

Cod

Gadus callarias Linnaeus 1758 [61]
[Jordan and Evermann, 1896-1900, p. 2541.]

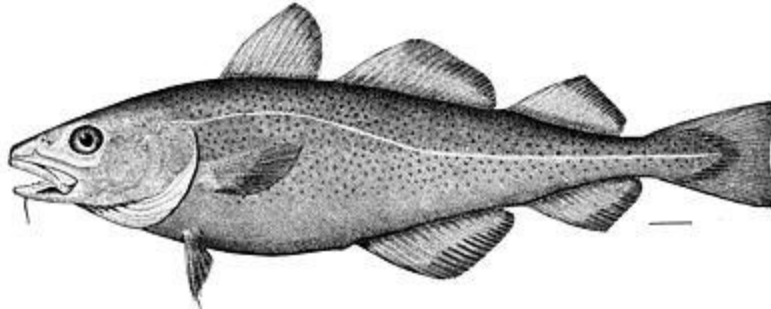


Figure 86 - Cod (*Gadus callarias*), Eastport, Maine.
From Goode. Drawing by H. L. Todd.

Description

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

The cod is a heavy-bodied fish, only slightly flattened sidewise, its body deepest under the first dorsal fin (cod neither very fat nor very lean are about one-fourth to one-fifth as deep as they are long), tapering to a moderately slender caudal peduncle, and with a head so large that it takes up about one-fourth of the total length of the fish. The nose is conical and blunt at the tip; the mouth wide, with the angle of the jaw reaching back as far as the anterior part of the eye; and there are many very small teeth in both jaws. The first dorsal fin usually (if not always) originates well in front of the midlength of the pectoral fins; it is the highest of the three dorsals, triangular, with rounded apex and convex margin. The second dorsal fin is nearly twice as long as the first dorsal and about twice as long as it is high, decreasing in height from front to rear with slightly convex margin. The third dorsal fin is a little longer than the first dorsal, and is similar to the second dorsal in shape.

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

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

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

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

Color

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

Size

Cod sometimes grow to a tremendous size. A huge one of 211¼ pounds and more than 6 feet long, was caught on a long line off the Massachusetts coast in May 1895; [62] one that weighed 138 pounds dressed (hence must have weighed 180 pounds or more alive) was brought in from Georges Bank in 1838; and Goode [63] mentions several others of 100 to 160 pounds as caught off Massachusetts. But cod of a hundred pounds are exceptional, the largest New England cod of which we have heard recently being one of 90 pounds, that was taken off the coast of Maine early in July 1922. Even a 75-pound fish is a rarity, but 50 to 60 pounders are not unusual. The so-called "large" fish that are caught near shore run about 35 pounds; and "large" ones taken on Georges Bank about 25 pounds. But the shore fish, large and small together, average only between 6 and 12 pounds in weight.

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

Females		Males	
Inches	Pounds	Inches	Pounds
19 to 20	2-1/3 - 3	20 to 21	3 - 3¾
21 to 22	3-1/8 - 4	23 to 24	4 - 5½
23 to 24	4½ - 7	25 to 26	6¼ - 8
25 to 26	5 - 7	27 to 28	7 - 8½

27 to 28	7 - 9	30 to 31	7 - 11
30 to 31	7½ - 10	32 to 33	7 - 13
32 to 33	9 - 13	34 to 35	12 - 17
34 to 35	12½ - 17½	36 to 37	12¾ - 17
36 to 36½	16 - 23	38 to 39	17 - 21
38 to 39	18 - 22	40 to 41	19 - 25
40 to 42	16 - 32	43 to 45	25½ - 29
43 to 44	29½ - 32	46	43
48½ to 50½	31 - 51		
52	50		
57½	54		

A 99½ pound fish recorded by Earll was 62 inches long, and one of 100 pounds caught off Wood Island, Maine, on April 9, 1883, measured 65 inches, its head 17½ inches. Any fish of 5½ to 6 feet will weigh 100 pounds or more.

Habits

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

During the first year after the young cod take to bottom (p. 186) many of them live in very shoal water, even along the littoral zone, and many young fry have been taken at Gloucester and elsewhere along the shores of New England, while [page 184] many small cod are caught about the rocks only a fathom or two deep even in summer. But it is certain that many cod fry take to bottom on the offshore banks also, for we have trawled young fry at many localities between Nantucket Shoals and Browns Bank. As a rule, the large cod lie deeper than 7 or 8 fathoms in summer in our latitudes. But the fishing is often good in only 3 to 5 fathoms of water in wintertime, especially in Ipswich Bay. At the other extreme, comparatively few cod are caught much deeper than 100 fathoms within the Gulf of Maine. And although fishermen sometimes do well at much greater depths on the slopes of the offshore banks, the 5- and 75- fathom contours probably include the great majority of all the cod living in the Gulf, summer or winter.

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

The cod, as appears from the foregoing, is typically a ground fish; except on some journey (a subject to be discussed later) or when following its prey, it usually lies within a fathom or so of the bottom. And large ones keep closer to the ground than small ones as a rule, so that the closer one fishes to bottom the larger the cod are likely to run. But even the large ones sometimes follow herring up to the surface; we have known of large cod gaffed from a vessel's side in Northeast Harbor, Mount Desert Island, in September, while they were chasing sardines. And they come to the surface more commonly on the Grand Banks and along the eastern coast of Labrador, when they are following capelin. Cod even strand on the Labrador beaches while harrying schools of capelin, but we have never known cod to strand anywhere around the coasts of the Gulf of Maine, as silver hake so often do (p. 175).

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

Food

When the larval cod first breaks from the egg it subsists on the yolk with which its abdomen is distended (fig. 88), as do most other sea fishes. But this source of nutriment is completely absorbed by the sixth day after hatching, and the future existence of the little fish depends as much on finding a plentiful supply of food as on escaping the enemies by which it is encompassed. So far as known, the larval and post-larval cod subsist almost exclusively on copepods and on other minute Crustacea, during the several months while they are drifting in the upper layers of water. [65] And this same diet, varied with amphipods, barnacle larvae, and other small crustaceans, as well as with small worms, is the chief dependence of the little cod when they first seek the bottom [66] but as they grow larger they consume invertebrates in great variety and in enormous amount.

Mollusks, collectively, are probably the largest item in the cod's diet in the Gulf of Maine; any shellfish that a cod encounters is gobbled up, so that their stomachs are mines of information for students of mollusks. Large sea clams (*Mactra*), [page 185] the empty shells of which are often found neatly nested in cod stomachs; cockles (*Polynices*); and sea mussels (*Modiolus*) are staples, all of which they swallow whole. Cod also eat crabs, hermit crabs, lobsters (large and small), shrimps, brittle stars (of which they are sometimes crammed full), sea urchins, sea cucumbers, and sea worms (*Nereis*). Brittle stars and small crabs, for example, had been the chief diet of the cod examined by Welsh on the Isles of Shoals-Boon Island ground in April 1913, while Wilcox [67] states that a number of 17-pound fish caught in Ipswich Bay were full of large red prawns 2 to 4 inches long (evidently the northern edible shrimp *Pandalus*). And we have found crabs (*Cancer*; *Libinia*) the chief food of the cod on Nantucket shoals.

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

Cod pursue and gorge on squid at every opportunity, and on various small fish, particularly on herring, on lance, and (in the north) on capelin; also on shad, mackerel, menhaden, silversides, alewives, silver hake, young haddock, and even on their own young, rising into the upper waters for this purpose when necessary (p. 184). They also pick up flounders, cunners, rock eels (*Pholis*), blennies, sculpins, sea ravens, small hake and skates from the bottom. In fact, they take any fish small enough to swallow, including the hard slim alligatorfish (p. 457) and even the sea horse (p. 315). And Welsh noted that many cod taken near the Isles of Shoals on May 1, 1913 spat up small rosefish from 4 to 6 inches long. The eggs of the longhorn sculpin [68] and of the eelpout (*Macrozoarces*) [69] also have been found in cod stomachs. Adult cod as well as small are also known to feed on pelagic shrimps in the waters around Iceland, [70] but we have never heard of them doing so in the Gulf of Maine.

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

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

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

Enemies

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

Migrations and wanderings

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

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

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

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

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

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

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

Breeding habits

The cod is one of the more prolific fishes. A female 39 or 40 inches long may be expected to produce about 3,000,000 eggs yearly, one of 41 inches at least 4,000,000. And Earll estimated the number in a 52½-inch fish weighing 51 pounds at 8,989,094, with 9,100,000 in [page 187] a 75-pounder. But the average production of eggs is perhaps not more than 1,000,000 for the general run of Gulf of Maine fish.

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

The period of incubation for cod eggs depends on temperature. According to experience at the hatcheries, hatching may be expected in 10 or 11 days at 47° F., in 14 or 15 days at 43° F., in 20 to 23 days at 38° to 39° F. and not for 40 days or more if the water is as cold as 32° F. Fertilization can take place and development commence in temperatures even lower than this, as proved by experiments by Krogh and Johansen. [77] But their observation that the mortality is great among eggs incubated at 32° F. (although full development can take place) corroborates the experience of the hatcheries, where it has proved impossible to hatch more than 25 to 50 percent of the eggs in water as cold as that. And the relative strength of the larvae that are hatched at different temperatures points to 41° to 47° F. as most favorable for incubation. All this suggests that extreme cold prevents the successful reproduction of the cod, not by interfering with spawning (for this can take place in the lowest temperatures to be found anywhere in the open sea, p. 195), but by its effect on the developing eggs. And it is interesting that cod in the tank at Woods Hole produced eggs in February, when the water may have cooled to 30° F. (and quite normally to judge from the fact that the eggs incubated successfully in the warmer water of the hatchery), for these same fish would have spawned naturally in temperatures at least as high as 36°-38° F. if they had been left at liberty.

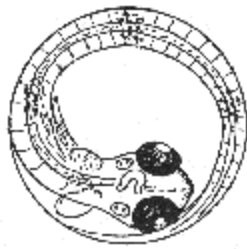


FIGURE 87.—Egg. After Heincke and Ehrenbaum.



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

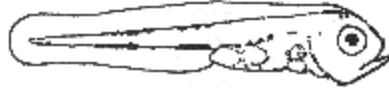


FIGURE 89.—Larva, 4.5 mm. After Schmidt.



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



FIGURE 91.—Fry, 20 mm. After Schmidt.



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

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

- Figure 87. - Egg. After Heincke and Ehrenbaum.
- Figure 88. - Larva, just hatched, 4 mm. After Masterman.
- Figure 89. - Larva, 4.5 mm. After Schmidt.
- Figure 90. - Larva, 9 mm. After Schmidt.
- Figure 91. - Fry, 20 mm. After Schmidt.
- Figure 92. - Young, 40 mm. After Schmidt.

Newly spawned cod eggs are indistinguishable from those of the haddock, with which they intergrade in size. But shortly before hatching, the pigment of the cod gathers in 4 or 5 distinct patches: one over the region of the pectoral fins, one above the vent, and the others equally spaced behind the latter (fig. 87); whereas in the haddock [page 188] the pigment cells are arranged in a row along the ventral side of the trunk (p. 203). There is also danger of confusing newly spawned cod eggs with those of the witch flounder (p. 287), which they overlap in size; but the black pigment of the cod eggs identifies them as gadoid as soon as this appears, for the embryonic pigment of the witch is yellow. (See also haddock on p. 203.)

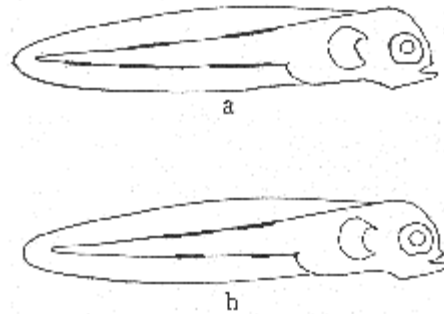


Figure 93. - Diagram of the pigmentation of the young larvae of the cod, A, and of the pollock, B. After Schmidt.

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

The young cod float helplessly, when first hatched, yolk uppermost. But they assume the normal position in about 2 days; the yolk being absorbed and the mouth formed in 6 to 12 days, according to temperature, when the larvae are about 4.5 mm. long. As the little cod grows the pigment bars gradually fuse, and at 8 to 10 mm. a median band forms. Cod 10 to 20 mm. long may easily be distinguished from pollock by the fact that the pigment extends to the tail, whereas it ends abruptly some distance in front of the tail in the pollock. Haddock of this size show much less pigment (p. 203). Cod fry of 15 to 30 mm. are made recognizable by the location of the vent under the second dorsal fin, combined with dense pigmentation. At 20 mm. The dorsal and anal fin rays have attained their final number and the separate fins are outlined, while at 30 mm. The fry begin to show the spotted color pattern so characteristic of the cod.

Rate of growth

In 1898 a large number of newly hatched larvae were released in December at Woods Hole in the "eel pond" (a lagoon freely communicating with the harbor and with a temperature about paralleling that of the outside water), where they grew to an average length of 50 to 100 mm. by the following June. [78] the experiment was repeated in the winter of 1899 [79] with similar results, as appears from the following table showing the growth of approximately 2 million freshly hatched larvae that were placed in the eel pond on January 11.

Date	Extreme lengths (mm)	Average lengths (mm)	Date	Extreme lengths (mm)	Average lengths (mm)
Apr. 8	29 to 30	32.9	May 25	28 to 68	64
Apr. 25	34 to 49	40	June 6	71 to 76	75.5
May 13	35 to 51	42.8	June 20	73 to 77	75

Captures of young fry 1½ to 3 inches long in the neighborhood of Cape Ann late in June (Earll 1880), and subsequently around Woods Hole and on Nantucket Shoals, show that cod hatched from January to March in the Gulf of Maine grow at about this same rate. But fish that are hatched in the rising temperatures of spring might be expected to grow faster during their first few months. European experience [80] is to the effect that young cod are 4¾ to 8 inches long by the end of their first autumn, which probably applies equally to the Gulf of Maine.

In later life cod grow at varying rates in different seas, and even fish that are caught in the same haul [page 189] may have grown at very different rates, as shown by the structure of their scales. Consequently, the length of a fish older than a yearling is no criterion to its age within 2 or 3 years. Wodehouse's [81] studies on cod caught at the mouth of the Bay of Fundy and the Bureau of Fisheries investigations on Nantucket Shoals, suggest that cod grow more rapidly in the Gulf of Maine than in European waters, as follows:

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

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

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

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

General range

Both sides of the North Atlantic, north to West Greenland, Davis Strait, Resolution Island, Hudson Strait in the west, [83a] south nearly if not quite to Cape Hatteras on the American coast; abundant from northern Labrador to Nantucket Shoals, and to New York and New Jersey in winter, when a few are annually caught as far south as the northern part of the North Carolina coast. The continental slope marks the offshore boundary for the cod off the North American coast. The range of the cod in the eastern Atlantic extends from Nova Zembla, Spitzbergen, and Bear Island in the north to the northern part of the Bay of Biscay in the south, and up the Baltic to Finland. The North Pacific cod, with smaller air bladder (*G. macrocephalus*) cannot be separated from the Atlantic cod by external appearance.

Occurrence in the Gulf of Maine

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

The eastern half of Georges Bank has always been a most productive cod ground and one of the most famous south of the Grand Banks of Newfoundland. The next largest Gulf of Maine fares are brought in from the South Channel-Nantucket Shoals region in the southwestern part of the Gulf, and from Browns Bank in the eastern part, the latter being especially productive in winter. The broken bottom off Seal Island, Nova Scotia, the ground near Lurcher Shoal, and Grand Manan Bank are all famous cod grounds. Other well-known inshore grounds are certain hard patches off Chatham (Cape Cod); between Provincetown and Plymouth and off the latter port; Jeffreys Ledge, Ipswich Bay, Cashes Ledge, Platts Bank, and Fippenies. Small vessels likewise make good catches on the succession of hard and rocky patches that border the coast [page 190] from the Isles of Shoals to the mouth of Casco Bay; on "Seguin" and "Kettle" bottoms off Seguin Island; on the "Matinicus ground" off Matinicus Island; on the "Grumpy" off Isle au Haut; in the neighborhood of Mount Desert Rock and of Mount Desert Island; and on sundry small ridges thence eastward to the mouth of the Bay of Fundy. Rich, [84] in fact, lists no less than 175 cod grounds around the inner parts of the Gulf, and many other smaller spots all up and down the coast yield a few cod to the small-boat fishermen.

The following summary of the landings of fresh cod from several of the more important Gulf of Maine grounds for 1935 [85] illustrates their relative productivity at that time, and there is no reason to suppose that the situation has altered significantly since then, so far as the numbers of cod are concerned.

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

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

Movements of cod in the Gulf of Maine

The young cod that are hatched within our Gulf tend to follow around the general coastline from northeast to southwest, during the period while they are adrift, as has been shown by Fish [86] very clearly for the Cape Ann—Massachusetts Bay spawning grounds. Our few captures of pelagic cod fry have, in fact, all been in the southwestern part of the Gulf, in which they agree with those of haddock, silver hake, and most of the common flatfishes. As Fish [87] pointed out, the fry from eggs that are spawned north of Cape Ann and on the Massachusetts Bay grounds have ample time to become distributed over the offshore banks before they seek the bottom (with 14 to 30 days' drift as eggs, and two months or more as pelagic larvae). They might even circle around to the coast of western Nova Scotia and so to the eastern Maine coast. And fry from the Georges Bank spawning grounds would have ample time to do this in years when they are neither held over the Bank by the local circulation nor carried out over the continental slope, to be lost, as happens in the case of the haddock in some years (p. 212). Our Gulf may also receive contributions of cod larvae and fry drifting past Cape Sable, from outer Nova Scotia waters farther east. On the other hand, the cod fry that are taken at Woods Hole in spring may have come from Nantucket Shoals. But those that we found as far south as the Capes of the Chesapeake in April 1930, probably were the product of the spawning that has long been known to take place in winter off New York and off New Jersey.

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

Some of the larger Gulf of Maine cod probably travel very little out of the spawning season, except as they gradually exhaust the food supply in one spot and are therefore driven to move on over the bottom to fresh foraging grounds. Such fish usually are dark and dull colored, with large heads, a sign of scanty diet. Thus tagging experiments, involving many thousands of fish, have shown that a large percentage of the rather [page 191] small cod that make up most of the population along the coast of Maine shift ground but little from season to season. The red fish that haunt the rocks also belong to this category, and red "rock" fish are sometimes caught as large as 10 or 20 pounds.

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

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

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

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

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

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

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

Spawning grounds and season

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

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

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

So far as we can learn few cod if any, spawn on the sandy bottom along the outer shores of Cape Cod. But great numbers of ripe fish congregate in Massachusetts Bay on well-defined grounds 3 to 10 miles offshore, extending from abreast of Sandwich (some 12 miles south of Plymouth) to Minots Light off Cohasset. Years ago many cod also spawned over a small area off Boston Lighthouse and thence northward toward Bakers Island. Few breeding fish have been reported here of late, however, probably because this general locality has been used as the dumping ground for the refuse from Boston, but a few still spawn on various small rocky patches off Gloucester.

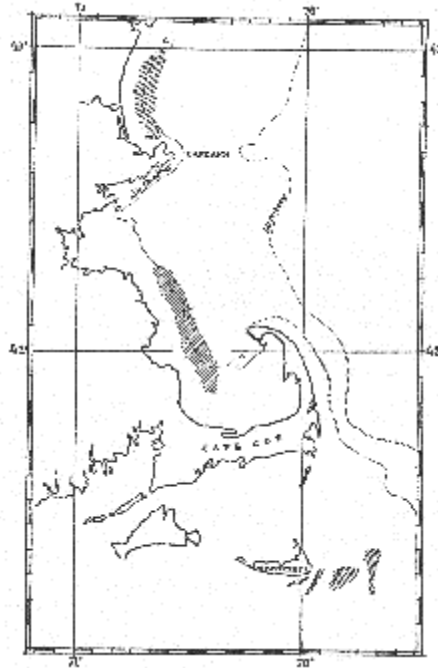


Figure 94. - Chief spawning grounds of cod in the western side of the Gulf of Maine.

The Ipswich Bay region, where large schools of ripe cod gather in winter and spring, is probably the most important center of production for the inner part of the Gulf of Maine north of Cape Ann, but this ground, like the Massachusetts Bay spawning ground, is limited to a rather small and well defined area extending only from a few miles south of the Isles of Shoals to abreast of the mouth of the Merrimac River and (less productively) to Cape Ann, chiefly within 4 to 6 miles of land. A glance at the chart (fig. 94) will show how limited the more important breeding grounds of the southwestern part of the Gulf of Maine are in extent (not more than 300 square miles in all) [page 193] compared to the whole peripheral zone of this part of the Gulf within the 50-fathom curve. And ripe fish are seldom found even close by, though the fishing for green or spent fish may be good there.

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

Spawning cod are caught only in small numbers, and at scattered localities in the coastal zone north and east of the Isles of Shoals, the more productive of these minor grounds being near Cape Elizabeth; off Casco Bay; off the Sheepscott River; off Boothbay; and in the neighborhood of Mount Desert Island. Very few ripe cod are reported along the Maine coast farther east. And the egg-collecting activities of the several hatcheries have been carried on over so many years that important centers of production there could hardly have been missed. Cod eggs have been taken in the Bay of Fundy but the larvae are unknown there. Neither has any definite evidence been obtained that cod breed in any abundance off the west coast of Nova Scotia. And we should emphasize that the small ledges in the western part of the Gulf, e. g., Jeffreys and Platts, are not breeding centers though they are important feeding grounds. We cannot speak for Grand Manan Bank or for German Bank. Cod, in short, are quite as local in their choice of spawning grounds in the Gulf of Maine as they are in Norwegian waters. [93]

Cod spawn at least as far south and west as New Jersey, [94] and captures, in 1930, of a considerable number of fry 1½ to 2½ inches long off New Jersey and off Virginia in April are evidence that spawning is successful at least as far south as the offing of Chesapeake Bay. But the fate of these southern-spawned cod is yet to be learned.

Following the cod eastward and northward, we learn that eggs are produced in profusion as far north as the Gulf of St. Lawrence and the Grand Banks. But it is not known how much spawning takes place along the eastern coast of Labrador, although eggs have been taken in some numbers along the west coast of Greenland as far north as latitude 66°56' N. [95]

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

It has long been known that while cod spawn chiefly in winter, both in American and in European waters, the breeding season lasts much longer and is less definitely limited at either end for cod than it is for the haddock or for the pollock. And experience has shown that the season when the production of eggs is most active differs widely even within the comparatively small area now under discussion. On Nantucket Shoals, ripening fish are caught from late October on, with the cod spawning there in early November to mid-February, and occasionally until April. Corresponding to this, the brood fish taken off Nantucket that were formerly brought in to the Woods Hole pool spawned there from about the first of December until well into February and occasionally as late as March, with the major production usually from December 20 to January 7. [96] And the spawning season is about the same as this off Plymouth in Massachusetts Bay, where ripe cod of both sexes are common from November until as late as April. [97] On the north side of Cape Ann, however, only 50 miles distant, ripe fish seldom appear in any numbers until January and not until February in some years, though odd ones may be expected from November on.

Earll, for example, found that not one female in ten had commenced to throw her eggs by February, in Ipswich Bay, though spawning was then [page 194] at its height in Massachusetts Bay, nor were as many as 50 percent of the Ipswich Bay fish ripe before mid-March. Commencing to spawn later there and near Cape Ann than they do off Plymouth, they also continue later, i. e., until the end of April or even into the first part of May, as appears from the following table of cod-egg collections supplied by the Gloucester hatchery:

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

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

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

The records of the hatcheries just summarized tell when eggs are produced in maximum abundance, but they throw little light on the limits of the spawning season, for it was only during the period when there were enough ripe fish to warrant the effort and expense that spawn taking was carried on. And occasional ripe cod of both sexes are seen long before the bulk of the fish breed, and long after. Thus Earll [99] reports the first ripe female as taken near Cape Ann on September 2 during the season of 1878-79, while we have taken cod eggs, far enough advanced in incubation for positive identification as such, off Shelburne (Nova Scotia) on September 6; near Mount Desert on September 15; and off Penobscot Bay on October 6 (all in 1915).

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

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

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

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

On the Massachusetts Bay ground, spawning fish appear in numbers (late November) when the bottom water is still as warm as 47°-48°; the chief production taking place in temperatures of 36°-42° (December through January), hence in warmer water than in Ipswich Bay. And the peak of the [page 195] spawning season has passed before the temperature drops to its winter minimum, although some cod spawn there through the coldest season (minimum temperature 33°-37°). The temperature range through which the cod breed on the offshore grounds cannot be stated so precisely, for want of data for autumn and for early winter.

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

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

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

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

We have yet to learn what proportion of the cod larvae that are hatched in the Gulf of Maine (doubtless a very small one) survive to grow to market size. And what few bits of evidence we have in this regard are contradictory. [6]

Importance

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

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

During the early days of the fishery, the entire Gulf of Maine catch of cod was made on hook and line; on hand lines at first, but with long or [page 196] trawl lines coming into general use about the middle of the 19th century. And it is not astonishing that a fish so nearly omnivorous as the cod should be caught on various baits. Those most in use in the Gulf of Maine are clams (*Mya arenaria*), cockles (*Polynices*), herring (fresh, frozen, or salt), and squid. General experience suggests that there is little to choose between the first two of these, while the razor clam (*Ensis directus*) is equally attractive though limited by the small supply. And tests made in the Gulf of St. Lawrence [10] proved that fresh herring and fresh squid are about as good as clams, but that frozen and salt herring are less attractive. Other kinds of fish are also used as cod bait in other parts of the world; capelin, especially, in more northern seas, and launce.

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

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

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

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

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

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

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

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

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

[68] Warfel and Merriman, Copeia, 1944, p. 198.

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

[70] Schmidt (Skript. Komm. Havundersøgelser, No. 1, 1904, p. 70) and Paulsen (Meddelel. Kommis. Havundersøgelser, Serie Plankton, vol. 1, No. 8, 1909, p. 39).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[84] Rept. U. S. Comm. Fish. (1929), 1930, App. 3, table 2, pp. 85-86; table 3, p. 96.

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

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

[87] Bull. U. S. Bur. Fish., vol. 43, 1929, p. 289.

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

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

[90] See Thompson (Research Bull. 14, Newfoundland Dept. Nat. Resources, 1943, pp. 20-45, charts 1-8) for detailed discussion in relation to spawning and to racial subdivisions of the local stock.

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

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

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

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

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

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

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

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

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

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

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

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

[4] Hjort, Canadian Fish. Exped. (1914-1915) 1919, p. XXVII.

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

[6] Fish (Bull. U. S. Bur. Fish., vol. 43, 1929, p. 266) caught no cod larvae in Massachusetts Bay, though eggs were abundant there, but the Albatross II towed several hundred little cod (4 to 9½ mm.) off the tip of Cape Cod nearby, on May 28, 1927. The paucity of our other catches of cod larvae (80 to 90 all told) for other parts of the Gulf of Maine may have been accidental.

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

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

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

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

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

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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