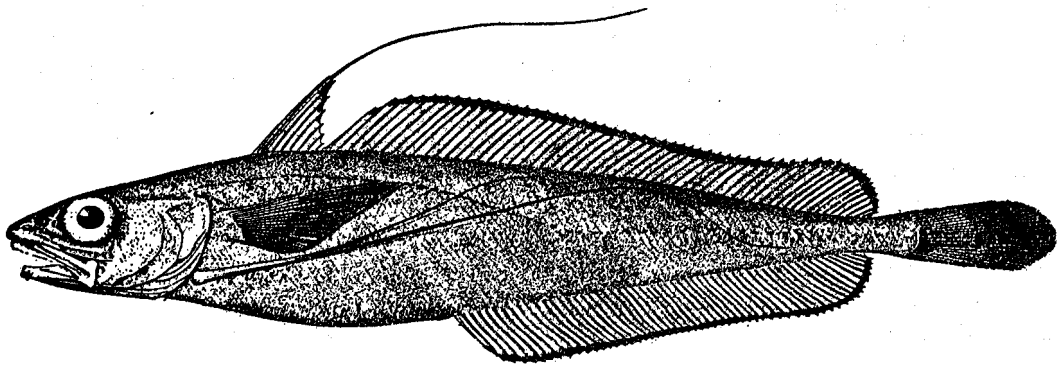

FIGURE 111.—Long-finned hake (*Urophycis chesteri*), off Cape Ann. From Goode. Drawing by H. L. Todd.

definite records of them from the inner parts of the Gulf had been of three specimens taken off Cape Ann,[57] in 110 to 140 fathoms, in 1878; and of a few others that were trawled on the northern edge of Georges Bank by the *Kingfisher*, in September 1929, in 85 to 100 fathoms. But captures of a number to the westward along the Bank and in the central basin of the Gulf in the summer of 1931, by the *Albatross II*[58] at depths of 70 to 140 fathoms, show that long-finned hakes are more numerous in the deeper parts of the Gulf than had been suspected previously.

Blue hake *Antimora rostrata* Günther 1878

Jordan and Evermann, 1896–1900, p. 2544, as *A. viola* Goode and Bean.

Description.—This species resembles the white, squirrel and spotted hakes in the form of its body and in having two separate dorsal fins, the first very short and the second very long; but it is readily distinguished from them by the fact that its anal fin is so deeply notched about midway of its length that it almost seems to have two separate anals, and that each of its ventral fins is 6-rayed, with the second ray prolonged and filamentous. The shape of the snout, which is flattened above, keeled at the sides, and blunted at the tip in some but forming an acute angle in others is distinctive, likewise its vent is situated much farther back than in the true hakes (genus *Urophycis*), and its body, in life, is deep violet, blackish brown, or blue black, below as well as above.

Size.—The longest yet measured was one of about 21½ inches (545 mm.).

Range.—The blue hake was reported at so many localities along the continental slope from the early cruises of the U. S. Bureau of Fisheries[58a] on the Nova Scotian slope; off southern New England; and southward to the offing of Cape Hatteras, North Carolina, at 350 to 1,000 fathoms that it must be one of the more plentiful of fishes there.

We have recently trawled a few at 220 to 460 fathoms, on the southeastern Nova Scotian slope, on the *Caryn* of the Woods Hole Oceanographic Institution, between longitudes 64° W. and 65° 56′ W., and halibut fishermen have occasionally brought them in. But the blue hake has not been taken within the limits of the Gulf of Maine, and it is hardly to be expected there; the shoalest capture recorded for it so far is from 220 fathoms. We mention it on the chance that vessels trawling on the slope may occasionally work deep enough to pick up a few.

The known range of this deep sea hake includes the North Atlantic from Denmark Strait to the offing of Gibralter in the east and from the Newfoundland Banks to the offing of Cape Hatteras in the west; Uruguay; the eastern Pacific, British Columbia to Panama, and the southern Indian Ocean. It has been taken as deep as 1,456 fathoms.[59]

Hakeling *Physiculus fulvus* Bean 1884

Jordan and Evermann, 1896–1900, p. 2547.

Description.—This fish is hakelike in its general appearance, also in the general arrangement of its

[57] These were the basis of Goode and Bean's original description of the species (Proc. U. S. Nat. Mus., vol. 1, 1878, p. 256).

[58] Reported by Bigelow and Schroeder, Bull. U. S. Bur. Fish., vol. 48, 1936, p. 339.

[58a] See Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895, pp. 374–375) for list of stations.

[59] For a recent summary, see Schroeder, Copeia, 1940, No. 4, pp. 236–237.

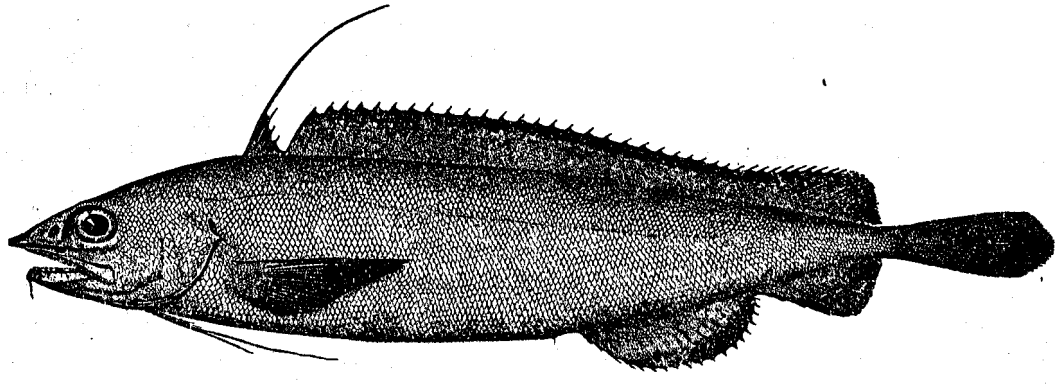

FIGURE 112.—Blue hake (*Antimora rostrata*), La Have Bank. From Goode. Drawing by H. L. Todd.

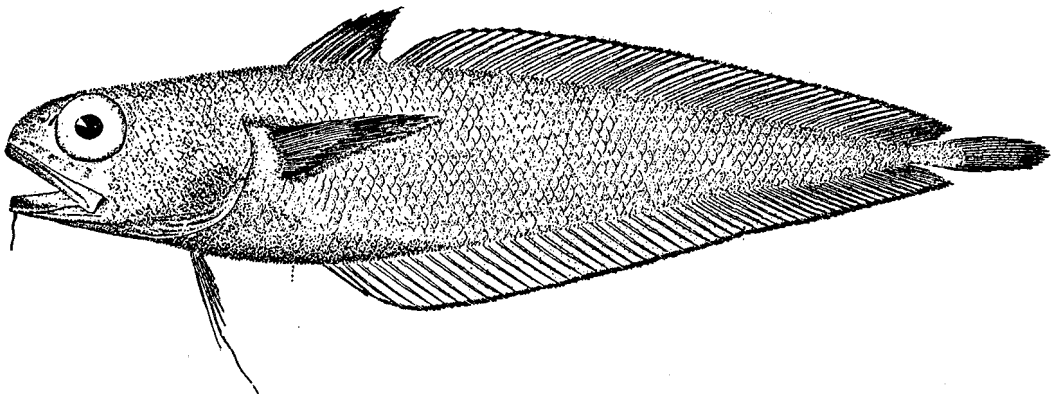

FIGURE 113.—Hakeling (*Physiculus fulvus*), outer edge of Continental Shelf off Nantucket. From Goode and Bean. Drawing by H. L. Todd.

fins, for it has two dorsals, the first (10 rays) triangular and much shorter than the second (about 49 rays) which is of nearly uniform height from end to end; one long anal fin (about 54 rays) which is similar to the second dorsal in shape; and ventral fins situated in front of the pectorals. It is separable from the white, squirrel, and long-finned hakes (genus *Urophycis*, pp. 221 and 232) in that its anal fin originates in front of the origin of the second dorsal fin instead of considerably behind the latter and that its ventral fins have 5 rays each instead of 2 and are much shorter than those of the true hakes, with the longest ray (the second, which is filamentous at the tip) hardly reaching back as far as the middle of the pectoral fins. Furthermore, the snout of the hakeling is blunter than that of any true hake; its caudal fin much smaller; its body tapers more abruptly; and none of the rays of its first dorsal fin are prolonged.

Color.—Described as light yellowish brown with the lower surface of the head, the abdomen, and the margins of the dorsal and anal fins very dark brown, and with a dark brown blotch on each cheek (on the subopercular bone). We have not seen it fresh from the water.

Size.—The maximum size is not known.

Habits.—Nothing is known of the habits of the hakeling except that it is a deep-water fish, having been taken from 79 fathoms down to 955 fathoms, where it lives on or near the bottom, to judge from its general structure.

General range and occurrence in the Gulf of Maine.—This hakeling has been taken at several localities in the Gulf of Mexico and on the continental slope off the eastern United States. The most northerly record for it is off Nantucket (lat. 40° 01′ N., long. 69° 56′ W.) in 79 fathoms, and it is on this record that the hakeling is mentioned here.[60]

Four-bearded rockling *Enchelyopus cimbrius* (Linnaeus) 1766

ROCKLING

Jordan and Evermann, 1896–1900, p. 2560.

Description.—The rocklings, of which this is the only common local representative, differ from their near relatives, the hakes (genus *Urophycis*), in the facts that their ventral fins are short, with 5 to 7 rays, and that the first section of their dorsal fin consists of only one ray, which is nearly as long as the head, and which stands over the upper corners of the gill openings, followed by a series of about 50 very short, separate, hairlike rays without connecting membrane, which can be laid down in a groove on the back. Thus there is only one well-developed dorsal fin. Rocklings differ further from all other gadoids in the presence of long barbels on the top of the nose as well as on the chin, the number of these being the most obvious specific character among the several species of rocklings. In the present species there are a pair of these barbels close in front of the nostrils, a third and somewhat shorter barbel standing alone on the tip of the snout, and there is a fourth barbel hanging from the chin.

Rocklings remind one of young hake in their slender bodies tapering back from the shoulders;

[60] Another small hakeling (*Lotella maxillaris*) has been taken off Marthas Vineyard. It is separable from the hakeling described above by the fact that its anal fin originates behind the origin of the second dorsal fin, and by its larger teeth.

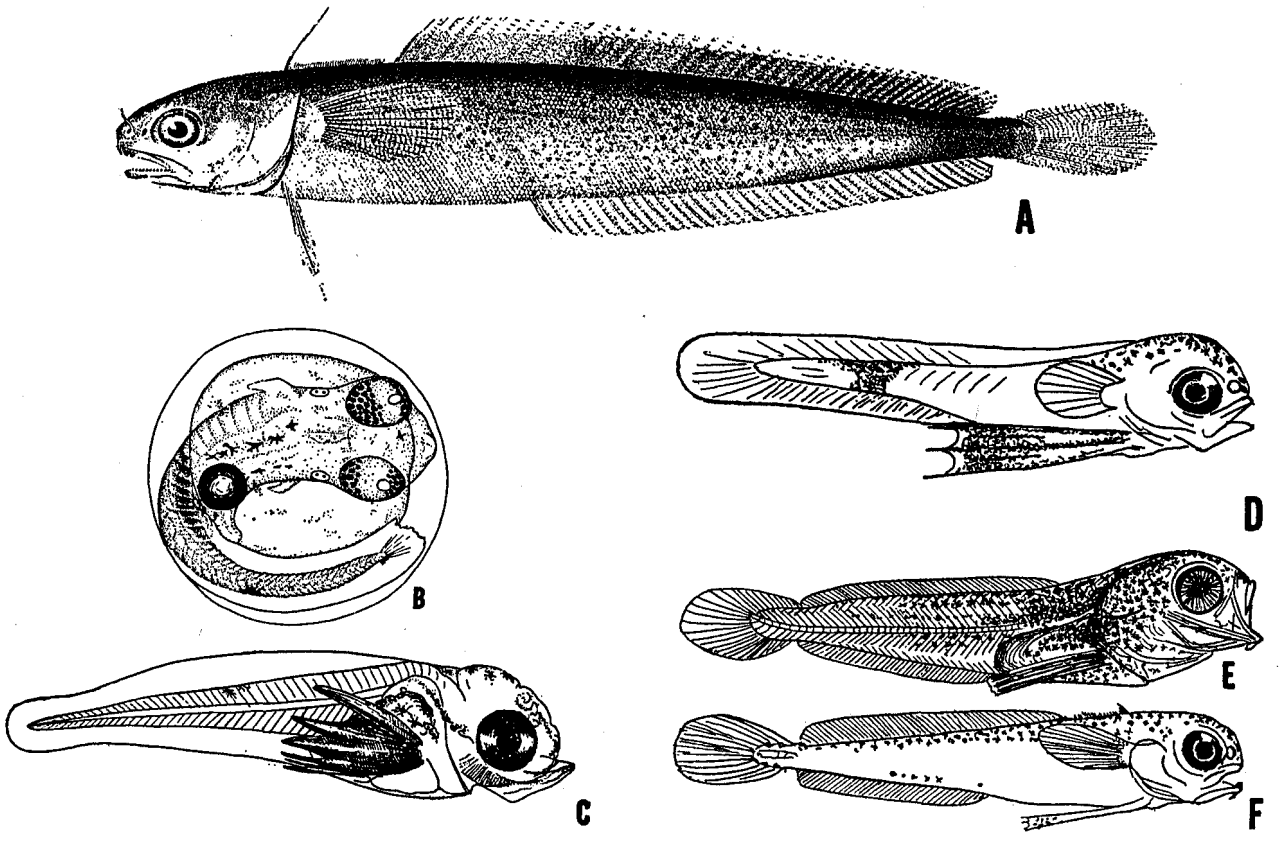

FIGURE 114.—Rockling (*Enchelyopus cimbrius*). A, adult, Bay of Chaleur, from Jordan and Evermann, drawing by H. L. Todd; B, egg; C, larva (European), 3.6 mm.; D, larva (European), 5.3 mm.; E, larva (European), 13.6 mm.; F, silvery fry (European), 17.5 mm. B, after Battle; C, after Ehrenbaum and Strodtman; D, after Brook; E, after Ehrenbaum; F, after Brook.

and (hakelike) they are rounded in front of the vent but flattened sidewise behind it. Their upper jaw is longer than the lower and their teeth are smaller than in the hakes, while their noses are shorter and blunter; their eyes are smaller, and the dorsal profile of their heads is more rounded than it is in any of the hakes. The pectorals are rounded and the narrow pointed ventrals are situated well in front of the latter. The second dorsal fin (45 to 53 rays) originates over the mid length of the pectorals, runs back nearly to the base of the caudal fin, and is equally high from end to end with a rounded rear corner. The anal fin is similar to the second dorsal in shape, but it is shorter (39 to 43 rays).[61] The caudal fin is oval when it is spread.

Color.—The color of this rockling is comparatively constant by all accounts and this is corroborated by our own experience. Its back is dark yellowish olive or dusky brown, its sides are paler, and its belly is white dotted with brown. On some individuals the sides behind the vent are more or less clouded with a darker shade of the general body hue. The first dorsal ray, the posterior edges of the second dorsal fin and of the anal fin, the lower half of the caudal fin, and the pectoral fins are sooty or bluish black. Otherwise the vertical fins are grayish or bluish brown. The ventral fins are pale, and the lining of the mouth is dark purplish or bluish.

Size.—This rockling has been described as growing to a length of 16½ inches in Scandinavian waters, but about 12 inches is the longest recorded from the Gulf of Maine, where they average only about 6 to 10 inches.

Habits.—Rocklings are bottom fish, like hake. Occasionally they have been found in very shallow water, on Nahant Beach in Massachusetts Bay, for example; in water only a few feet deep at Woods Hole; in 6 to 7 fathoms, both in St. Mary's

[61] Storer credits it with 48 rays, but subsequent students have not found so many.

Bay, Nova Scotia, and in Buzzards Bay on the south coast of Massachusetts. But they appear to be more plentiful in depths of 25 to 30 fathoms or more; there are rocklings in the deep gully off Halifax, and also in the deep trough of the Gulf of St. Lawrence.[62] They have been taken on the continental slope off southern New England to a depth of 724 fathoms.[63] And there is no reason to suppose that the adult fish ever rise far above the bottom, unless by accident.

The occasional appearance of adult rockling in very shallow water in winter near Woods Hole [64] suggests that some may work inshore and into shoal water in autumn, to work offshore again and deeper in spring, for the summer. Beyond this they seem to be year-round residents wherever they are found.

The name "rockling" is a misnomer for this fish for it is found most often on soft bottom in the Bay of Fundy, while those that we have trawled in Massachusetts Bay and in Ipswich Bay from the *Grampus* were on smooth muddy sand between the hard patches. And most of the rockling living in the deep sinks and channels in the western side of our Gulf, and on the continental slope, are on soft smooth ground.

Judging from the stomach contents of Scandinavian and British fish (their stomach contents have not been examined on this side of the water so far as we know) they feed chiefly on shrimps, isopods, and other small crustaceans, less often on fish fry. On the other hand, rockling have been found in cod stomachs in Massachusetts Bay, and no doubt all fish of prey devour them on occasion.

The eggs are buoyant, described (we have never seen them) as 0.66 to 0.98 mm. in diameter. When newly spawned the oil is in small droplets, most of which soon coalesce into one globule of 0.14 to 0.25 mm., often with one or two smaller ones close to it. The danger of confusing them with squirrel-hake eggs is discussed in the account of that fish (p. 226). And Battle has found that they develop normally at temperatures ranging from 55° to 66°.[65]

Newly hatched larvae are a little more than 2 mm. long. The yolk is absorbed at about 3.6 mm. and the later larval stages, up to about 10 mm. long, are characterized by the very large black ventral fins shown in the illustrations (fig. 114); by the presence of only one post anal band of black pigment; and by the short stocky body-form. Young hake are more slender and have scattered pigment; young cusk have two post anal bands; and all other Gulf of Maine gadoids have short ventral fins. After the rockling is 17 to 20 mm. long the structure of the first dorsal fin serves to identify it.

These larger fry are silvery, awaiting their descent to bottom before assuming the dull colors of the adult. In British waters they are sometimes called "mackerel midges" because they suggest little mackerel remotely, in their general appearance. In European waters, where there are more plentiful populations of the silvery fry of one or the other species of rockling they are often cast ashore. And one such instance is described for our Gulf by Storer [66] who writes that many were picked up on Nahant Beach during one tide in the summer of 1860; and others found in the surf at West Beach, Beverly.[67]

Rockling fry, like those of other gadoids, drift at the surface for their first few months. How long they do so in our waters is not known, but analogy with cod, haddock, and other species suggests three months at most. And it may be assumed they seek the bottom at a length of about 2 inches for our largest pelagic fry were 40 to 45 mm. long. During this pelagic stage they drift with the current like any other fish fry, and are at the mercy of mackerel and other fish. But they are not plentiful enough in the Gulf of Maine to be as important an article in the diet of the mackerel as the fry of the far commoner European

[62] Huntsman (Trans. Roy. Soc. Canada, 3, vol. 12, Sect. 4, 1918, p. 63) and further information contributed by him.

[63] Goode and Bean, (Smithsonian Contrib. Knowl., vol. 30, 1895, pp. 384–385) give a long list of locality records for the rockling on the shelf and slope between the offings of eastern Nova Scotia and of North Carolina (lat. 35°40′ N.).

[64] Sumner, Osburn, and Cole, Bull. U. S. Bur. Fish., vol. 31, Pt. 2, 1913, p. 771.

[65] Battle (Contrib. Canadian Biol., N. Ser., vol. 5, No. 6, 1930) has made a careful study of the effects of extreme temperatures and salinities on the development of the eggs of the rockling.

[66] Fishes of Massachusetts, 1867, p. 279.

[67] These fry, and one recorded at Nahant earlier by Gill (Proc. Acad. Nat. Sci., Philadelphia, (1863)1864, p. 241) were reported as an Arctic 3-bearded species (*Gaidropsarus argentatus* Reinhardt) which was described originally from Greenland and which has been found widely distributed in Denmark Strait; on the north coast of Iceland; and in the Norwegian Sea from the Faroes north to Bear Island. But there is no reason to suppose that the Nahant specimens were anything other than the fry of our common four bearded rockling. For a recent account and discussion of the species *argentatus*, with excellent illustrations, see Jensen, Spolia Zool. Mus. Hauniensis, Copenhagen, vol. 9, 1948, pp. 167-173, pl. 4, fig. 4.

rocklings are, on the other side of the Atlantic. Nothing is known of their subsequent rate of growth.

General range.—Both sides of the North Atlantic. The American range is from the northern part of the Gulf of St. Lawrence and the northeastern coast of Newfoundland (perhaps even farther north) to Narragansett Bay and Long Island Sound in coastal waters, and to the latitude of Cape Fear (N. C.) in deep water along the continental slope.[68] The Arctic three-bearded rockling (*Gaidropsarus ensis* Reinhardt), otherwise known only from Greenland, has been trawled on the lower part of the continental slope in the offings of southeastern Nova Scotia, of Cape Cod, of Martha's Vineyard, of New York and of New Jersey at depths of 858 to 1106 fathoms, by the *Fish Hawk* and *Albatross I*, but this is not shoal enough to bring it within our limits.[69]

There are several other species of rockling in north European waters, but none of them have been recorded from our side of the Atlantic.

Occurrence in the Gulf of Maine.—The little rockling is of no commercial value, and it seldom comes up into very shallow water where it would force itself on the notice of seaside visitors. But it is a common bottom fish in the deeper parts of Massachusetts Bay as Goode and Bean [70] remarked long ago, while our experience, corroborated by Huntsman for the Bay of Fundy, is that this applies to the entire Gulf. Definite Gulf of Maine records for adult rocklings are from St. Mary Bay (Nova Scotia); various localities in the Bay of Fundy including Passamaquoddy Bay; Jonesport; off Mount Desert; off Pemaquid; near Seguin Island; mouth of Casco Bay; the deep gully to the westward of Jeffreys Ledge; Ipswich Bay; Gloucester; Nahant; various stations in the deeper parts of Massachusetts Bay; Provincetown; the deep open basins of the Gulf; [71] and Georges Bank. And we have taken its young fry rather frequently in our tow nets in season.

Huntsman [72] and Battle [73] have found the eggs of this rockling in Passamaquoddy Bay throughout the summer, commencing in May and most abundantly at the time the bottom water warms to 9° or 10° C. And its breeding season probably continues from spring to early autumn in the western Atlantic as it does in the eastern,[74] for Dannevig [75] (1919) records rockling eggs (probably this species) as early as the end of May near Halifax, while we have taken rockling larvae only 5.5 mm. long as late as September and October in our tow nets in Massachusetts Bay.

It is probable that the rockling spawns all around the peripheral belt of the Gulf, with Massachusetts Bay as an important nursery, to judge from our repeated captures of its larvae there. And we have taken the pelagic fry in our tow nets at the various localities marked on the accompanying chart (fig. 109) from the first week in July until October; seldom, however, more than half a dozen in any one haul (the largest catch was 18 specimens). Huntsman, similarly, describes the fry as common in the center of the Bay of Fundy, and they have been taken in the tow nets at Woods Hole in April. But we have taken neither the eggs, the larvae, nor the pelagic fry in any of our tow nettings in the central parts of the Gulf, which perhaps justifies the assumption that the spawning grounds of the rockling within our Gulf are limited mostly to depths less than 75 fathoms, though it may spawn much deeper than that on the continental slope.

To the west of Cape Cod, the rockling is now known to occur in coastal waters as far as Narragansett Bay, and in Long Island Sound, where it was found generally in 5½ to 9 fathoms, and abundantly at 21 fathoms by the *Fish Hawk* in the summer of 1914.[76] And it has been trawled by the *Fish Hawk* and by the *Albatross I* at many stations in deeper water offshore along the shelf and slope, southward to the offing of Cape Hatteras (lat. 35° 40′ N.).[77]

[68] A specimen trawled by the *Albatross II* in 12 fathoms off the mouth of Chesapeake Bay on February 10, 1930, is the only one recorded in shallow water so far southward.

[69] Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895, p. 381) give a list of these localities. For a recent account of *G. ensis*, with illustrations, and list of Greenland localities, see Jensen, Spolia Zool., Mus. Hauniensis, Copenhagen, vol. 9, 1948, p. 167, pl. 4, fig. a.

[70] Bull. Essex Inst., vol. 11, 1879, p. 9.

[71] The *Atlantis* trawled it both in the Jeffrey bowl, and in the open basin of the Gulf, August 1936; and we trawled it in the central basin in July 1931.

[72] Contrib. Canadian Biol. (1921) 1922, p. 69.

[73] Contrib. Canadian Biol., Fish., N. Ser., vol. 5, No. 6, 1930, p. 13 [119].

[74] It spawns from the end of January until August in the Baltic.

[75] Canadian Fisheries Exped., (1914–1915) 1919, p. 53, table 1C.

[76] Nichols and Breder, Zoologica, N. Y. Zool. Soc., vol. 9, 1927, p. 172.

[77] For list of early stations, see Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895, pp. 384–385). They also report a specimen apparently of this species from the offing of Cape Fear, N. C. (lat. 34° 01′ N., long. 76° 11′ W.). But it was in poor condition, hence of doubtful identity.

Eastward and northward from our limits, the rockling is said to be rather common in Nova Scotia waters in general, coastwise as well as on the fishing banks. The *Albatross* trawled it at three stations along the continental edge between the offing of southwestern Nova Scotia and of Sable Island, at 93 to 134 fathoms; and while Huntsman [78] describes it as characteristic of the deep channels of the Gulf of St. Lawrence, Dannevig [79] points out that the stations within the Gulf of St. Lawrence where the Canadian Fisheries Expedition took rockling eggs and larvae in any number, rather generally distributed in the southern part, a few in the northeastern part, were all "close to land or above the more shallow banks." Pelagic rockling fry are listed under this name in the Reports of the Newfoundland Fishery Research Commission also, from many stations in the Grand Banks region, and around the coast of Newfoundland to the Northern Peninsula on the east and to the inner end of the Strait of Belle Isle on the west. But it would not be astonishing if the fry of the three-bearded rockling (p. 237) should prove to be represented in these collections, together with those of our four-bearded species. Dannevig, indeed, has suggested that part of the rockling eggs taken by the Canadian Fisheries Expedition in Nova Scotian waters and south of the Grand Banks in May and June belonged to some species other than *cimbrius*.

Importance.—The rockling is neither large enough nor plentiful enough to be of importance commercially, or of interest to the angler.

Cusk *Brosme brosme* (Müller) 1776

TUSK; TORSK

Jordan and Evermann, 1896–1900, p. 2561.

Description.—The cusk is separable from all its Gulf of Maine relatives at a glance by the fact that it has only one dorsal fin. The relationship of the anal and dorsal fins to the caudal and the outline of the latter are distinctive also, for both the dorsal and the anal are continuous with the caudal at the base but are separated from it by notches so deep that they are obviously distinct. And the caudal is evenly rounded. The cusk is a more slender fish than the hakes, being only about one-fifth to one-sixth as deep as it is long, round-bodied in front of the vent but flattened sidewise behind the vent, and tapering evenly backward to the base of the caudal fin. The mouth is large, gaping back to opposite the rear third of eye, is set slightly oblique, and is armed with small, sharp, curved teeth. The snout is blunt at the tip. The upper jaw encloses the lower when the mouth is closed; the eye is of moderate size; the chin bears one barbel; and the entire head and trunk are clad with small scales. The dorsal fin (85 to 105 rays) runs the whole length of the back from the nape of the neck, and is of uniform and moderate height from end to end with rounded corners. The anal fin is similar to it in outline but is only a little more than half as long (71 to 76 rays). The pectoral fins are rounded, and about half as long as the head. The ventral fins are about as long as the pectorals, with their 5 rays free at the tips, and are situated a little (but obviously) in front of the pectorals. All the fins are so thick and fleshy at their bases that it is only near their margins that the rays are to be seen.

Color.—The cusk varies in color, no doubt conforming to the bottoms on which it lives. Its upper parts range from dark slaty to dull reddish brown or to pale yellowish, paling to grayish on the lower part of the sides and to dirty white on the belly. Old fish are plain colored, the sides of small ones, however, are often cross-barred

[78] Trans. Roy. Soc. Canada, Ser. 3, vol. 12, Sect. 4, 1918, p. 63.
[79] Canadian Fisheries Exped. (1941–1915) 1919, p. 27: charts figs. 18, 19.

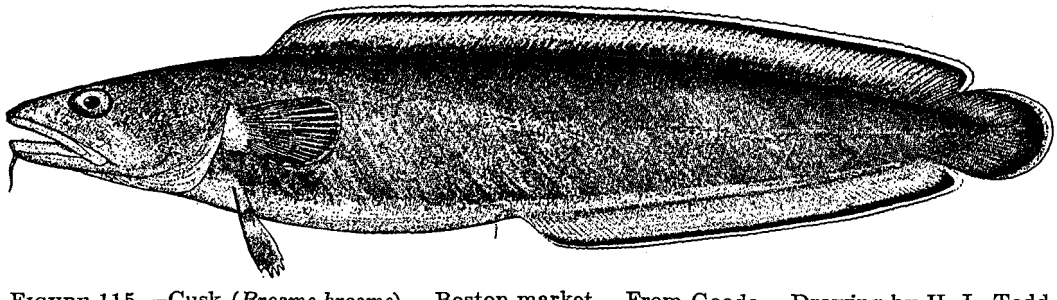

FIGURE 115.—Cusk (*Brosme brosme*). Boston market. From Goode. Drawing by H. L. Todd.

with about half a dozen yellowish bands. The pectoral and ventral fins are of the same color as the sides, and the ventral fins are sooty at their tips. The most characteristic color mark is that all three of the vertical fins (dorsal, caudal, and anal), which are of the general body tint at their bases, are black at the margin, and they are narrowly edged with white, except that the anal may lack the white edging on some individuals.

Size.—Cusk grow to a maximum length of about 3½ feet; one 40 inches long, weighing 27 pounds, trawled by the *Albatross II* in the central part of the Gulf of Maine, in 120 fathoms, was the largest that has been recorded definitely from our waters. But those caught in the Gulf of Maine average only 1½ to 2½ feet long, and from 5 to 10 pounds in weight. The relationship of weight to length, in fish we have handled recently, was as follows: 26 inches, about 5½ pounds; 33½ inches, about 14¾ pounds; 36 inches, about 20 pounds. The size at which cusk first mature sexually seems not to have been recorded.

Habits.—Once the young fry have taken to the bottom they are ground fish so exclusively that we have never heard of one swimming up to the upper waters, as cod so often do, and even hake. They are sluggish, too, and weak swimmers, but powerful of body; when a cusk is hooked it is likely to twine itself around one's line in a bothersome way.

They are more or less solitary, not so abundant anywhere as cod, haddock, or hake are, as may be illustrated by the following catches counted as they came from the water by representatives of the Bureau of Fisheries in 1913: Twenty miles east of Cape Cod Light, November 16 and 17, 1913, long line, 460 cusk to 2,150 haddock and 1,228 cod; 15 miles southeast of Monhegan Island, June 24 and 25, 1913, long lines, 580 cusk to 2,880 hake; Jeffreys Ledge, December 11 and 12, 1913, long line, 230 cusk to 470 haddock and 475 cod; northwest part of Georges Bank, October 10 to 13, 1913, otter trawl, 4 cusk and 12,473 haddock; 6 miles east of Boon Island, March 30, 1913, gill net, 5 cusk, 1,055 haddock; 51 cod, 20 pollock, and 76 dabs (*Hippoglossoides*).

It also seems that cusk move little from bank to bank. Thus the "Massachusetts fishermen tell me," wrote Goode [80] "that these fish are usually found in considerable abundance on newly discovered ledges, and that great numbers may be taken for a year or two, but that they are soon all caught. Sometimes, after a lapse of years, they may be found again abundant on a recently deserted ground." Neither is there any definite evidence that the cusk performs in or offshore migrations with the seasons, at least in our Gulf.

The cusk is so purely a fish of at least moderately deep water that we have never heard of one taken in less than 10 to 15 fathoms of water within our Gulf. On the other hand, it is safe to say that there are few cusk living below 100 fathoms or so in the deep basins of the Gulf. But they range down to 250–300 fathoms on the continental slope off southern New England, according to Goode and Bean.[81] And they have been caught down to 530 fathoms in the Faroe Channel.

Cusk are decidedly fastidious, too, in their choice of bottoms, being found chiefly on hard ground, especially where the sea floor is rough with rocks or boulders; on gravelly or pebbly grounds; occasionally on mud with hake, but seldom on smooth clean sand. In Norwegian waters they often lurk among gorgonian corals, and they may have this same habit on the parts of our offshore banks where these are plentiful.

The cusk is a fish of cool water, but not of the coldest. In the Gulf of Maine (once the fry have deserted the surface for the bottoms at their chosen depths), cusk spend their lives in water which does not warm above about 48° to 50° at the warmest season, nor cool below about 33° to 34° at the coldest. And it is probable that temperatures of 32° F. or lower are the factor that limit their American range in the north (p. 242).

Food.—Little is known of the diet of the cusk. European students describe the stomachs as usually containing crustaceans, sometimes mollusks. And crabs, with occasional mollusks, that we found in the stomachs of several cusk caught on Platts Bank in the summer of 1924, are the only record of its food of which we know, for this side of the Atlantic. But the cusk is not fastidious as to bait, accepting clams, cockles, and herring readily.

Cusk spawn in spring and early summer in both sides of the Atlantic. In European waters the season lasts only from April until June; but

[80] Fish. Ind. U. S., Sect. 1, 1884, p. 233.

[81] Smithsonian Contrib. Knowl., vol. 30, 1895, p. 385.

throughout July in the Gulf of Maine, for we have caught several nearly ripe females on Platts Bank and around Boon Island at the end of that month, though we have seen no perfectly ripe fish. In the eastern Atlantic cusk spawn chiefly deeper than 100 fathoms, to judge from the distribution of the eggs at the surface. But the chief production of eggs probably takes place in shallower water in the Gulf of Maine, since most of the stock lives in lesser depths there. And some must spawn close inshore, for we have taken cusk larvae only 6 to 13.8 mm. long off Cape Cod; in Provincetown Harbor; and near the Isles of Shoals.[82]

We owe what is known of the eggs and larvae to European students. The cusk is among the more prolific of fishes, more than 2 million eggs having been estimated in a female of medium size. Their eggs are buoyant like those of other gadoids; 1.29 to 1.51 mm. in diameter, with one oil globule of 0.23 to 0.3 mm.; and they may be recognized by the brownish or pinkish color of the oil globule, together with the fact that the entire surface of the egg is finely pitted.

The larvae are about 4 mm. long when they hatch. The vent is situated at the base of the ventral finfold as it is in other gadoids, but they are separable from all other gadoid larvae that occur in the Gulf of Maine by the pinkish oil globule at the posterior end of the yolk. The yolk is absorbed in about a week after hatching, when the larvae are about 5 mm. long. The ventral fins of the little cusk elongate as it grows, like those of young hake and of young rockling, besides becoming heavily pigmented with black. But cusk larvae are separable from those of hake and of rockling by the fact that their ventral fin rays are separate one from another, and by the presence of three patches of black pigment: one on the top of the head; a second over the gut; and a third at the tip of the tail, besides two vertical black bands which divide the trunk behind the head into three nearly equal sections. The rockling has only one band of pigment behind the vent, and neither of the hakes that are common in the Gulf of Maine has a definite cross-band of pigment.

The first traces of the vertical fin rays of the young cusk are visible at about 12.5 mm.; the dorsal and anal fins are differentiated at about 28 mm.; and it is at this stage that the ventrals are at their longest, relatively. Fry of 40 mm. and upward show most of the characters of the adult. And the relationship of their dorsal and anal fins to the caudal, and the presence of only one dorsal fin and one anal fin is sufficient to identify them from this stage on.

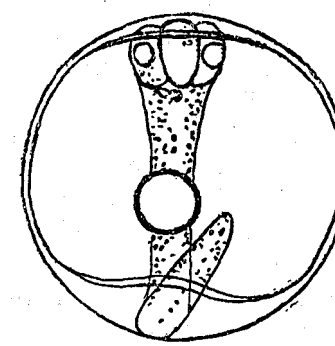

FIGURE 116.—Egg (European). After Schmidt.

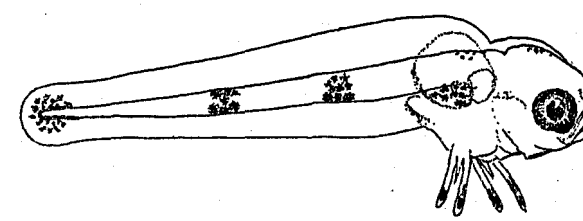

FIGURE 117.—Larva, 6.8 mm. (European). After Schmidt.

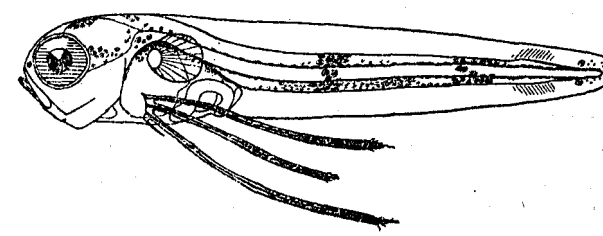

FIGURE 118.—Larva, 9.25 mm., off northern Cape Cod.

CUSK (*Brosme brosme*).

The older cusk fry, while still living at the surface, are described by Schmidt [83] as greenish yellow with blue eyes, not silvery-sided.

The young cusk drifts near the surface, as other gadoids do, until it is 2 inches long or more, and there is reason to believe that in European seas they first seek the bottom in considerable depths. But we have nothing to offer on this point for the Gulf of Maine.

[82] The records are July 22, 1912, 1 specimen; July 20, 1916, 4 specimens; and July 22, 1916, 1 specimen.

[83] Meddel. Kommis. for Havundersøgelser, Serie Fiskeri, vol. 1, No. 8, 1905, p. 7. He also describes the larval stages of the cusk.

The rate of growth of the cusk has not been studied, so far as we know.

General range.—Both sides of the North Atlantic, chiefly in moderately deep water and on hard bottoms; north on the American coast to the Newfoundland Banks, and to the Strait of Belle Isle, south regularly to Cape Cod, rarely to southern New England, and occasionally to New Jersey; northern coasts of the British Isles, Denmark (Jutland), northern part of the North Sea, and Kattegat off Bohuslan, Sweden, to Iceland and the Murman coast in the eastern Atlantic. It reaches east and west Greenland only as a rare stray from the south.

Occurrence in the Gulf of Maine.—The cusk is distributed very generally in the Gulf in water deeper than 10 to 15 fathoms, its presence or absence depending on the precise type of bottom. Because of its preference in this respect (p. 239), it varies greatly in abundance in different parts of the Gulf, and the grounds occupied by it are much less extensive than those haunted by cod, by haddock, by pollock, or by the hakes. Thus cusk are rarely taken in Cape Cod Bay or in the deeper holes in Massachusetts Bay, and we have taken none on the soft mud of the deep bowl west of Jeffreys Ledge. But considerable numbers are caught on the ledges off Chatham, Cape Cod, on Stellwagen Bank, and on the broken grounds between the latter and Cape Ann, while they are plentiful off Cape Ann and on Jeffreys Ledge, the latter being one of the most productive cusk grounds of our Gulf. The rocky slopes of Cashes Ledge, also have long been famous for cusk. In past years when more fishing was done there (as in 1902 and 1905) this ground was the chief source of supply for the cusk landed in New England. In 1935, similarly, about 30 percent of all the cusk landed in Portland, Gloucester, and Boston came from Cashes. And we have caught more cusk there than anywhere else. As might be expected, cusk are also caught on Fippenies and Platts Banks by the few vessels that fish there as is illustrated by the catches reported from these inshore grounds for the 5-year period 1931–35.[84]

The landings, 1931–1935, in Boston, Gloucester, and Portland (to nearest 1,000 pounds) follow:

Locality	*1931*	*1932*	*1933*	*1934*	*1935*
Cashes	225,000	98,000	173,000	612,000	1,023,000
Fippenies	19,000	69,000	35,000	47,000	61,000
Platts	7,000	6,000	165,000	84,000	45,000
Jeffrey Ledge	301,000	143,000	148,000	122,000	53,000
Stellwagen Bank	65,000	63,000	85,000	259,000	78,000

We are inclined to believe that the wide differences from year to year, in the catches on these small grounds reflect the number of vessels that fished there, rather than the number of cusk waiting there to be caught.

Cusk are said to be plentiful on the rather indefinite ground off Penobscot Bay that is known as Jeffreys Bank (not Ledge) or "Matinicus Sou'-sou'west." In 1921, for example, 43,545 pounds were reported thence, and considerable numbers are taken, in the aggregate, on the patches of hard bottom that skirt the coast of Maine, as appears from the approximate amounts landed in the smaller ports [85] in the different Maine counties in 1919 and in 1945: York, 9,000 pounds and 2,600 pounds; Cumberland (exclusive of vessel landings at Portland), 79,000 pounds and 182,000 pounds; Sagadahoc, 15,000 pounds and 44,000 pounds; Lincoln, 27,000 pounds and 3,000 pounds; Knox, 52,000 pounds and 109,000 pounds; Hancock, 12,000 pounds and 22,000 pounds; Washington, 4,000 pounds and 500 pounds, respectively.

Some cusk are caught at the mouth of the Bay of Fundy also, especially about Grand Manan on the New Brunswick side, and off Brier Island on the Nova Scotian side, as Doctor Huntsman informs us, though none are reported toward the head of the Bay. Small rocky patches along the west Nova Scotian shore and off Seal Island also yield some cusk; and they are taken regularly on Grand Manan Bank. German Bank and the fishing grounds off Lurcher Shoal are less productive of cusk, perhaps because they are floored, mostly, with patches of gravel and pebbles and small stones alternating with sand and clay. But large catches are taken on Browns Bank, and fair numbers on the rougher spots on Georges Bank, though its smoother expanses yield only an occasional cusk.

The only important exceptions in our Gulf to the rule that cusk hold to rocky ground are that they are at least tolerably plentiful in the co-called

[84] 1935 is the most recent year when landings were reported from these grounds, separately.

[85] Mostly by small boat fishermen.

South Channel, where the bottom is mostly smooth (see regional summary of 1945 catches, p. 242); that some are caught with hake off the coast of Maine on broken or even muddy bottom; and that we have trawled a few, on the *Atlantis*, in depths greater than 78 fathoms off Cape Cod, where the bottom is mostly a sticky sand.

One striking accompaniment of the preference of cusk for rough or stony grounds in moderately deep water, is that many more are caught around the peripheral belt of the Gulf, between, say, the 15-fathom and the 75-fathom contour lines, than are on the off-shore rim formed by Nantucket Shoals, Georges Bank, and Browns Bank. The one notable exception is that there are so few cusk, if any, in the inner parts of the Bay of Fundy that they are not mentioned in the fishery returns for the Bay, except for a few thousand pounds taken near its mouth on the Nova Scotian side.

This regional contrast is illustrated by landings by United States fishermen (1945) [86] and Canadian fishermen (1944, 1946) combined, of between 215,000 and 250,000 pounds off western Nova Scotia; [87] 1,000 to 15,000 [88] pounds at the mouth of the Bay of Fundy, Nova Scotian side; about 63,000 pounds off eastern Maine; about 333,000 pounds off central Maine; about 255,000 pounds off western Maine; about 419,000 pounds off eastern Massachusetts; about 338,000 pounds from the small grounds in west central part of the Gulf; about 68,000 pounds from the South Channel; a few hundred pounds only from Nantucket Shoals; about 25,000 pounds from the northwest part of Georges Bank; none reported from the southwestern part of Georges; about 17,000 pounds from the eastern central and northeastern parts of Georges Bank; and about 18,000 pounds from Browns Bank.

Following the cusk eastward and northward, we find that considerable quantities are caught all along the Nova Scotian Banks, from Browns to Banquereau and to the Canso grounds off Cape Breton Island (catch, in 1946, about 542,000 pounds by United States and Canadian vessels combined). Cusk were also reported from the Newfoundland Banks many years ago by Goode,[89] but there cannot be many of them there, for they are not included among the fishes reported thence from cruises of the Newfoundland Fishery Research Commission.[90] And the only report we have found of cusk anywhere in the Gulf of St. Lawrence is at Cheticamp, on the Cape Breton shore.[91] In fact, the only definite record we have found of cusk on the American coast farther north than Cabot Strait is of one that was caught in the Strait of Belle Isle at 80 fathoms many years ago.[92] And while the cusk has been credited repeatedly to Greenland, it is a rare stray there from the south, only 7 specimens having been reported there during the period 1936–46, 5 of them on the west coast, 2 on the east.[93]

Westward from Cape Cod, the cusk is said to have been "not uncommon" formerly in Vineyard Sound, but it is so rare there now (if it ever occurs there) that we have not heard of one caught anywhere in the Woods Hole region of late years. But one was caught off Newport, Rhode Island, in November 1898,[94] and two were reported from Cape May, New Jersey, many years ago.[95]

Importance.—The cusk is a good food fish and there is a ready market for all that are brought in. The landings from the Gulf of Maine by United States fishermen ranged between about 1,600,000 pounds and about 2,200,000 pounds for the years 1945–47; between about 100,000 pounds and about 200,000 pounds by Canadian fishermen for 1944 and 1946, which contrasts with 2 to 7 million pounds yearly by United States fishermen alone for the few years that preceded the publication of the first edition of this book (in 1925). We attribute this decrease to the evolution that has taken place in the fishery from long lining to otter trawling chiefly, and to the

[86] Most recent year for which landings have been published by counties, for Maine and Massachusetts, in addition to the landings at Portland, Gloucester, Boston, and New Bedford.

[87] Off western Nova Scotia, by United States fishermen, 1945, about 108,000 pounds; Yarmouth County landings, Nova Scotia, about 140,500 pounds in 1944, about 106,000 pounds in 1946.

[88] 1944, 15,000 pounds; 1946, 700 pounds.

[89] Fish. Ind. U. S., Sect. 1, 1884, p. 232.

[90] Frost (Service Bull. 8, Newfoundland Dept. Nat. Resources, 1938, p. 29) states that there is no definite record of cusk on the Newfoundland fishing grounds.

[91] Recorded by Cornish (Contrib. Canadian Biol. (1918–1920) 1921, p. 114) from fishermen's reports. W. R. Martin of the Fisheries Research Board of Canada, writes us that any fisheries reports of cusk for the Gulf of St. Lawrence actually refer to hake.

[92] Weitz, Proceedings, Boston Soc. Nat. Hist., vol. 10, 1866, p. 274; Packard, Labrador Coast, 1891, p. 819.

[93] For further details and discussion of the status of the cusk as a Greenland fish, see Jensen (Spolia Zool., Mus. Hauniensis, Copenhagen, vol. 11, 1948, p. 175).

[94] Tracy, 40 Ann. Rept. Commiss. Inland Fish. Rhode Island, 1910, p. 159.

[95] Abbott, Geol. New Jersey, 1868, p. 819.

fact that the cusk (frequenting rough bottom) is not a good trawl fish. And 80 to 90 percent as much cusk (pounds) are caught on long lines as are caught in otter trawls even today (as illustrated by 1947), although the yearly landings of fish of all kinds in Maine and Massachusetts now are 70 to 80 times as great by otter trawls as by long lines.[96]

A few cusk are caught from party boats by sportsmen hand lining for ground fish in general, but most of the cusk live too deep to be of any particular interest to anglers.

THE GRENADIERS. FAMILY MACROURIDAE

The grenadiers are characterized externally by having large heads, projecting snouts, and slender bodies that taper to whiplike tails, with no definitely demarked caudal fin. They have two dorsal fins, the first high, the second very low but occupying the greater part of the back. The anal fin is nearly as long as the second dorsal, or longer.

The grenadiers are allied to the cod family, in classification, by the structure of their skull, but they differ from the cod tribe in having one stout spine in the first dorsal fin. They are deep-sea fishes, living on the bottom, loose in texture and weak swimmers. Many species are known, but only three of them have ever been taken within the confines of the Gulf of Maine.

Besides the species described below, three others, *Coryphaenoides rupestris, C. carapinus* and *Nematonurus armatus*,[97] have been taken on the continental slope abreast of the Gulf and off southern New England often enough to show that they are common there below 350 fathoms. They are typical inhabitants of the deep-sea floor, never likely to rise shoal enough to come within the limits of the Gulf of Maine.[98] But fish have a way of straying, and if any grenadier should be picked up in the Gulf that proves difficult to identify, we recommend forwarding it either to the Laboratory of the Fish and Wildlife Service at Woods Hole, to the U. S. National Museum, Washington, D. C., or to the Museum of Comparative Zoology, Cambridge, Mass., to be named. Parr[99] has recently published a detailed synopsis of all the species known from the western North Atlantic and from central American seas.

KEY TO GULF OF MAINE GRENADIERS

1. The dorsal spine is perfectly smooth---------- Long-nosed grenadier, p. 246
   The dorsal spine is serrated, with teeth which can be felt if not seen---------- 2

2. The vent is considerably in front of the origin of the anal fin; the skin surrounding the vent is naked and black; the dorsal fin spine is strongly serrated----- Common grenadier, p. 243
   The vent is close to the origin of the anal fin; the skin around the vent is scaly and pale colored; the serrations on dorsal fin spine are so fine that they are hardly visible, though they can be felt---------- Rough-headed grenadier, p. 245

Common grenadier *Macrourus bairdii* Goode and Bean 1877.[1]

RAT-TAIL; MARLIN-SPIKE

Jordan and Evermann, 1896–1900, p. 2583.

Description.—This grenadier could hardly be mistaken for any other fish except for one of its own tribe, so characteristic is its slender body (flattened sidewise behind the vent and tapering to a whiplike tail with no definite caudal fin), in combination with a pointed snout that overhangs the mouth; very large eyes; and high first dorsal fin with one large spine; but very low second dorsal fin. And it has a chin barbel like a cod (not shown in the illustration). As noted above, the second ray of the first dorsal fin is a true spine, serrated along its front edge with about 15 sharp and very noticeable teeth pointing upwards.

The first dorsal fin (2 stiff rays, the first very short, and 11 softer rays) is triangular, about twice as high as it is long; and it originates over the pectorals, close behind the gill openings. The space between the two dorsal fins is about as long

[96] Otter trawlers landed about 499 million pounds of fish of all sorts in Maine and Massachusetts in 1947; long liners about 7 million pounds.

[97] According to Parr (Bull. Bingham Oceanogr. Coll., vol. 10, art. 1, 1946, p. 54) this is the correct name of the grenadier that was reported by Goode and Bean (Smithson. Contrib. Knowl., vol. 30, 1895, p. 407) as *Hymenocephalus goodei* Günther, 1887.

[98] For descriptions and lists of localities where they were taken during the early cruises by vessels of the U. S. Fish Commission, see Goode and Bean (Smithson. Contrib. Knowl., vol. 30, 1895). In June 1949 we trawled about 200 *rupestris* on the slope off southern Nova Scotia and off the southeastern face of Georges Bank, at 290–420 fathoms, from *Caryn* of the Woods Hole Oceanographic Institution.

[99] Bull. Bingham Oceanographic Coll., vol. 10, art. 1, 1946.

[1] Parr (Bull., Bingham Oceanogr. Coll., vol. 10, art. 1, 1946, p. 37) places this grenadier in the genus *Nezumia* of Jordan, 1904. But it seems wiser to follow the older and more familiar usage here.

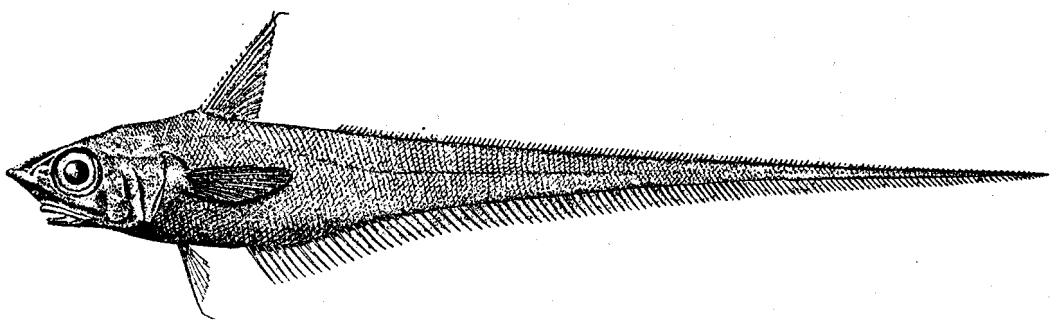

FIGURE 119.—Common grenadier (*Macrourus bairdii*), off Cape Ann. From Goode and Bean. Drawing by H. L. Todd.

as the height of the first dorsal fin. The second dorsal fin (about 137 rays) extends back to the tip of the tail, is so low that its membrane is hardly visible, and tapers to practically nothing at the rear end. The anal fin is considerably longer than the second dorsal (only about 120 rays, however) and more than twice as high as the second dorsal. The pectoral fins are rounded at the tip. The ventral fins, which stand under the pectorals or a little behind the latter, are triangular, with the first ray prolonged as a threadlike filament.

The exposed parts of the scales on the body, including the head and shoulders, are rough with minute sharp spines closely crowded together. The jaws are armed with several bands of small recurved teeth. The vent is situated a considerable distance in front of the point of origin of the anal fin, and the skin immediately surrounding it is scaleless and black.

Color.—The many we have seen have been uniform gray above and below. Also described as light brownish gray above, silvery below, with dark bluish or blackish belly. The lower surface of the snout is pink, the throat is deep violet, the first dorsal is pink with blackish spines, and the eyes are dark blue.

Size.—Usually about 1 foot long. The largest we have seen was 16 inches long.

Habits.—Grenadiers are bottom fish, usually found on soft mud, and they are very feeble swimmers. They usually live in at least 80 to 90 fathoms of water, and down to 1,000 to 1,200 fathoms (deepest record 1,255 fathoms). But one was trawled in 9 fathoms in Vineyard Sound by the *Fish Hawk* many years ago; a second was found floating near the surface at Eastport, Maine, by Dr. W. C. Kendall; and a third was taken in a weir at Lubec, Maine, as reported by Huntsman. Hansen [2] reports pelagic euphausiid shrimps (*Thysanoessa longicaudata*) in a grenadier stomach, while several examined by us from 100 fathoms on the edge of Georges Bank contained amphipods chiefly, together with an occasional worm and euphausiid shrimp.

It is probable that grenadiers spawn in summer and autumn, for the spermaries of a specimen taken in the western basin of the Gulf on August 19 were nearly ripe, while a fully ripe male has been reported from South Channel in the last week of September. The eggs of this fish have not been seen, but it is probable that they resemble other macrourid eggs described by European authors [3] in being buoyant at least for the first part of the period of incubation, with a large oil globule, wide perivitelline space, and with the surface sculptured into concave hexagonal facets. The larvae have not been seen yet. Those of other species of grenadiers have the rays of the first dorsal and ventral fins greatly prolonged.

General range.—This (normally) deep-water fish has been found at many localities along the continental slope from the West Indies northward and eastward to the Grand Banks of Newfoundland,[4] and rarely in the Gulf of St. Lawrence. It is also known from the mouth of the Laurentian Channel, on the Scotian Banks, in the Gulf of Maine, and even in Vineyard Sound. It has also been reported from the Azores.

Occurrence in the Gulf of Maine.—The common grenadier was formerly regarded as a rare stray in the inner parts of the Gulf of Maine for only two had been recorded there aside from the Eastport and Lubec specimens mentioned above, the

[2] Proc. U. S. Nat. Mus., vol. 48, 1915, p. 99.

[3] Ehrenbaum (Nordisches Plankton, vol. I, 1905–1909) summarizes what little is known of the eggs and young of this group of fishes.

[4] Rept. Newfoundland Fish. Res. Comm., (1933) 1934, p. 116.

one from the western basin in 160 fathoms, the other from off Gloucester, both of them taken many years ago. But they must be rather common on the muddy bottoms of the deeper parts of the Gulf in 85 to 125 fathoms, for we have caught more than 100 of them at various localities on recent trawling trips. No doubt it is because few vessels ever fish on these grounds, which are not productive either of cod or of haddock, that the presence of grenadiers there has been overlooked. A grenadier, too, was reported from the slope of Jeffreys Ledge, in about 50 fathoms, during March 1934.

Grenadiers, together with the long-finned hake (p. 232), are the most abundant fish on the continental slope abreast of the Gulf below 100 fathoms.[5]

Rough headed grenadier *Macrourus berglax* Lacépède 1802 [6]

RAT-TAIL; ONION-EYE

Jordan and Evermann, 1896–1900, p. 2583.

Description.—This species resembles the common grenadier (p. 243) so closely in general appearance that we need only indicate the points of difference. Most obvious of these are that its snout is shorter and blunter, with more highly arched dorsal profile; that it has 4, 5, or 6 distinct ridges on the top of its head; that its head is relatively larger (about one-fourth to one-fifth the length of the fish, only one-sixth to one-seventh in the common grenadier); that its trunk is relatively stouter (about six times as long as it is deep); that its vent is close to the point of origin of the anal fin with the skin scaly around it, and no darker colored than on the back; and that the serrations on the large spine in the first dorsal fin are so fine that they are hardly visible.

Furthermore, there are fewer (about 124) rays in the second dorsal fin, but more rays (about 148) in the anal than in the common grenadier, and its first dorsal fin is of rather different outline. The second dorsal fin, too, is relatively higher than in the common grenadier and with its membrane more developed (compare fig. 120 with fig. 119), while the filamentous prolongation of the outer ray of the ventral fins is not so long in *berglax* as it is in *bairdii*. The structure of the scales, too (visible to the naked eye), is diagnostic, for those on the head and shoulders of *berglax* are armed with either one longitudinal row of spines (10–12 rows of spines on each scale), or with up to 3 or 4 radiating ridges of spines while those farther back each have a single row of spines, which together form conspicuous longitudinal ridges along each side of the rear part of the body.

Color.—The only newly caught specimens we have seen were ash gray below as well as above; with the chest a little darker; with the rear edges of the scales on the rear part of the body still darker; with the anal fin narrowly dark edged; with the first dorsal fin and the pectoral fins sooty; and with the ventral fins sooty, except that the outermost rays are white after preservation in alcohol.

Size.—This fish is larger than the other grenadiers (p. 243). It is credited with a maximum

[5] For a list of captures on the continental slope during the early cruises of the U. S. Fish Commission vessels, see Goode and Bean (Smithsonian Contrib. Knowl., vol. 30, 1895, p. 394).

[6] Authorities disagree as to the correct scientific name of this grenadier, for while it has usually been referred to as *berglax* Lacépède, 1802, Jensen (Spolia Zool., Mus. Hauniensis, Copenhagen, vol. 9, 1948, p. 178) prefers the species-name *fabricii* that was applied to it more recently by Sundevall, 1840, on the ground that the grenadier to which Lacépède gave the name *berglax* was another fish, *Coryphaenoides rupestris* Gunnerus, 1765, which is commonly termed "berglax" on the west coast of Norway.

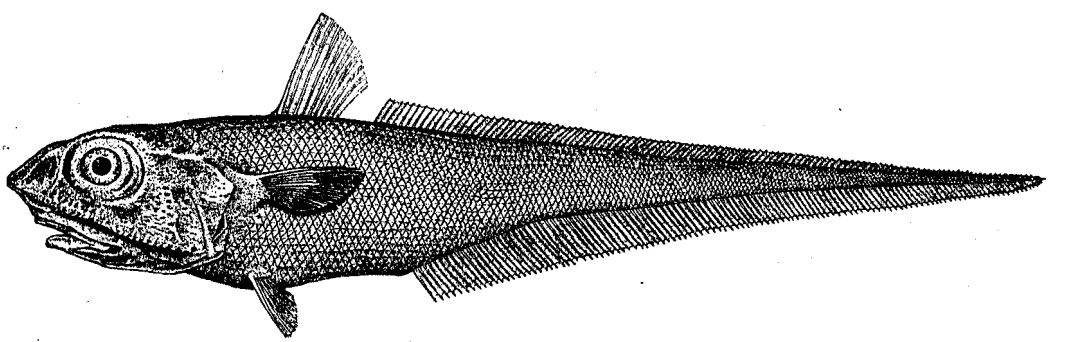

FIGURE 120.—Rough-headed grenadier (*Macrourus berglax*), Banquereau Bank. From Goode and Bean. Drawing by H. L. Todd.

length of 3 feet and a weight of 4 or 5 pounds but the largest we have seen is only 29 inches long.

General range.—This is a deep-water fish like its relative, but is more northerly in its distribution, being known off northern Norway, Spitzbergen, Iceland, southern Greenland, in Davis Strait, and southward along the continental slope of North America as far as Georges Bank. One has even been found floating dead on the surface, off New York Harbor, but it may have been thrown overboard from a fishing boat returning from the off shore banks.

Occurrence in the Gulf of Maine.—Three quarters of a century ago, when halibut were more plentiful in the Gulf of Maine than they are today, and when vessels, long-lining from Gloucester, still resorted regularly to the deep channel between Georges Bank and Browns Bank as well as to the deep gullies that interrupt the Nova Scotian banks, large grenadiers were often hooked. Fishermen described them as common enough to be a nuisance, for they stole the baits meant for other fish and were of no commercial value themselves. It was on the strength of such reports that Goode[7] characterized them as "exceedingly abundant on all of our offshore banks." A few were brought in "from off the coast of New England."[8] And our re-examination of three specimens, one taken on the outer edge of either La Have Bank or Banquereau in 1878 a second taken "off New England" in 1880, the third (probably from the Grand Banks) obtained in Boston Market by Prof. G. H. Parker in 1903 [9] has proved that earlier identifications of them as *berglax* were correct.

We have not heard of one, either from Nova Scotian waters or from the Eastern Channel since 1903;[10] not because they have vanished thence, but simply because very little long-line fishing is now done deep enough off our coasts. And there is always the chance that some vessel, fishing down the slopes of Sable Island Bank, La Have Bank, or southeastern Georges, may pick a few rough headed grenadiers at any time when least expected.

One hundred fathoms may be set as about their upper limit; most of those caught have been from 100 to 300 fathoms on both sides of the Atlantic; and they have been taken as deep as 677 fathoms by the *Albatross* off the southeast slope of Georges Bank. They are supposed to feed on small fish and on Crustacea but we find no definite record of the contents of their stomachs. Females with the roe nearly ripe have been taken off northern Norway in May, suggesting that this is a spring spawner, but nothing definite is known of its breeding habits.

Long-nosed grenadier *Coelorhynchus carminatus* (Goode) 1880

Jordan and Evermann, 1896–1900, p. 2588.

Description.—This species resembles the common grenadier (p. 243) so closely in its general appearance that there is danger of mistaking it for the latter; but it is identifiable by the facts that its dorsal spine is perfectly smooth and that its first dorsal fin is rounded instead of triangular; and that its snout not only overhangs the mouth slightly farther, but is thinner tipped.[11]

[7] Fish. Ind. U. S., Sect. 1, 1884, p. 244.

[8] Bean, Proc. U. S. Nat. Mus., vol. 3, 1881, p. 80.

[9] These three specimens, the largest 29 inches long, are in the Museum of Comparative Zoology.

[10] The most recent record with which we are acquainted is of one 16 inches long that we trawled on the southeastern slope of Georges Bank, at 500 fathoms, June 1949, on *Caryn* of the Woods Hole Oceanographic Institution.

[11] Commonly described as "sturgeon-like," but this characterization applies better to other members of the genus which have still longer snouts.

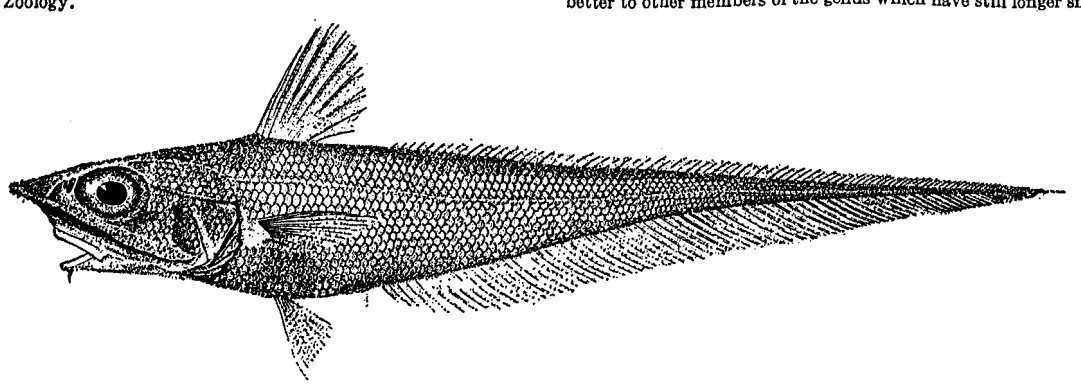

FIGURE 121.—Long-nosed grenadier (*Coelorhynchus carminatus*), continental slope off Marthas Vineyard. From Goode and Bean. Drawing by H. L. Todd.

Color.—Described as silvery gray.

Size.—About 10 inches long.

General range and occurrence in the Gulf of Maine.—This deep-water ground fish has been taken at many localities off the American coast from the West Indies and Gulf of Mexico northward along the continental slope to abreast of southern Nova Scotia, in depths of 104 to 464 fathoms. It is included here because it has been recorded once off Nantucket in 148 fathoms.

THE OPAHS. FAMILY LAMPRIDAE

For the characteristics of this family, see the following description of its unique representative, the opah.

Opah *Lampris regius* (Bonnaterre) 1788

MOONFISH; JERUSALEM HADDOCK

Jordan and Evermann, 1896–1900, p. 954, as *Lampris luna* (Gmelin) 1789.

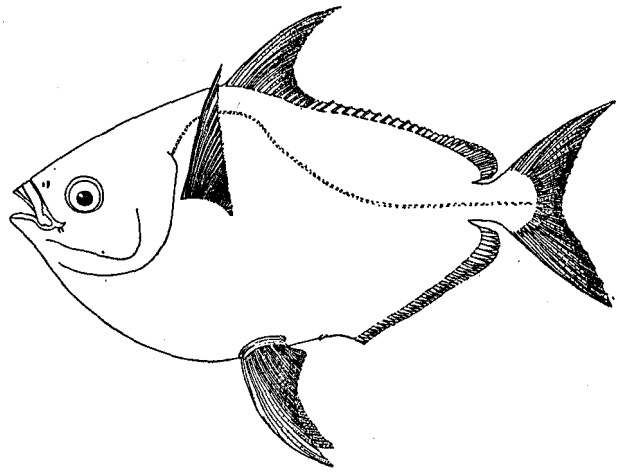

FIGURE 122.—Opah (*Lampris regius*). After Goode and Bean.

Description.—The thin, deep form of the opah (trunk less than twice as long as it is deep) with moderately slender caudal peduncle, which does not have longitudinal keels, and the rather pointed snout, might suggest an enormous butterfish, were it not provided with very long falcate ventral fins, whereas the butterfish has no ventrals. The ventrals, also, of the opah have 14 to 17 rays; none of the mackerel or pompano tribes has more than 8.

The forward part of the single dorsal fin (53 to 55 rays) is high, its outlines strongly falcate. The anal (38–41 rays) is shorter than the dorsal, and it is about equal in height to the low part of the dorsal throughout its length. Both anal and dorsal fins extend back close to the base of the caudal fin, and each of them is depressible in a groove. The tail fin is emarginate, the pectorals are conspicuously pointed, with their bases horizontal instead of vertical. The mouth is small and toothless, the scales are minute, and the lateral line is strongly arched upward above the pectoral fin, then downward toward the rear.

Color.—We have never seen this fish alive, but it is described as of a beautiful dark steel blue above, shading into green with silver, purple, gold, and lilac luster down the sides, and as rosy on the belly, with vermilion fins, while the whole body is speckled with silvery and milk-white spots.

Size.—The opah grows to a length of 3 to 6 feet; most of them are 3 to 4 feet long.

Habits.—The opah is usually spoken of as a deep-sea fish, but this is a misnomer, for it is caught on hook and line no deeper than 50 to 100 fathoms off Madeira, where it is taken in some numbers. Being so very rare off our coast, we need merely note that it feeds chiefly on squid, isopods, and small fish, as well as on seaweeds; that it is an excellent food fish; and that nothing is known of its breeding habits.

General range.—Open waters of the Atlantic and Pacific Oceans; recorded off Madeira, Scandinavia, the British Isles, Norway, Iceland, Newfoundland, Nova Scotia, Maine, Cape Cod, and Cuba in the North Atlantic; also in the Gulf of Mexico off the west coast of Florida.

Occurrence in the Gulf of Maine.—Two specimens, only, of this oceanic wanderer have been reported definitely within the limits of our Gulf, one caught on a long line on Browns Bank in the spring of 1932,[12] the other, weighing 165 pounds fresh, was taken in an otter trawl on the northeastern part of Georges Bank, in August 1947.[13]

One also was reported from Maine by Goode and Bean,[14] but this may have been based on a letter to D. S. Jordan from Everett Smith, July 19, 1888, reporting that a "Sun Fish," identified

[12] Reported by Vladykov, Proc. Nova Scotia Inst. Sci., vol. 19, 1935, p. 6.
[13] This specimen is in the Museum of Comparative Zoology.
[14] Goode and Bean, Smithsonian Contrib. Knowl., vol. 30, 1895, p. 223.

as an opah by the included description and sketch, had been landed in Portland, Maine, from the Grand Banks.[15]

One was caught off Sable Island, Nova Scotia, about 1856, and another off La Have Bank many years ago; [16] a specimen about 3 feet long was taken in July 1925 on Western Bank, southwest of Sable Island, by the schooner *Falmouth;* [17] and another of the same size stranded on the beach at Hyannis, Mass., on September 17, 1928.[18]

THE FLOUNDERS AND SOLES. FAMILIES HIPPOGLOSSIDAE, PARALICHTHYIDAE, PLEURONECTIDAE, BOTHIDAE, AND ACHIRIDAE

The flatfishes are a very homogenous tribe, so different from all other fishes that no one is likely to mistake any one of them for any other sort of fish. What strikes one first is their flatness; less obvious is the fact that they do not lie on the belly but on one side, right or left. And their skull twists in the course of development so that the eye which was originally on the side that is fated to be underneath, migrates around the head, until both the eyes finally come to lie close together, on the side that is uppermost as the fish lies on bottom. But the mouth retains its original position more nearly, so that it is often described as opening sidewise. The larval flounder swims on edge like any other fish; the migration of the eye takes place shortly before the fry take to the bottom.

All of the flatfishes have a single long fin on each edge, one the dorsal and the other the anal; they also have well-developed ventral fins (at least on the eyed side) which are either on the right-hand edge or on the left-hand edge as the fish lies. Most of the Gulf of Maine species also have pectoral fins, one on the upper side as the fish lies on the bottom, the other on the lower side. The ventral fins are in front of the pectorals or in line with them; the abdominal cavity is very short, and some species are armed with a stout anal spine.

Our several flatfishes look much alike; indeed, they are often confused. But it is not difficult to tell one from another, for the distinctive characters are rather precise, even if not obvious at first glance. Huntsman [19] has published a very useful key to the eastern Canadian species, which is expanded here to cover the Gulf of Maine.

KEY TO GULF OF MAINE FLATFISHES

1. Eyes on the left-hand side, and guts at left-hand edge, as the fish lies on bottom 2
   Eyes on the right-hand side, and guts at right-hand edge 5
2. The lateral line is straight ..... *Citharichthys arctifrons*, p. 294
   The lateral line is arched over the pectoral fin [20] 3
3. The two ventrals are not alike, the left (upper) being continuous with the anal fin, the right (lower) separate from it ..... Sand flounder, p. 290
   The two ventral fins are alike 4
4. The upper side is marked with four large oblong black eye-spots; there are fewer than 82 rays in the long right-hand (dorsal) fin ..... Four-spotted flounder, p. 270
   The upper side is marked with many small spots; there are more than 84 rays in the long right-hand (dorsal) fin ..... Summer flounder, p. 267
5. There is a well-developed pectoral fin on the eyed side 6
   There are no pectoral fins ..... Hog choker, p. 296
6. Mouth large, gaping back as far as the eye; jaws and teeth nearly equally developed on both sides 7
   Mouth small, not gaping back as far as the eye; the jaws are nearly straight on the upper side, but curved on the lower side 9
7. Margin of tail fin rounded ..... American dab, or plaice, p. 259
   Margin of tail fin slightly concave, with angular corners 8
8. Lateral line arched close behind the gill opening ..... Halibut, p. 249
   Lateral line nearly straight ..... Greenland halibut, p. 258

[15] We are indebted to Norman J. Willimovsky for showing us a copy of this letter.

[16] Vladykov, Proc. Nova Scotia Inst. Sci., vol. 19, 1935, p. 6.

[17] Radcliffe, Copeia, No. 151, 1926, p. 112.

[18] Reported by Robert Goffin of the Bureau of Fisheries station at Woods Hole, Mass.

[19] Our Eastern Flat Fishes, Canadian Fisherman, vol. 5, No. 6, 1918, pp. 788–790.

[20] In all the flounders of this type so far recorded from the Gulf of Maine both of the pectoral fins are well developed. Should one be taken with no pectoral fin on the blind side it would probably be the deep-water *Monolene sessilicauda*.

9. Lower side of head with large open mucous pits; 100 or more rays in the long left-hand (dorsal) fin--Witch, p. 285
   Lower side of head lacks open mucous pits; fewer than 90 rays in the long left-hand (dorsal) fin---------- 10
10. Lateral line arched behind the gill opening----------Yellow-tail, p. 271
    Lateral line nearly straight---------- 11
11. Top of the head between the eyes rough with scales--Winter flounder (including the Georges Bank flounder) p. 276
    Top of the head between the eyes naked and smooth----------Smooth flounder, p. 283

Atlantic halibut *Hippoglossus hippoglossus* (Linnaeus) 1758

Jordan and Evermann, 1896–1900, p. 2661.

Description.—This is not only the largest of flatfishes, but is one of the best characterized; its most obvious distinctive characters, apart from its size, being the fact that it lies on the left side; [21] that its mouth gapes back as far as the eyes, and is armed with sharp curved teeth; that the rear edge of its tail fin is concave, not rounded; that its two ventral fins are alike; and that its lateral line is arched abreast of the pectoral fin. Furthermore it is a narrower fish, relatively, than most of our flatfishes (only about one-third as broad as it is long) but is very thick through, and its eyes are farther apart than they are in most of the other flounders.

The dorsal (long) fin (98 to 105 rays) commences abreast of the eye and runs back the whole length of the fish, broadening but slightly for the first third of its length and then abruptly, to narrow again toward the caudal peduncle. The anal fin is similar to the dorsal fin in shape but is shorter (73 to 79 rays), originates close behind the pectorals, and is preceded by a sharp spinelike extension of the post-abdominal bone, which projects in young fish but is hidden by the skin in old fish. The two pectoral fins are of different shapes, the one on the upper (eyed) side of the fish being obliquely pointed while the fin on the lower side is rounded. The rather small ventral fins, which are situated in front of the pectorals and are separated from the anal by a considerable space, are alike. Halibut, like other flatfishes are scaly on the whole head and body and they are very slimy with mucus.

Color.—The halibut is chocolate to olive or slaty brown on the eyed (upper) side. Young fish are paler, and are more or less mottled, while large ones are more uniform and darker, sometimes almost black. The blind (lower) side usually is pure white in small fish, but large ones are often more or less blotched or clouded below with gray (known by fishermen as "grays"). Occasionally a halibut is taken the blind side of which is marked with patches of the same color as the eyed side. And we have seen one medium-sized fish in which the rear third of the lower surface was uniform dark brown.

Size.—Only swordfish, tuna, and some of the larger sharks reach a greater size than the halibut, among Gulf of Maine fishes for while reports of specimens as large as 600 to 700 pounds have usually been looked on as exaggerations we are glad to be able to give at least one record of a Gulf of Maine halibut in this weight class. The

[21] Left-handed halibut have been caught, occasionally.

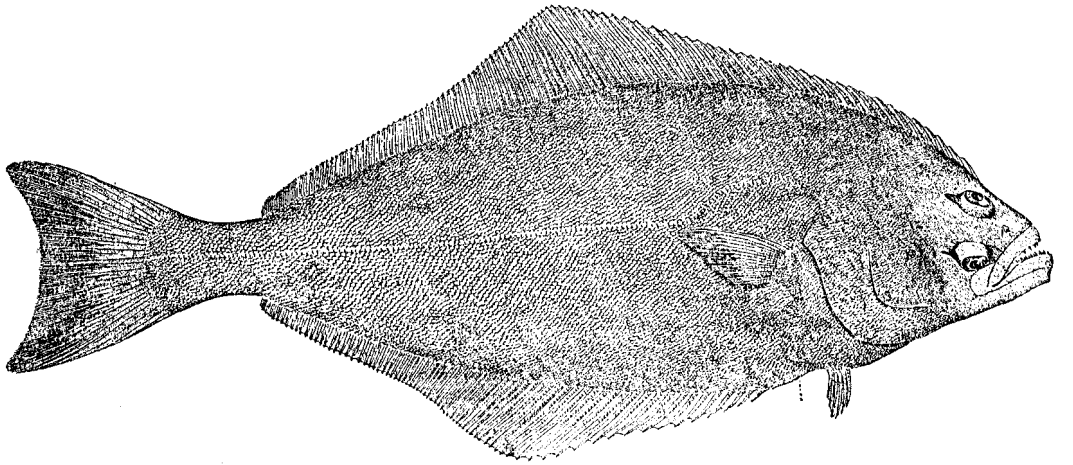

FIGURE 123.—Halibut (*Hippoglossus hippoglossus*), Eastport, Maine. From Goode. Drawing by H. L. Todd.

fish in question was taken in June 1917, by Capt. A. S. Ree, about 50 miles eastnortheast of Cape Ann, and since it weighed 615 pounds, eviscerated with the head still attached, when brought in to the Boston fish pier, it must have been as heavy as 700 pounds while alive.[22] Another halibut of 602 pounds is said to have been taken near Isle au Haut in 1902, but we cannot vouch for this one.

Halibut of 500 to 600 pounds are rumored almost every year, but the next largest of which we have definite knowledge was one of about 450 pounds caught on a hand line in the deep water between Browns and Georges Banks in 1908 by W. F. Clapp. Goode [23] likewise had records of a dozen fish of 350 to 400 pounds caught off the New England coast; the heaviest was one of 401 pounds taken near Race Point, Cape Cod, in July 1849. But a 410-pound halibut that was brought in to the Boston fish pier by the *Dawn*, March 27, 1941,[24] was spoken of as the largest that had been landed there in a "score of years," and it seems that halibut heavier than 300 pounds always were rarities anywhere in the North Atlantic.

Full-grown females average about 100 to 150 pounds. Males run smaller, and most of the "large" fish landed in New England ports weigh from 50 to 200 pounds. The largest we have caught, taken on Browns Bank, weighed exactly 100 pounds and was 5 feet long. Halibut between 7 and 8 feet long usually weigh 300 to 350 pounds, and the following table based on Icelandic fish measured by Jesperson,[25] and others from the Gulf of Maine, give the relationship of length to weight for the smaller sizes.

Iceland		Gulf of Maine	
Length in inches	Weight in pounds	Length in inches	Weight in pounds
74	215	63	[1] 120
70	168	42½	30
61	107	42	33
54 to 56	60½	41½	27½
40 to 42	29	31	12
36	11 to 12	20	2¾
30	9½	--	---
27	6½	--	---
24	5½	--	---

[1] This fish weighed 98 pounds dressed, the intestines accounting for 15 pounds and the ovaries (with immature eggs) for 7 pounds.

[22] An account of this fish was published in the Boston Globe, June 12, 1917. It was bought by the Shore Fish Co.

[23] Fish. Ind. U. S., Sect. 1, 1884, p. 194.

[24] Reported in the Boston Herald, March 28, 1941.

[25] Meddelel. Kommis. Havundersøgelser, Ser-Fiskeri, vol. 5, No. 5, 1917.

Habits.—The halibut, like all the flatfish tribe, is normally a ground fish, once the young fry have taken to bottom. But it comes to the surface on occasion (p. 257), and it is a very powerful fish, when hooked. Halibut caught in shallow water are very active, usually starting off at great speed when they are hauled up from the bottom, often spinning the dory around in their attempts to escape.[26] They are usually found on sand, gravel, or clay, not on soft mud or on rock bottom; 400–500 fathoms may be set as the lower boundary to their existence in any numbers,[27] but their absolute depth limit is not known.

The young halibut, like the young of so many other ground fishes, drift helplessly with the current for some months after hatching (just how long is not known); not at the surface, however, but in the mid-depths (p. 253). During this period they tend both to rise in the water as they grow, and to be carried inshore, so that when they finally take to the bottom they do so in quite shallow water (p. 254). But the fry as a whole tend to work offshore again thereafter, and deeper, so that halibut caught in deep water are larger than those caught in shallow water. This fact was noticed early on Georges Bank, where most of the fish taken on the bank in depths of 30 to 40 fathoms or less ran from 125 to 180 pounds, whereas much larger ones were caught on the deeper slope to the southeast. Fishermen have also reported catching smaller fish on the inner ends of long lines set from shoal water out into deep, and larger fish on the outer ends.[28] And this rule holds equally for the other side of the Atlantic.

The halibut is a boreal, not an arctic fish, in its relationship to temperature. Thus, large catches are (and were) made only at times and places where the water is at least as warm as 36°–38° F. (about 3° C.). In the Grand Banks region, for instance. halibut are mostly caught either far enough down the slope to be below the icy touch of the Labrador Current, or at times and places where the latter does not reach bottom, if the fish are on the bank. But the lower limit to the temperature range of the halibut is not sharp-cut. We do, in fact, find record of at least one halibut

[26] Goode and Collins (Fish. Ind. U. S., Sect. 5, vol. 1, 1887, p. 17) give a readable account.

[27] Capt. Baldersheim (Rapp. Cons. Internat. Explor. Mer, vol. 56, 1929, p. 25) reports good catches at that depth in Davis Strait off west Greenland.

[28] Goode, Fish. Ind. U. S., Sect. 1, 1884, p. 195.