

Haddock

Melanogrammus aeglefinus (Linnaeus) 1758

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

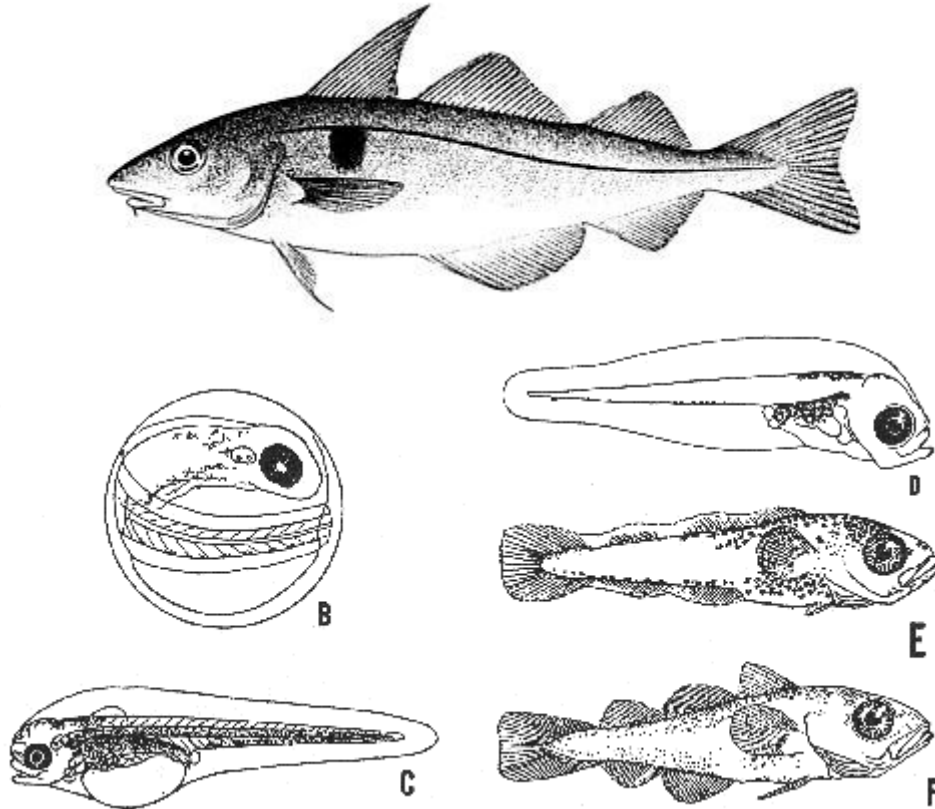


Figure 96 - Haddock (*Melanogrammus aeglefinus*).

A, adult, Eastport, Maine,
From Goode, Drawing by H. L. Todd;

B, egg (European);
C, larva (European) just hatched;
D, larva (European), 4.2 mm.;
E, larva (European), 15 mm.;
F, young fry (European), 25 mm.

B and C, after Heincke and Ehrenbaum;
D, after Ehrenbaum; E and F, after Schmidt.

Description

The most obvious ways in which the haddock differs from the cod are in its black [page 200] lateral line (that of cod and of pollock is paler than the general ground tint) and in the presence of a dusky blotch on each side over the middle of the pectoral fin, and close below the lateral line. Furthermore the first dorsal fin of a haddock (higher than that of a cod, relatively) is considerably higher than either the second or third dorsal, more acutely triangular in outline, and with slightly concave margin. The margin of the haddock's tail is more concave than that of the cod; and its second and third dorsal fins are more angular than is usually the case with the cod, though they are similarly rhomboidal in outline.

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

Color

When a live haddock is first taken from the water, the top of its head, back, and sides down to the lateral line are dark purplish gray, paling below the lateral line to a beautiful silvery gray with pinkish reflections, and with the black lateral line and the sooty shoulder patch (just mentioned) standing out vividly. This patch, the "devil's mark," is indefinitely outlined and varies in size and in distinctness, but only very rarely does a haddock fail to show it. The belly and lower sides of the head are white. The dorsal, pectoral, and caudal fins are dark gray; the anal fins pale like the lower part of the sides and black specked at the base; and the ventrals are white, more or less dotted with black. Haddock usually run very uniform in color, but occasionally one shows from one to four dark transverse bars or splotches in addition to the black shoulder blotch. Several of these serially striped haddock have been taken in Passamaquoddy Bay[21] and we have seen such near Mount Desert. Occasionally a haddock may be decidedly golden on the back and sides, with the lateral line golden, and such fish may lack the dark blotches.

Size

The haddock is a smaller fish than the cod, the largest on record having been only 44 inches long, weighing about 37 pounds.[22] One of 30 pounds, caught on La Have Bank in the autumn of 1949[23] is said to have been the heaviest ever landed at the Boston Fish Pier. The largest among 1,300 fish that were measured and weighed by Welsh near Gloucester during the spring of 1913 was 35½ inches long, weighing about 16½ pounds. Only 4 or 5 out of the more than ten thousand haddock that we have helped to tag were as long as 32 to 34 inches. And the great majority of the fish that are brought in measure from 14 to 23 inches long, and weigh from 11/8 to 4¾ pounds. The largest among 627,996 fish measured during the period 1931-1948 was 34½ inches long.[24] the relationship between length and weight averages as follows, according to Shuck:[25] 10 inches, 7 ounces; 12 inches, 12 ounces; 14 inches, 1 pound 2 ounces; 16 inches, 1 pound 11 ounces; 18 inches, 2 pounds, 6 ounces; 20 inches, 3 pounds 3 ounces; 22 inches, 4 pounds 3 ounces; 24 inches, 5 pounds 5 ounces; 26 inches, 6 pounds 9 ounces; 28 inches, 8 pounds 3 ounces; 30 inches, 9 pounds 15 ounces.

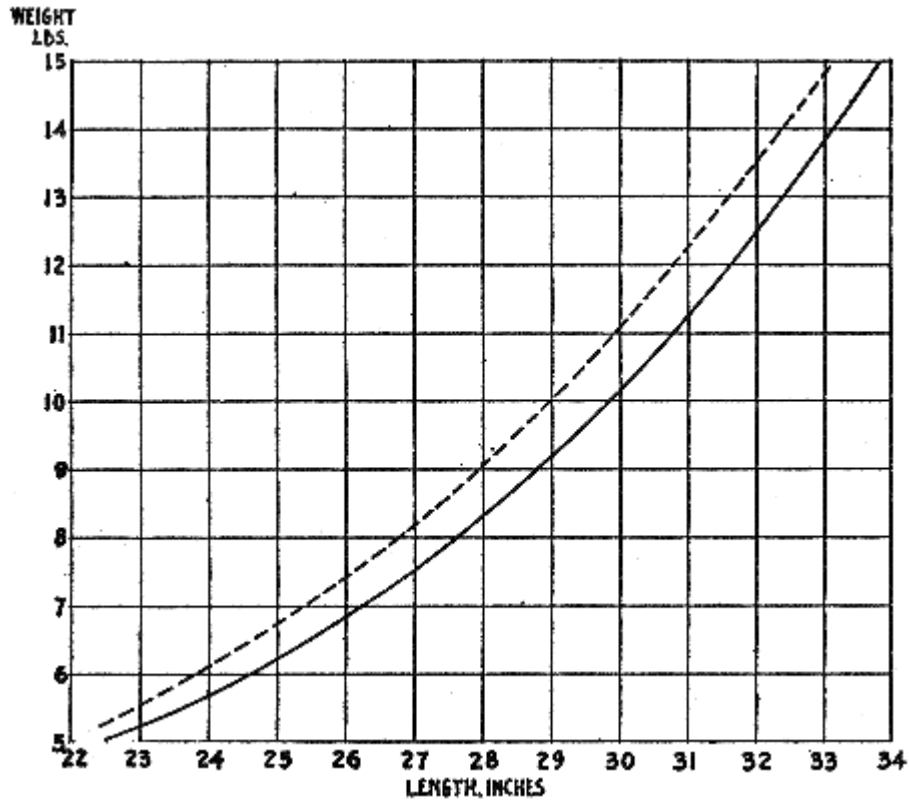


Figure 97. - Average weight of ripe haddock of different lengths; male (—) and female (--) at Gloucester, Mass., March to May 1913.

Habits

Haddock live deeper than cod on the whole; few are caught in less than 5 to 10 fathoms of water and most of them in 25 to 75 fathoms. In fact, they so seldom come into shoal water where young cod are so plentiful that the pound nets of Massachusetts reported only about 5,000 pounds of haddock in 1919, as compared with almost 300,000 pounds of cod. Neither do we remember hearing of a haddock of any size in any of the shoal harbors where little pollock so abound. And the difference in habitat between these closely related species holds from the time the young fry [page 201] 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]

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 uppermost 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 [page 202] 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 of 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 diet 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 (*Macra*) 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 23/8 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 [page 203] 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	Length, inches		
	Gulf of Maine	North Sea	Norway
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	21¼	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 [page 204] 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 Martha's 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 [page 205] 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, [page 206] 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	320 [1]	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	399,000

[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.

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 [page 207] 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 [page 208] 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° F. 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 [page 209] 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 [page 210] (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 recaptured 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. [page 211] 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]

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 [page 213] 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]

Table 1. 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	119,400,000	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.

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

[21] Prince, Contrib. Canadian Biol., (1915-1916) 1917, p. 86.

[22] This giant was an Icelandic fish, reported by Thompson (Rapp. et Proc. Verbaux, Conseil Internat. Perm. Explor. Mer, vol. 57, 1929, p. 29).

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

[24] Information from Howard W. Schuck.

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

[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.
- 33] Rept. U. S. Comm. Fish (1896) 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.
- [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.
- [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 1910; 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.
- [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.

[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.

[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.

[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.

[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, 1939, 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.

[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.

[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]).

[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. 13.

[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.

[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 ¾-4/5 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.

[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).

Fishes of the Gulf of Maine by Bigelow & Schroeder is the seminal work on North Atlantic fishes. It was originally published in 1925 with William Welsh, a Bureau of Fisheries scientist who often accompanied Henry Bigelow on his research cruises. In the late 1920's, Bigelow began a long association with William C. Schroeder, publishing a number of papers and reports on fishes of the North Atlantic, including the first revision of *Fishes of the Gulf of Maine*. This excerpt is from that 1953 edition.

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