Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

INVESTIGATIONS INTO THE HISTORY OF THE YOUNG SQUETEAGUE.

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In July, 1900, I was instructed by the U. S. Commission of Fish and Fisheries to make certain studies of the squeteague, in accordance with the following:

The Commission desires that you take up the study of the young squeteague (*Cynoscion regalis*) which is found schooling in Buzzards Bay, Narragansett Bay, and other waters of southern New England. As the squeteague is one of the most important food-fishes of this region, a more thorough knowledge of the young is very much needed. The following topics are suggested for your consideration: Habits; physical and biological surroundings; food; enemies; diseases; sexual conditions; rate of growth; changes in appearance incident to growth; length of sojourn in local waters; movements preceding and attending departure; route of migration, etc.

I herewith present my report on the work done during July, August, and September of 1900. I take pleasure in acknowledging my indebtedness to the director of the Woods Hole laboratory, Dr. H. C. Bumpus. Mr. Vinal N. Edwards, the collector of the station, has in most cases selected the site for making examinations, and, owing to his long experience, his advice has always been of great value. I am indebted to him for his ever-ready assistance.

I have not been able to approach a solution on the following topics:

(1) The diseases of the young squeteague, if it has any, are not known. The Peridinium which is destructive to the adult is probably also destructive to the young. The appearance of the Peridinium is periodic, with long intervals between. After the young leave the shallow water they are probably subject to the same enemies that the young of all fish are subject to, viz, adult squeteague and blue-fish.

(2) The line of migration has not been even remotely established.

DISTRIBUTION OF YOUNG SQUETEAGUE.

During the early period covered by this report, the latter half of July and August, 1900, the only location where young squeteague were found in Buzzards Bay was in the extreme upper parts, near Wareham. Mr. Edwards states that this is the only place where he has secured them during corresponding periods in previous years. In the region mentioned they were found in loose schools,[1] with occasionally stray individuals. Only occasionally a single individual was found in a haul of the

[1] The following record of catches near Wareham may be of interest as bearing on the matter of schooling:
July 25. First haul, about 100; second haul, about 25; made alongside the first.
Aug. 2. First haul, 7; succeeding hauls, none.
Aug. 9. First haul, 1; second haul, 6; third haul, none; made side by side.
Aug. 22. Three specimens in one haul, none in six other hauls.

seine. Usually, if any were caught at all, there were several or many individuals, the maximum being about 100. They were much more abundant at Wareham in the earlier part of the season than at the latter part, in the proportion of about 40 to 1. They were also found at Fields Point, Indian Point, and in Seekonk River at Providence. No further collections were made in Narragansett Bay. The young appear at the lower end of Buzzards Bay during September and October.

On September 9, 1893, several young squeteague, from 80 to 100 mm. long, were taken in Hadley Harbor and are preserved in the U. S. Fish Commission Museum at Woods Hole. On September 7, 1900, a single young specimen was taken in the Fish Commission trap on the Vineyard side of Nonamesset, near the gut separating Nonamesset from Naushon. Mr. Edwards states that occasionally they are found in Quissett Harbor during the latter part of the summer, but none was found at Quissett Harbor, Hadley Harbor, or at the Breakwater during 1900.* The line and rate of migration could not be determined from the few data secured. The one specimen caught in the trap was just large enough to be held by the meshes. Any smaller ones that may have gotten in are not available for record.

GENERAL HABITS.

Over 20 young were put into an aquarium, where they could be watched without disturbing them. They were entirely pelagic, never being found either at the bottom or at the top of the water. They kept together in a loose school, but without any definite coordination of the individuals of the school, either when they were undisturbed or when disturbed.

PHYSICAL AND BIOLOGICAL SURROUNDINGS OF YOUNG SQUETEAGUE.

The examination was limited to drawing a 150-foot seine, which enabled me to determine their distribution in a limited area about the shore. They were found here during July and August in water with a low specific gravity. They were most abundant in floating weeds and other places where shrimp were abundant. They were found most plentifully when it was scarcely possible to draw in the net on account of the masses of floating weeds. Their associates were almost invariably young eels, silversides, puffers, sea-robins, tautog, cunners, minnows, hog-chokers, scup, and king-fish, and occasionally toad-fish, bill-fish, various flounders, alewives, menhaden, sea-bass, and young dog-fish. A direct connection of only two of these with the squeteague was established, i. e., the silversides and alewives, which serve the squeteague as food.

FOOD.

The food of the young squeteague consists exclusively of shrimp and young fish. In young individuals, 43 mm. long, the contents of the stomach made about 4 per cent of the total weight. The proportion of the shrimp and fish making up the food may be gathered from the following—it should be borne in mind that the stomach is usually full:

Of 14 specimens, with an average length of 60 mm., 9 contained shrimp only, 5 contained shrimp and young fish. One specimen, 55 mm. long, contained a silversides 28 mm. long. In another, the fish in the stomach was a clupeoid, probably an alewife. The other fish found in the stomach defied identification.

*Young squeteague were abundant at New Bedford on October 5, 1900.

Of 7 specimens, with an average length of 89.5 mm., 4 contained shrimp, 2 contained débris of fish, and 1 was empty.

Of 3 specimens, with an average length of 117 mm., all contained shrimp and fish, the latter in excess of the former.

The details of the food of 6 small specimens from Providence may be given here:

No. of specimen.	Length of specimen.	Stomach contents.
	mm.	
1	33	Fragments of 8 small shrimp.
2	33	Fragments of 11 shrimp (heads with eye-stalks forming the basis of the count); 3 silversides, longest 11 mm.
3	45	13 shrimp, 3 silversides.
4	61	7 shrimp, 1 fish.
5	47	4 shrimp.
6	45	10 shrimp.

Observations on those in the tank showed that they would readily take chopped fish dropping through the water, but not after it had reached the bottom. They are exclusively pelagic, and in nature confine themselves entirely to living or moving food. Even such unsatisfactory creatures as sticklebacks were taken by those in confinement.

RATE OF GROWTH.

The rate of growth during the period of observation is practically uniform, the young doubling their length in about thirty days. The details may be gathered from the accompanying table which gives the rate of growth of this species and also of some of the constant associates in the same water:

Date.	Squeteague.	King-fish.	Swell-fish.	Scup.	Bill-fish.	Sea bass.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
July 12	.....	*a* 32.6	.....	.....	.....	.....
July 25	59.5	68.2	29	45	123	*b* 25
Aug. 2	79.5	79	35.6	58	155	.....
Aug. 9	89.5	107	.....	.....	.....	.....
Aug. 22	117	123	63	.....	.....	67
Sept. 7	*c* 200	.....	.....	.....	.....	.....
Sept. 15	.....	.....	.....	.....	.....	*d* 76
Sept. 20	*e* 92.5	.....	.....	.....	.....	.....
Oct. 5	*f* 180	.....	.....	.....	.....	.....

a 1899. Based on 11 specimens ranging from 28 to 30 mm.
b July 24, 1899. Based on 9 specimens ranging from 23 to 26 mm.
c One specimen, probably much above the average; 6 in collection at Woods Hole, taken in Hadley Harbor Sept. 9, 1893, range from 80 to 100 mm., and average 91 mm. in length.
d Based on 3 specimens ranging from 73 to 82 mm.
e Based on 4 specimens from Seekonk River, 70, 85, 95, and 120 mm. long, respectively.
f On October 5 Mr. Edwards found young squeteague 6 to 8 inches long quite abundant in New Bedford River. Many were caught off the wharf with hook and line by fishing on the bottom. No definite measurements were recorded.

At the rate of growth indicated here, the size of many adults (400 mm.) sent to the market would be reached in about seven months, but the rate of growth in length very probably decreases with age. Nevertheless, it seems very probable that the fish reaches marketable size in about a year from birth.

The specimens collected in Narragansett Bay were much smaller than those of Buzzards Bay of the same date; 41.9 mm. in Narragansett Bay on August 3 and 4; 79.5 in Buzzards Bay on August 2. If the rate of growth is uniform, the Narragansett specimens are eighteen days younger than the Buzzards Bay specimens.

CHANGES WITH AGE.

The young of the fish differs so strikingly from the adult that it would readily be referred to another species or genus. The more striking changes with age occur in the relation of depth to length, in the relative size of the eye, in the color, and in the shape of the caudal fin. The smallest secured came from the head of Narragansett Bay; it is 25 mm. long to the base of the caudal. The greatest depth is below the

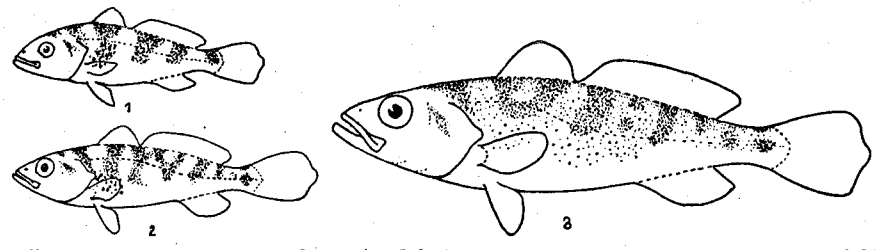


FIG. 1.—Smallest specimen, 32 mm. long, Indian Point, July 5, 1900, showing color pattern in deeper layer of skin.
FIG. 2.—Specimen 41 mm. long, Indian Point, July 5, 1900, showing color pattern. Color entirely in deeper layer of skin.
FIG. 3.—Specimen 70 mm. long, Indian Point, July 5, 1900, showing addition of color cells between those grouped into bars.

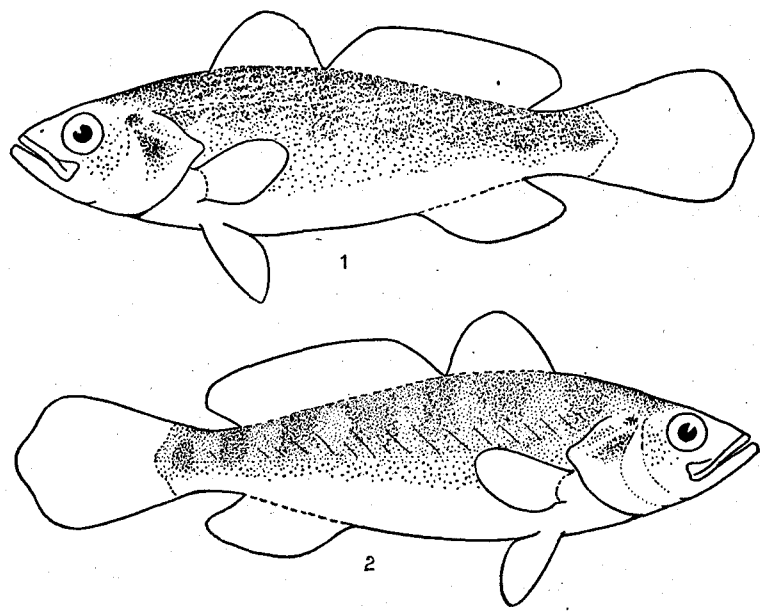


FIG. 1.—The left side of a specimen 95 mm. long, Wareham, August 9, showing indistinct bars and oblique streaks.
FIG. 2.—The right side of the same specimen with the outer skin removed and showing the bars made less distinct than in younger specimens by the appearance of numerous color cells between them. No evidence of oblique streaking, which is entirely due to color cells in the outer layer of the skin. The blood vessels are surrounded by pigment cells and show as black lines.

first dorsal spine and measures 8 mm. The average depth in 10 individuals from the same place, with an average length of 29.2 mm., is 8.7 mm., or 29.4 per cent of the length. The average width is 4 mm., or 13.7 per cent.

In 7 specimens from the same place, taken at the same time, ranging from 46 to 60 mm., and with an average length of 50.6 mm., the depth averages 13.14 mm., or 25.96 per cent; the width 5.71 mm., or 11.08 per cent. In 3 specimens from

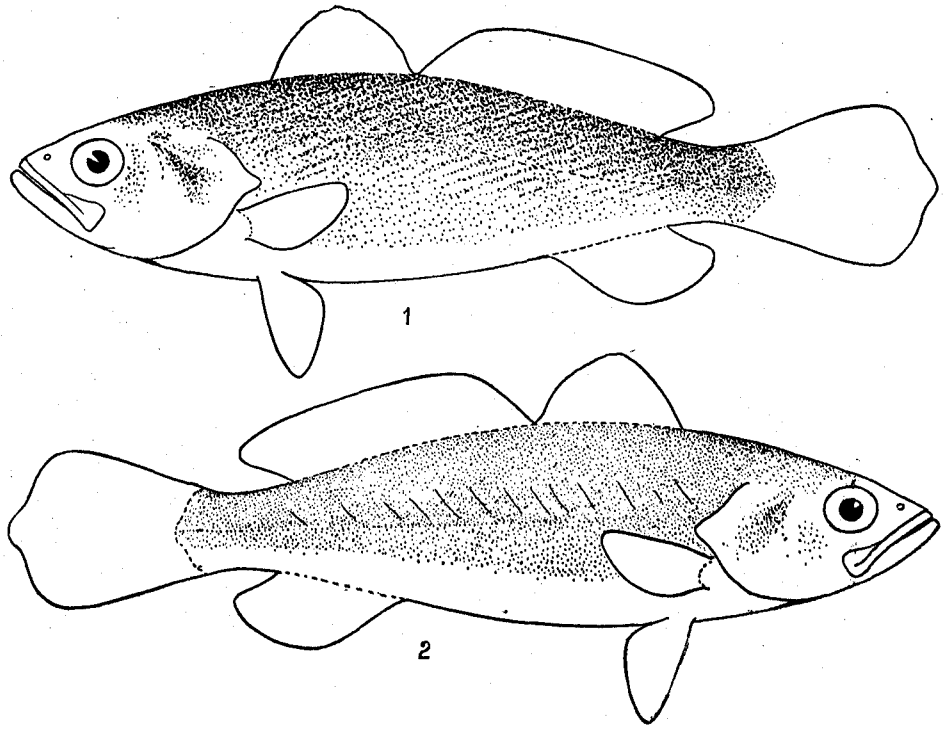
Wareham, taken August 22, averaging 97 mm., the depth averages 26 mm., or 26.8 per cent. The average width is 13 mm., or 13.41 per cent.

In 1 specimen, 170 mm. to base of caudal, the depth is 40 mm.

In 2 adult specimens, 420 (415 and 425) mm. long to the base of the caudal, the depth measures 86.5 mm., or 20.59 per cent. The width at the axils averages 67 mm., or 15.95 per cent.

In 2 specimens, 50.6 mm. long to base of caudal, the depth is 113 mm.

The fish when adult are much more cylindrical than the young, which are compressed and elevated. In the adult the head is nearly conical, but little deeper than



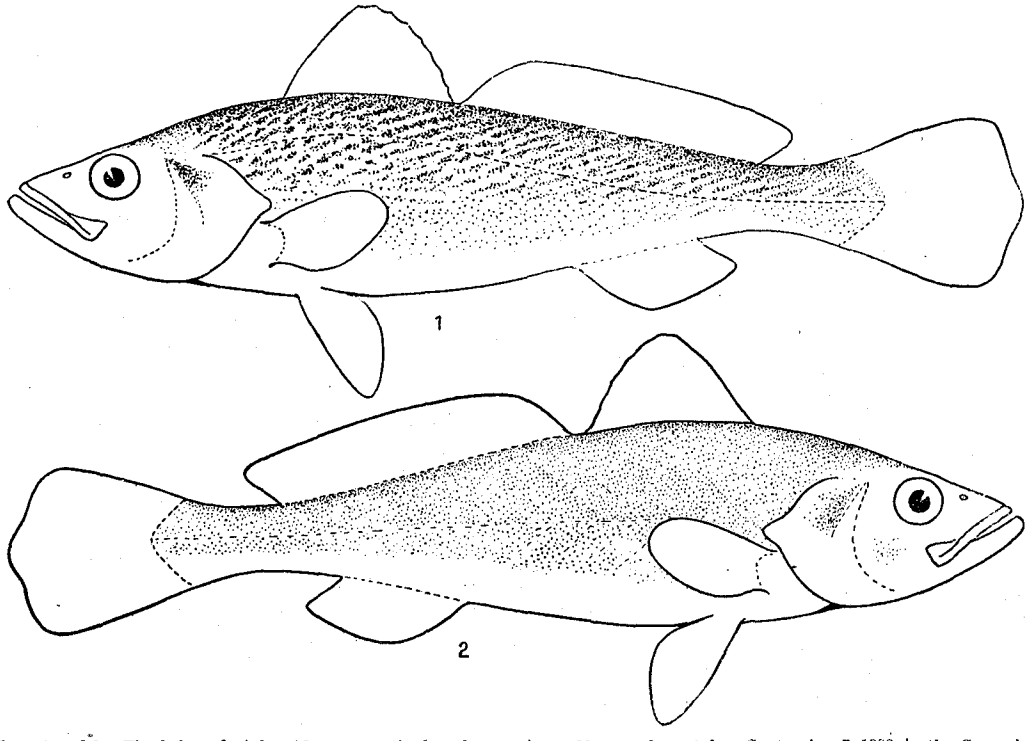
FIGS. 1 and 2.—The left and right sides respectively of a specimen 120 mm. long taken at Wareham, August 22. Fig. 1 represents the general color which is largely due to the color cells in the outer layer of the skin. The streaking which is conspicuous in the adult is here still obscured by the general distribution of pigment in the deeper layer shown in fig. 2, which represents the coloration of the right side after the removal of the outer skin.

high; in the young it is much deeper than high. The eye changes its relative proportions to the size of the head, as in other fishes. This is due to the fact that while the eye grows throughout life it does not grow in the same proportion as the rest of the fish.

Length of fish.	Length of eye.
	mm.
26 mm. to base of caudal	2.5
44 mm	4.5
108 mm	8
170 mm	11.5
415 mm	20
560 mm	22

A very marked change takes place in the shape of the caudal. In the adult the margin of the caudal is distinctly concave or lunate. In all stages of the young, on the other hand, the caudal rays between which the lateral line extends are the longer, the caudal being obtusely pointed, with 9 rays in the upper and 8 in the lower lobe. The upper lobe of the caudal is slightly lunate, while the rays of the lower lobe are graduated, and this lobe is rounded.

Very marked changes take place in the color with age. The changes occur largely in the sides of the body. The color pattern of the head changes little with age. There is here chiefly an addition of color cells to those already present in the



FIGS. 1 and 2.—The left and right sides, respectively, of a specimen 200 mm. long taken September 7, 1900, in the Commission's net in Vineyard Sound. The left side shows the characteristic markings of the adult which are due entirely to the color in the outer layer of the skin. The nearly uniform distribution of color in the deeper layer of the skin seen after removal of the outer skin is represented in Fig. 2. This deeper layer of color no longer enters into the general coloration owing to the formation of connective tissue between it and the outer layer.

smallest specimens. In the smallest specimen there is a series of four pigmented bands, extending across the back. The first at the spinous dorsal, the second at the beginning of the soft dorsal, the third some distance in front of the end of the soft dorsal, and the last across the caudal peduncle. All of these extend but little beyond the lateral line. Their margins correspond roughly with the margins of myotomes. At the dorsal angle of the myotomes the bands are usually bent, but without regularity. In the specimen under discussion, those on the left side are shifted backward, at this point, of those on the right side; two are continued straight down, one is shoved forward and the other backward. The region between the bands is not free

from pigment, but the cells are here smaller and contracted. A line of cells extends along the base of the anal and to the tail. The spinous dorsal is largely black; the soft dorsal and caudal have pigment cells along the membrane. All the chromatophores at this stage are in the deeper layers of the dermis below the scales.

With an increase of a few millimeters in length additional bands are interpolated between those mentioned, first one between the two under the soft dorsal, then one below the end of the soft dorsal, and lastly one between the two dorsals. All of these are formed by the time the fish has reached a length of 44 mm. to the base of the caudal. Eventually the deeper layer becomes deeply pigmented through the appearance of chromatophores in the spaces between the bands. Numerous small chromatophores have also appeared in the superficial layer of the dermis, especially along the edge of the scales, so as to give a distinct black margin. With growth the chromatophores at the margin of the scales and those in the superficial layers of the dermis, as well as those on the fins, become very numerous. In specimens 75 mm. long to the base of caudal the bars are still faintly visible but the whole fish has taken on a dusky color on the sides, back, and fins, with a distinct black border to the dorsal and caudal.

In a specimen 110 mm. long the black margins of the fins are less conspicuous, the black edge of the scales has become obscure on account of the great multiplication of superficial pigment cells. The bars of the young stage are entirely obliterated and the superficial pigment shows the characteristic oblique streaking of the adult, but much less conspicuously than in the adult.

At this stage the color is due to the now uniform pigmentation of the deeper layers of the dermis blending with the streaked pigmentation of the superficial part of the dermis. With age the connective tissue between these two layers of pigment becomes so thick as to entirely eliminate the deeper pigment as a factor in the formation of the color pattern. The surface pigment, which is from the first laid down in streaks, alone gives value to the pattern in the adult.

The obvious differences of the sexes appear so late that I can only report on the sex relations that no sex differences are apparent at a length of about 100 mm.