CONTRIBUTIONS TO LIFE HISTORIES OF SCIÆNIDÆ OF THE EASTERN UNITED STATES COAST.

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INTRODUCTION.

The control of the commercial fisheries of the United States, excluding Alaska, rests entirely in the hands of the State governments. All legislation directly affecting the fisheries is the work of the legislatures of the States within the boundaries of which the fisheries are conducted. In this legislation there is the greatest diversity, both in scope and character. In many cases the laws enacted have been wise and their enforcement beneficial. In other cases the laws have been framed without full knowledge of the many factors demanding consideration, and their enforcement has brought little or no benefit, sometimes even positive injury, to the very interests they were designed to uphold.

A fundamental prerequisite for intelligent fisheries legislation—legislation that will serve the true interests of the fisheries and assist toward the increase and perpetuation of the prime sources of supply—is an accurate knowledge of the life histories of the species contributing to that supply. Lacking such knowledge, legislation must be largely a matter of guesswork, based on the varied and often conflicting opinions of interested parties. Such accurate knowledge is by no means easy to obtain, however, since it is manifestly impossible to observe directly the habits, growth, breeding, and wanderings of individual fish that possess the freedom of the sea.

The desired knowledge can be accumulated but slowly through the pursuit of oceanographic studies and the continual collection of fishes under conditions of accurate record, with especial reference to eggs and larvæ. The material and the data accumulated at any one time may tell no useful story, but when there has been gradually gathered together a great store of materials many of the several elements will be found to fall into series. A patchwork quilt is eventually formed which depicts in accurate form and in more or less complete detail the interesting and long-desired story of the migration and feeding and breeding habits of one or more species of fish. [Coker, 1920, p. 10–11.]

In this paper an effort has been made to bring together such facts as have been recorded concerning the life histories of the family Sciænidæ found on the Atlantic coast of the United States. The matter contained in it is fragmentary, and the blank spaces in our knowledge of the subject are many and large. As yet there has been no systematic attempt on the part of investigators to study the life histories of this economically important group of fishes, and such facts as have been brought to light form a very imperfect patchwork, which may well be compared to a picture puzzle in which most of the parts are still missing.

The greater part of the material upon which the paper is based consists of collections and records made by the vessels and stations of the Bureau of Fisheries, and the acquisition of most of it was incidental to other work. Especially valuable was the work of Lewis Radcliffe on the embryology and development of the squeteague (*Cynoscion regalis*), hitherto unpublished, and his copious notes on other species contained in the records of the steamer *Fish Hawk* and of the Beaufort (N. C.) laboratory. The collections of young fishes made during the past nine years by the senior author in the fisheries vessels *Fish Hawk*, *Grampus*, and *Albatross* and in the shrimp-trawling boats at Fernandina, Fla., yielded much material of value for the study of growth. Collections made at the Woods Hole (Mass.) laboratory were utilized, and many specimens were loaned for study by the National Museum.

The methods used in the study of growth are of two kinds. Wherever possible large numbers of young fish taken at different times and places have been measured and from the data thus obtained curves of growth have been constructed. When the material at hand was inadequate for the application of this method the examination and measurement of the scales of the adult fish were made, and in many cases scale examination has been used to supplement and confirm the results obtained by measurement of the young.

The general principles of scale examination have been fully set forth by Hjort (1919). The determination of age by means of an examination of the scales is based on the fact that many fishes form concentric rings of growth on their scales which are believed to be analogous to the annual rings found in dicotyledonous wood. That is, the slow growth during the winter causes the formation of a band of narrow rings unlike the broader ones of the summer growth. Since the length of a fish is proportional to the size of its scales, it follows that a microscopical examination of the latter with measurements of their previous sizes (as indicated by the winter bands) will give, by simple proportion, the length of the fish during any winter. As age increases it becomes progressively more difficult to interpret the markings on the scales, partly because the growth becomes less each year and the winter rings consequently become confusingly close, generally at an age of about 6 years. Further difficulty is found in connection with cessations of growth due to accident or spawn-

ing, which likewise cause the formation of rings that must be allowed for. The difficulties encountered in the application of this method to the scales of many species are almost as varied and numerous as the species themselves. Time has been lacking for a thorough study of the scales of any of the species herein treated, and any conclusions in this paper based upon scale examination must be considered as merely tentative and suggestive of the results that might be obtained from further study.

There appear to be no unusual difficulties in the way of a more thorough study of the life histories of this group of fishes, the chief requirement being that the investigator should be at the right place at the right time. The eggs of most, if not all, of them can be obtained readily by following the operations of the commercial fisheries and accompanying the fishermen to their nets. The simplest apparatus (a few finger bowls, or Petri dishes) will suffice for the incubation of the eggs, which is rapid. The use of small townets, operated as near the bottom as possible, will supply material in the larval and post-larval stages, and the shrimp trawl and collecting seine will yield a harvest of examples intermediate in size between these and the adult fishes.

Although a detailed discussion of the economic importance of the fishes of this group is not within the province of this paper, a brief summary for the Atlantic and Gulf States of the quantities annually caught and their approximate values may not be out of place, as it will point to the desirability of a more thorough study of the entire subject. A careful compilation of the latest statistics available has therefore been made. Unfortunately, these statistics do not cover the entire field for any one year. Statistics of the Gulf States are for 1919, of New York and New Jersey for 1917, and of the remainder of the Atlantic coast States for 1908. As the quantity of these fish marketed has generally increased during recent years (notably so in the case of the croaker, *Micropogon undulatus*), and as the value per pound has also increased greatly since the collection of a large part of these statistics, the figures, both for quantity and value, are doubtless below the truth at the present time.[1] The summary follows:

TABLE 1.—*Summary, for the Atlantic and Gulf States, of quantities and approximate values of regularly marketed fish caught yearly.*

Species.[a]	Pounds.	Value to fishermen.
Squeteagues:		
Cynoscion regalis	40,941,043	$1,843,070
Cynoscion nebulosus		
Cynoscion nothus		
Croaker: Micropogon undulatus	10,717,812	351,938
Drum:		
Sciænops ocellatus	7,231,778	280,484
Pogonias cromis		
Spot: Leiostomus xanthurus	1,762,151	52,215
King whiting:		
Menticirrhus saxatilis	1,644,396	78,065
Menticirrhus americanus		
Menticirrhus littoralis		
Total	62,297,180	2,605,772

[a] Figures for the only other important species of the group, the silver perch, *Bairdiella chrysura*, are not available.

[1] Of the total amount of fish received at the Municipal Fish Wharf, Washington, D. C., during the year 1919, no less than 37½ per cent, or 3,039,000 pounds, were of species included in this paper. First in importance were the squeteagues, *Cynoscion regalis* and *C. nebulosus*, of which, in round numbers, 2,098,000 pounds were marketed. Following in the order of their importance were: Croakers, *Micropogon undulatus;* spot, *Leiostomus xanthurus;* king whiting, *Menticirrhus saxatilis* and *M. americanus;* red drum, *Sciænops ocellatus;* and silver perch, *Bairdiella chrysura*. The figures for the last species are not included in the total given above, as no distinction is made between it and the white perch, *Morone americana*, in the market report.

It will be noted that the above figures include only the fish regularly marketed and their first value to the fishermen. They do not take into account the immense quantities (in the aggregate) taken by anglers for their private use nor the very considerable number of fish too small for market that are incidentally destroyed in the net fisheries. Nor is the tribute yielded by these fish on their journey from the hands of the fishermen to the hands of the ultimate consumers included in the figures. This sum will often amount to from three to ten times the first value. In addition must be considered the many thousands of dollars spent for tackle, transportation, bait, boat hire, and board and lodging by an ever-increasing army of salt-water anglers, most of whom come from the large cities and for whom the squeteague, king whiting, red drum, black drum, croaker, and spot form the chief incentives to this expenditure.

Anything like an accurate estimate of the total quantities taken and of the aggregate values represented is impossible when all the above factors are taken into consideration, and it can only be pointed out that the interests depending wholly or in part upon the fishes of the family Sciænidæ are exceedingly large and varied.

In view of the great importance of this family of fishes, alike of value to the market fishermen, the distributors, the consuming public, and the angler, it is hoped that the fragmentary observations recorded in this paper may form a nucleus for more thorough study of the group. An adequate knowledge of the life histories and ecology of these species would be of great value in relation to many problems of conservation that are certain to arise in the near future.

The responsibility for any errors and shortcomings that may be present in this paper is assumed by the junior author, and he desires to refrain from sharing in any credit for the analyses of the larger questions involved, as they are almost entirely the result of years of study on the part of the senior author. The untimely death of Mr. Welsh, whose loss is keenly felt from a personal standpoint as well as from the standpoint of his value to the United States Bureau of Fisheries and science generally, militates largely against the value of the present paper. Many of the data are more or less incomplete, since the tables as given here had been tentatively prepared by Mr. Welsh before his death, and it has been impossible for the junior author to undertake the task of again examining the original material and preparing the tables in the more complete form that Mr. Welsh would undoubtedly have preferred. The foregoing introduction and the following general discussion emanated solely from his pen. The additions since his demise have been the notes on food of the various species, the key to identification, the treatment of Pogonias and subsequent species, and various notes inserted throughout the body of the paper.

Figures 16 to 19 were drawn by Mrs. E. B. Decker; 2 to 10, by Templeton Van de Bogert; and 1, 13, 15, 22, 33, 35 to 37, 39, 40, 42, 44, 46 to 54, and 56, by Charles M. Breder, jr. Figures 11 and 12 are reprinted from Tracy (1908); all remaining figures, from previous bulletins of the United States Bureau of Fisheries. Measurements throughout the paper are given in metric units, followed by their approximation in the English system in those cases that have a general interest. The total length is referred to, except where the standard length is specifically mentioned.

GENERAL DISCUSSION.

The Sciænidæ, or drum family, embrace about 30 genera and 150 species, and although a few species are confined to fresh water the great majority inhabit shallow water near the sandy shores of the warmer seas. Most of the marine species freely enter bays and sounds, and some of them at times ascend rivers to waters of low salinity, occasionally being taken in water that is practically fresh.

One of the striking characteristics of the family is the ability of most of the species to emit sounds, which have been variously described as "drumming," "croaking," "grunting," "snoring," "bellowing," "purring," "buzzing," and "whistling." These sounds are produced by vibrations of the air bladder and are frequently so intense that they may be heard for a long distance. The "drums" take their common names from the character of the sounds they produce. The sound that emanates from a school of spawning squeteague in full "voice" is a humming, purring, throbbing trill, which fluctuates in intensity and seems to come from all directions at once. All fishermen for these species are familiar with the croaking and grunting sounds these fish make when captured.

So far as known, all the species of the family feed chiefly on fish, crustaceans, mollusks, or annelids. The food of the early post-larval forms as far as studied consists of similar forms and the smaller plankton organisms.

The family is represented on the eastern coast of the United States by 12 genera and 18 species, none of which ranges north of Cape Cod. Of these, 5 species, *Eques acuminatus*, *E. pulcher*, *E. lanceolatus*, *Umbrina coroides*, and *Corvula sialis*, occur only as stragglers. Two others, *Larimus fasciatus* and *Stellifer lanceolatus*, attain only a small size, and although taken in great numbers in the trawls of the shrimp fishermen have not as yet been utilized. The 11 remaining species are all of commercial importance as food fishes, and most of them are keenly sought by anglers as well.

If the summer migration of adult drum (*Sciænops ocellatus* and *Pogonias cromis*) to the New Jersey coast be excepted, each species appears to breed in suitable localities throughout the full extent of its range. In northern waters, and to some extent in southern waters also, the fish disappear during the winter months, and although it is known that some species merely seek deeper water the whereabouts of others during this time is still a matter of speculation. A case in point is that of the squeteague (*Cynoscion regalis*). Several theories are held among fishermen as to the whereabouts of this species during the winter. The most popular theory is that of a general and extensive migration to the southward, but many believe that the fish move offshore to the deep water on the inner edge of the Gulf Stream, and others, that the fish hibernate—place not stated. However, there is no positive evidence to sustain any of these theories, the only fact that can be substantiated being that the fish do disappear from their summer haunts.

Local migrations in the search for food or for the purpose of reproduction occur with most of the species. In these movements the fish usually travel in schools, more or less compact, but sometimes scattering. The movement usually takes place on or near the bottom, but the squeteagues often travel in mid-water and sometimes at the surface.

The spawning habits vary, both as to season and as to the character of environment preferred, but none of the species is known to spawn in waters of a greater depth than 5 fathoms. In all known cases the eggs are minute, transparent, and buoyant, containing one or more oil globules within the yolk. Under normal circumstances the eggs float freely at or near the surface during at least a part of the period of incubation and are carried about by the currents. There are indications that spawning takes place chiefly at night. The period of incubation, at water temperatures of 65° F. and over, is short, seldom over 48 hours in the species that have been studied.

The newly hatched fry are minute, transparent, and practically helpless, drifting about for the first few days in an inverted position, owing to the location of the bouyant oil globule in the posterior ventral region of the yolk sack. After the absorption of the yolk the growth is usually rapid, spring-hatched fry often doubling their length within 30 days during July and August. The growth of fry hatched during the fall and winter months is very slow until the following spring.

The size at which the young begin to resemble the adults in form and color pattern varies greatly among the several species, the most precocious forms being Larimus and Menticirrhus. In all species the very young differ from the adults in having the head and eye larger and the vertical fins much higher in proportion to the body length.

The growth throughout life is most rapid in the summer months and practically ceases in the winter, even in southern waters. The annual growth is greatest during the period of immaturity, decreasing rapidly after the first spawning and normally becoming less each year thereafter. So far as known spawning occurs every year after maturity is attained. The age at the time of the first spawning varies, according to species, from one year (Stellifer) to three or four (Micropogon and others) and in some cases possibly more. In certain species the males appear to mature a year earlier than the females of the same age. The material available is insufficient for a reliable determination of the average and extreme ages attained, but a thorough study of the scales would probably throw much light upon this subject.

KEY TO SCIÆNIDÆ OF ATLANTIC COAST.

The key included in this paper has been designed chiefly for the nontechnical man who may want a ready aid to the identification of the species of this family encountered. With this point of view in mind, the key was constructed with the use of external characters only, or such that are readily accessible without the aid of dissecting instruments or a knowledge of their use. This, of course, prevents the identification of greatly mutilated specimens; but a person not trained in such work would do better to submit such material to institutions that are qualified for the identification of fragmentary material. It is believed, however, that no one should have difficulty in using this key with the supplementary aid of the accompanying illustrations of adult and immature fish.

All technical terms are explained in the glossary and diagram (fig. 1) that precede the key proper. The diagnosis of the family will eliminate any specimens somewhat resembling Sciænidæ known from the Atlantic coast.

In using the key proper, the letters with their corresponding notes should be read off until a letter is found whose note disagrees with the specimen in hand. Then all intervening matter should be passed over until the last letter's double is reached.

Table 2 (p. 149), which gives the number of rays of the dorsal and anal fins of each species treated in this paper, is intended to be used in connection with the key. In identifying a specimen by means of this table it is simply necessary to count the rays (not the spines) of the dorsal and anal fins. Reference to the table

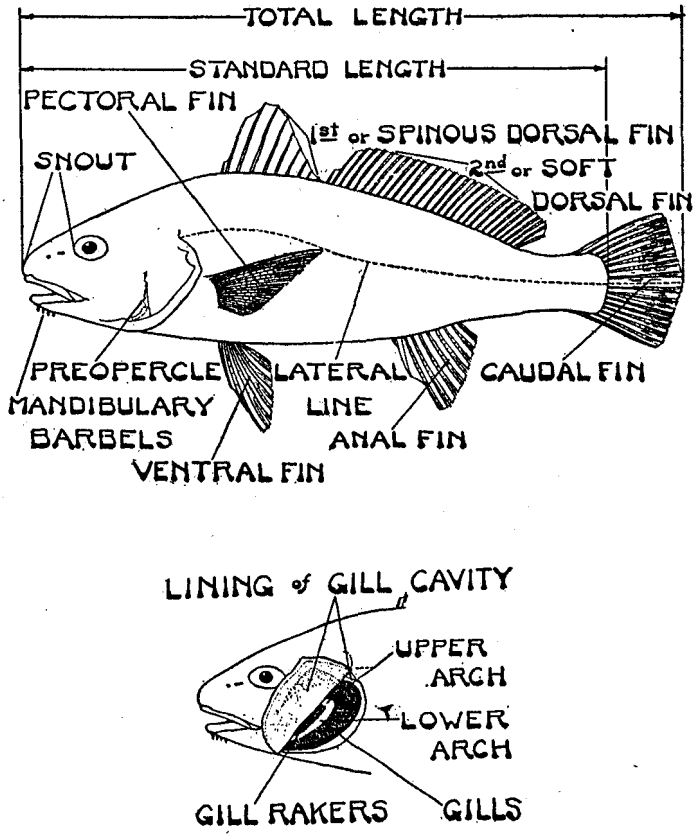

FIG. 1.—Diagram of a sciænid explaining terms used in key.

isolates the specimen in hand, or at least brings it down to a few possibilities from which the specific appelation should be determined readily by reference to the key.

GLOSSARY OF TERMS USED IN KEY.

Canine teeth.—Conical teeth in jaws, larger and longer than the rest.

Cavernous.—Containing cavities, empty or filled with mucus.

Ctenoid scales.—Scales with rough edges, due to minute prickles being directed backward. Can be distinguished from smooth scales (cycloid) by passing finger along side of fish from tail to head.

Deciduous teeth.—Such that readily fall out on slight pressure.

Excluded jaw.—Projecting beyond. Said of lower jaw when it reaches farther forward than upper, as opposed to "included," in which case the opposite is true.

Fusiform.—Tapering gradually at both ends; cigar shaped.
Inferior mouth.—Directed downward with snout usually projecting beyond.
Ocellated spot.—An eyelike mark, similar to those of a peacock's fan.
Rays.[2]—Flexible rods supporting fin membranes, usually branched at tip.
Septum.—A thin partition.
Serrate.—Notched like a saw.
Spines.[2]—Firm spines supporting the fin membrane, unbranched and more or less stiff.
Thoracic fins.—Said of ventral fins when attached to body immediately below pectorals.
All other terms used in key.—Explained in the accompanying diagram (fig. 1).

DIAGNOSIS OF FAMILY.

Ventral fins I, 5 thoracic.
Anal spines, 1 or 2 (never more), soft rays 5 to 13.
Scales ctenoid.
Lateral line continuous and extending on caudal fin.
Dorsal spines X or XI plus I at beginning of soft dorsal, except *Eques lanceolatus*, which has XIV to XVI plus I.
Scale count varies in the different species from about 45 to 75 along the lateral line.

KEY TO GENERA AND SPECIES.[3]

A. Dorsal spines well separated; dorsal rays 20 to 32.
  B. No manibulary barbels.
    C. Mouth large, lower jaw excluded, 2 canine teeth at tip of upper jaw, none at tip of lower jaw; back not elevated; body fusiform, little compressed.....CYNOSCION.[4]
      D. Soft rays of dorsal and anal fins more or less closely scaled; gill rakers long and slender, 9 to 12 on lower arm of first arch.
        E. Coloration nearly uniform silvery.....*C. nothus.*
        EE. Body marked by numerous irregular dark blotches, some of which form wavy oblique lines running forward and downward.....*C. regalis.*
      DD. Soft rays of dorsal and anal fins scaleless; gill rakers comparatively short and thick, 6 to 8 on lower arm of first arch; body covered with round black spots.....*C. nebulosus.*
    CC. Body somewhat compressed, back elevated; no canine teeth in jaws.
      F. Teeth well developed, permanent in both jaws.
        G. No black spot at base of caudal fin.
          H. Lower jaw projecting; interorbital space not cavernous, head not broad above.
            I. Snout less than diameter of eye; mouth large, very oblique, no bony teeth on margin of preopercle.....*Larimus fasciatus.*[5]
            II. Snout equal to or greater than eye; mouth moderate, slightly oblique, margin of preopercle serrate.....*Bairdiella chrysura.*[6]
          HH. Lower jaw equal to or shorter than upper; interorbital space, cavernous, the septa very thin, head broad above.....*Stellifer lanceolatus.*
        GG. One or more black ocellated spots at base of caudal fin.....*Sciænops ocellatus.*
      FF. Teeth very small, those in lower jaw deciduous or wanting, mouth inferior and small.....*Leiostomus xanthurus.*

[2] The number of spines and rays in the fins are often expressed in a formula for convenience. The spines are given in Roman numerals and the rays in Arabic with a comma between if the fin is continuous and a dash if broken into two fins. Thus, the formula for *Cynoscion regalis* is dorsal X–I, 26 (to 29) anal II, 11 (to 13) ventrals I, 5.

[3] This key is modified from that of Smith (1907).

[4] *Cynoscion thalassinus* (Holbrook), which has not been recognized since the describer's time, seems to be merely nominal, as the description is close to *C. regalis* and *C. nothus*. See page 169 under *C. nothus*.

[5] *Corvula sialis* recorded from the Florida Keys is close to *Larimus*, but the dorsal rays are 28 and anal 8, whereas the latter has 24 to 26 dorsal and 5 to 6 anal.

[6] *Bairdiella chrysura* somewhat resembles *Morone americana* (Gmelin), a serranid, but the latter has three anal spines.

BB. Mandibulary barbels present.

J. A row of minute barbels on each side of lower jaw..... *Micropogon undulatus.*

JJ. A single thick barbel at tip of lower jaw.....MENTICIRRHUS.[7]

K. Lining of gill cavity dusky; body marked with irregular pattern of bars and blotches.

L. Third dorsal spine reaching much past origin of soft dorsal; coloration usually dark..... *M. saxatilis.*

LL. Largest dorsal spine not reaching soft dorsal; coloration usually light. ..... *M. americanus.*

KK. Lining of gill cavity pale; body not blotched or barred, longest dorsal spine just reaching origin of soft dorsal..... *M. littoralis.*

JJJ. Numerous large barbels along inner edge of each side of lower jaw, the series usually reaching back to below middle of eye..... *Pogonias cromis.*

AA. Dorsal spines close together; dorsal rays 36 to 53; body tapers rapidly backward.....EQUES.

M. Dusky gray with at least traces of about seven lengthwise streaks. ..... *E. acuminatus.*

MM. Not with seven streaks.

N. Three brown longitudinal bands along sides, central one reaching from eye backward to tips of middle caudal rays..... *E. pulcher.*

NN. Three edged bands, one vertically through eye, one diagonally from nape to ventrals, third curving from dorsal to caudal. ..... *E. lanceolatus.*

TABLE 2.—*Number of dorsal and anal rays in species discussed.*

[D, indicates dorsal rays; A, anal rays.]

Number of rays.	Cynoscion nothus.	Cynoscion regalis.	Cynoscion nebulosus.	Larimus fasciatus.	Corvula sialis.	Bairdiella chrysura.	Stellifer lanceolatus.	Sciænops ocellatus.	Leiostomus xanthurus.	Micropogon undulatus.	Umbrina coroides.	Menticirrhus americanus.	Menticirrhus saxatilis.	Menticirrhus littoralis.	Pogonias cromis.	Eques acuminatus.	Eques pulcher.	Eques lanceolatus.
5				A											A			A
6				A							A				A			
7							A			A		A		A		A	A	
8					A		A	A				A	A					
9	A		A										A					
10	A		A			A												
11	A	A																
12		A							A									
13		A																
20							D								D			
21							D								D			
22						D	D											
23							D							D				
24				D				D				D		D				
25			D	D							D	D		D				
26	D	D	D	D									D					
27	D	D	D										D					
28	D	D			D					D								
29	D	D								D								
30									D									
31									D									
32									D									
36																D		
37																D	D	
38																D	D	
39–46																D		
53																		D

[7] *Umbrina coroides*, recorded from Florida, has a single mandibulary barbel like Menticirrhus, but the ventrals are one-half longer than the pectorals, instead of being shorter, as in the latter. Menticirrhus has a single anal spine, whereas Umbrina possesses two.

Cynoscion regalis (Bloch and Schneider). SQUETEAGUE, WEAKFISH, TROUT, SEA TROUT, GRAY TROUT, SUMMER TROUT, SHAD TROUT, SUN TROUT, YELLOW-FINNED TROUT, BLACK-TAIL.

Cynoscion regalis (fig. 14) is found in abundance along the Atlantic coast, from Cape Cod to eastern Florida. It is one of the important food fishes of the United States and is economically the most important species of the Sciænidæ, or drum family. In 1917 the fisheries of New Jersey alone produced 11,000,000 pounds, with a first value of $480,000.

The fish first appear along the middle Atlantic coast in April and May, when there is a run of adult fish into the bays and sounds. Shortly after their first appearance the fish return to the larger bays and possibly to the ocean to spawn. The spawning season is an extended one, commencing early in May and continuing until September, but the great majority of the fish spawn between the middle of May and the middle of June. The season appears to be little affected by latitude, spawning occurring at approximately the same time from the Carolinas to Cape Cod.

In Delaware Bay the principal spawning ground is on the eastern side of the bay between Maurice River Cove and Cape May, in from 3 to 5 fathoms of water, with a bottom of mud and sand. The fish assemble there in large schools in the latter part of May, and spawning takes place on the bottom. The fertilized eggs immediately float up to the surface and are carried about by the tidal currents. By July 1 the greater part of the spawning is completed, but ripe fish are occasionally taken throughout the summer, and it is certain that large numbers of fish do not spawn until September. The existence of this prolonged season is confirmed by the wide variation in size among the samples of young fish that have been taken from time to time in the winter months, the range in length of fish of the previous summer's hatch extending from 6 to 22 cm. (2⅜ to 8⅝ inches).

The water temperatures at which fertile eggs have been taken in the townets range from 60 to 70° F. (15.5 to 21° C.); the salinity, from 28.01 to 30.9; and the density (at 17.5° C.), from 21.39 to 23.6.

EGGS AND DEVELOPMENT.

The ripe eggs of *Cynoscion regalis* are buoyant, floating as soon as extruded. They are spherical and for any one fish are almost uniform in size, although the eggs of different individuals vary greatly in this respect, the diameter of some measured at Cape May ranging from 0.8 to 1.03 mm. They are almost colorless and are slightly adhesive at first. The yolk contains from one to four (possibly more in some cases) highly refractive oil globules, pale amber in color. When only one globule is present, its diameter ranges from 0.2 to 0.27 mm.

TABLE 3.—*Measurements of eggs and oil globules of two examples of the squeteague, Cynoscion regalis.*

First example.					Second example.			
Diameter of egg (millimeters).	Diameter of globules (millimeters).				Diameter of egg (millimeters).	Diameter of globules (millimeters).		
1.01	0.26				0.80	0.20		
1.02	.27				.81	.20		
1.03	.24	0.20			.81	.20		
1.00	.23	.17			.82	.20		
1.01	.21	.20			.84	.22		
1.00	.19	.18	0.15		.81	.19	0.09	
.98	.21	.17	.12		.83	.20	.07	
1.00	.17	.16	.15	0.14	.84	.17	.14	
					.84	.17	.12	
					.83	.15	.14	0.05

The development of the eggs and larvæ of this species has been studied by Radcliffe, but his results have not been published. The following account of the embryology and larval development (figs. 2 to 10) is taken from his notes. The work was done on board the United States Fisheries steamer *Fish Hawk* in the spring of 1916, in the lower part of Chesapeake Bay.

From the relative numbers of eggs taken in the townets at different hours spawning appears to occur chiefly at night, especially in the early evening.

The eggs are pelagic, transparent, spherical, from 0.74 to 1.10 mm. in diameter, with one to four oil globules within the yolk. The egg membrane is thin and horny. The smaller eggs (0.74 to 0.85 mm. in diameter) rarely have more than one globule, its diameter being about 0.18 mm., but the larger eggs often contain two globules, sometimes three, rarely four. As development advances these coalesce into one. After fertilization a very narrow perivitelline space is apparent between the egg membrane and the delicate vitelline membrane investing the yolk sphere. Occasionally eggs are encountered with a wide perivitelline space, and although such eggs may hatch, the resultant larvæ are less hardy and the condition is presumably abnormal. The smaller eggs appear to considerably outnumber the larger ones.

Eggs in the later stages of development and newly hatched larvæ were rarely taken in the townet at the surface of the water, and it would appear that during development the specific gravity of the eggs increases sufficiently to cause them to sink. This also was normally the case with eggs held in containers on shipboard.

EMBRYOLOGY.

The eggs of *Cynoscion regalis* develop in the manner typical of most teleostean eggs. Upon fertilization the protoplasm concentrates at one pole of the yolk sphere, forming a thin lenticular mass, the blastodisc. Cleavage is regular, the first two (fig. 2) and four blastomeres being symmetrical and nearly equal in size. Figure 3 illustrates an advanced cleavage stage of the blastoderm in an egg containing two oil globules. The differentiation of the germ ring and development of the embryonic shield are typical. The appearance of the egg just before the closing of the blastopore (12 to 14 hours after fertilization, at temperatures of from 68 to 70° F.) is shown in Figure 4. At this stage the embryo extends nearly halfway round the

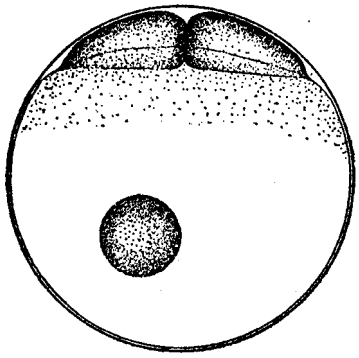

FIG. 2.—Egg with blastoderm of two cells.

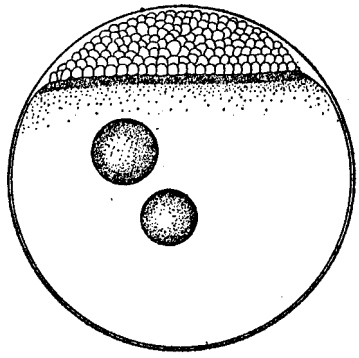

FIG. 3.—Egg with blastoderm in late cleavage stage.

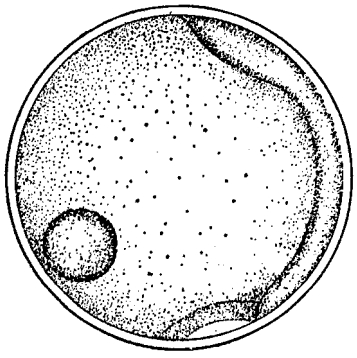

FIG. 4.—Egg showing a moderately advanced stage.

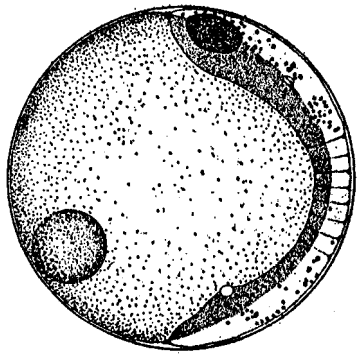

FIG. 5.—Egg with advanced embryo, with seven somites.

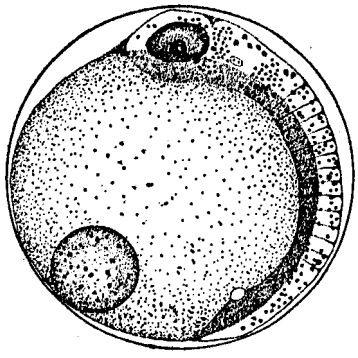

FIG. 6.—Egg with advanced embryo, with 13 somites.

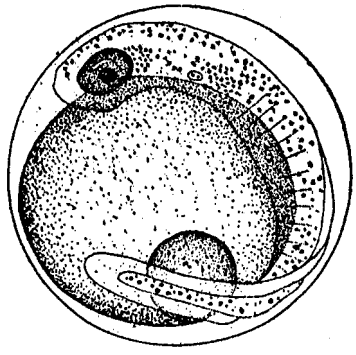

FIG. 7.—Egg with advanced embryo, shortly before hatching.

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yolk sphere. Shortly thereafter (fig. 5) yellow chromatophores appear along the sides of the embryo and on the surface of the oil globule. In about 18 to 20 hours after fertilization (fig. 6) the embryo extends halfway round the yolk, and the number of chromatophores has greatly increased. In certain areas the yellow chromatophores are more or less grouped, especially behind the eye, in a transverse band behind the otocyst and on the underside of the snout. The median ventral surface of the body is practically free from pigment. Scattered black chromatophores are present on the dorsal surface of the body and on the oil globule. Yellow chromatophores persist on the surface of the yolk sphere, either aggregated or evenly scattered. Figure 7 shows the appearance of the embryo shortly before hatching.

The period of incubation at water temperatures of from 68 to 70° F. (20 to 21° C.) is 36 to 40 hours. The newly hatched larvæ (fig. 8) are approximately 1.75 mm. in length; the yolk sac is relatively large, and the oil globule lies at its posterior end. The vent lies immediately behind the yolk sac. The arrangement of the chromatophores is essentially the same as in later stages within the egg, but they appear to be less numerous. In about eight hours after hatching (fig. 9) the yellow pigment spots are aggregated about the eye and behind the otocyst and form two more or less distinct bands upon the body behind the vent, and the yolk sac has decreased slightly in size. When about 24 hours old (fig. 10), the length has increased to approximately 2.2 mm., the yolk sac is much reduced, and the oil globule occupies a more median position. The pectoral fins are distinct. The arrangement of the pigment is similar to that of the preceding stage, with the addition of a band of yellow chromatophores near the caudal extremity of the body. (In these figures black pigment is indicated by solid black, and yellow pigment by stippling.)

No examples of early post-larval forms of *Cynoscion regalis* are present in the collections now available, but fortunately this gap is filled by the excellent account, with figures, of two specimens 6.5 and 12.5 mm. long, given by Henry C. Tracy in the Report for 1908 of the Commissioners of Inland Fisheries of Rhode Island (Tracy, 1908). His illustrations are here reproduced (figs. 11 and 12), and the accompanying descriptions are condensed from his account. The two specimens figured were taken with about a dozen others, of intermediate sizes, on July 28, 1907, in Mill Cove, Wickford Harbor, R. I., having been found in the canvas bags used in the rearing of young lobster fry. (Some of these fish were kept alive until October, by which time they were large enough to afford a certain identification.)

In the specimen 6.5 mm. long (fig. 11) the larval fin fold has not yet disappeared, although the rays of the vertical fins are well differentiated. The head is rounded in profile, and teeth are present. Along the lateral line is a row of about eight rather large chromatophores, forming two groups, one above the anal and the other below the anterior part of the soft dorsal, each group having a few smaller chromatophores above and below it. A large chromatophore lies at the base of the anal fin. To the naked eye the effect is of two grayish or dusky bands upon the sides, the posterior one being more conspicuous. Other large chromatophores are found on the underside of the head, at the base of the spinous dorsal, and on the ventral edge of the caudal peduncle. The pigmentation of the posterior part of the body cavity is also visible.

In the specimen 12.5 mm. long (fig. 12) the fins are fully differentiated and the larval fin fold has completely disappeared. The snout has become somewhat pointed and the mouth more oblique. The maxillary and premaxillary have grown broader, and the teeth of the lower jaw are large, strong, and incurved, particularly along the sides. In this stage chromatophores are present in greater numbers on every part of the fish. Those on the lateral line have increased in number, extending along nearly its whole length, and two new groups have been added, one just under the spinous dorsal, the other in front of the base of the caudal fin. To the naked eye the fish looks darker than in the preceding stage, and the dusky bands on the sides have increased to four. A row of branched, anastomosing chromatophores runs vertically along the base of the caudal fin rays, and a similar row lies all along the base of the anal fin. Two or three rows of compact chromatophores run along the back parallel to the dorsal fin, and three or four short rows run longitudinally on the top of the head. Two or three branched, somewhat tenuous pigment cells lie in the fin membrane of the spinous dorsal, and scattered chromatophores occur along the gill covers, on the upper and lower jaws, and on various other parts of the body.

The later post-larval stages of *Cynoscion regalis* (fig. 13) differ greatly from the adult (fig. 14) both in form and color pattern, the back being crossed by dark-colored saddles that extend down on the sides to slightly below the lateral line. Eigenmann (1901, p. 48) has illustrated the color markings of the young. In a specimen 32 mm. long he shows four distinct saddles on body, the first under the spinous dorsal, the second and third under the second dorsal, and the fourth on the caudal peduncle. Of later changes (p. 51) he says:

> 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. * * * 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 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.

In specimens 4.7, 5.1, and 6.3 cm. long from Beaufort, N. C., taken in July, the two smaller examples have the additional bars interpolated between those that first appear; in the largest they are less distinct, merging into the ground color below the lateral line. In specimens 10 to 14 cm. in length from Beaufort and Chesapeake Bay the characteristic oblique markings of older fish are apparent along the rows of scales, and the bars of the young stage show faintly or not at all, varying with individuals. In specimens 18 cm. long the oblique markings following the rows of scales are very distinct. In older fish these are broken and less uniform, giving a more blotched appearance.

The form of the young squeteague also differs from that of the adult. The body is more compressed and less cylindrical, with a higher dorsal arch; the greatest depth is about 3 in standard length (about 4 in the adult); the head is proportionately longer, about 2.75 in standard length (3 in the adult); the eye is larger,

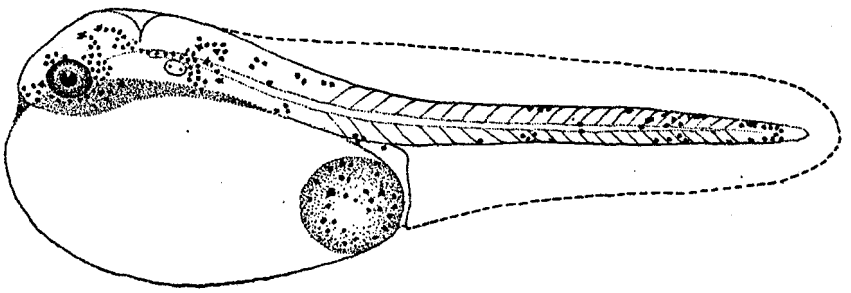

FIG. 8.—Newly hatched fish; actual length, 1.75 mm.

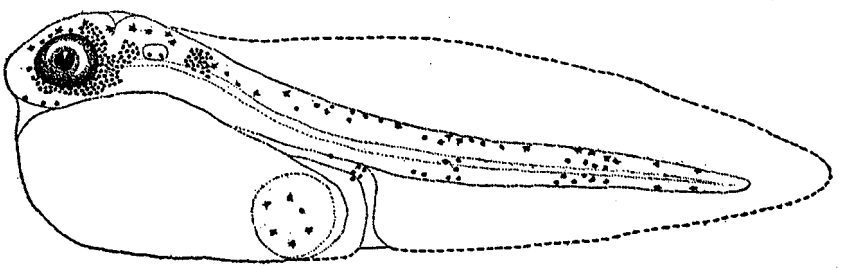

FIG. 9.—Larval fish, 8 hours after hatching.

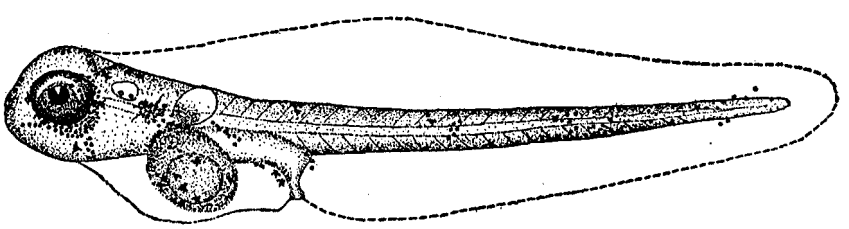

FIG. 10.—Larval fish, 24 hours after hatching; actual length, 2.2 mm.

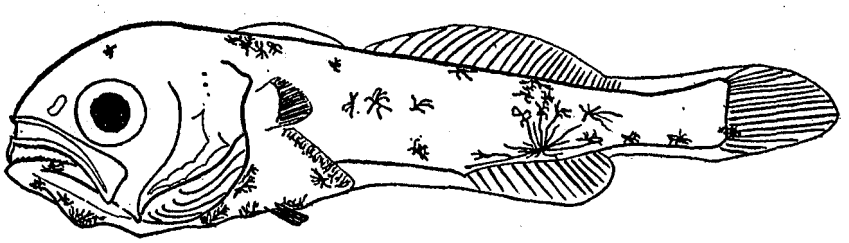

FIG. 11.—Larval fish; actual length, 6.5 mm. (After Tracy, 1908.)

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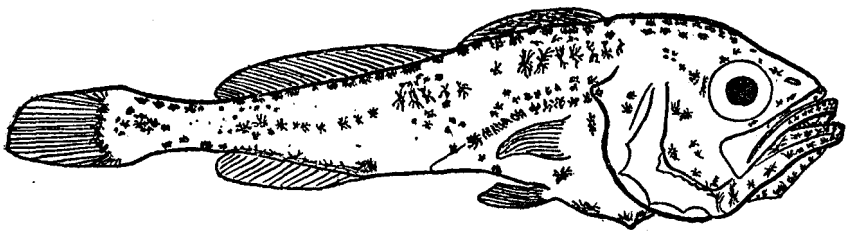

FIG. 12.—Larval fish; actual length, 12.5 mm. (After Tracy, 1908.)

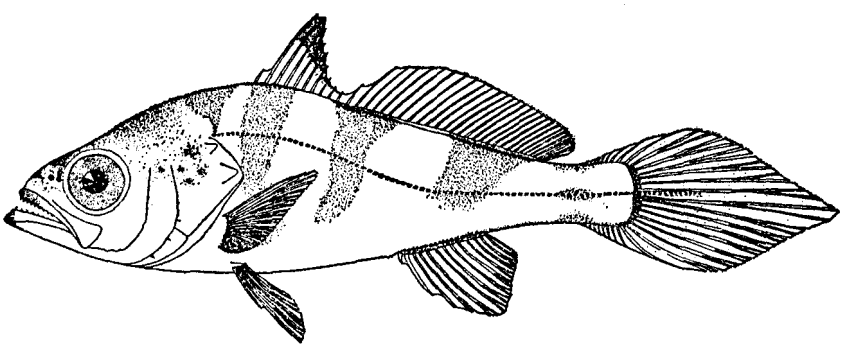

FIG. 13.—Young fish; actual length, 32 mm.

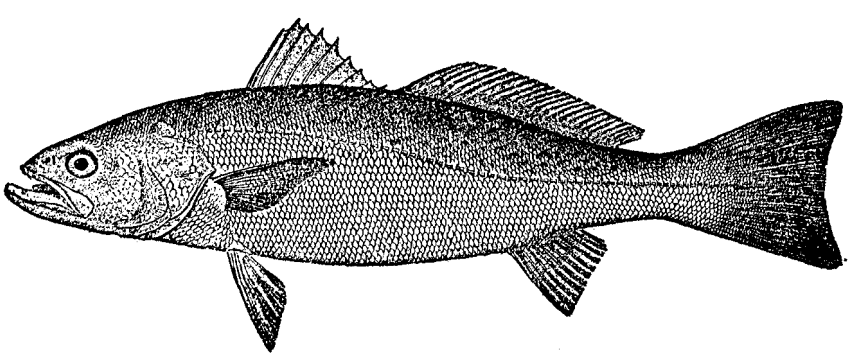

FIG. 14.—Adult fish.

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about 3.5 in head (5 or less in adult); the maxillary reaches to the posterior edge of the pupil (to behind pupil, even to hinder edge of eye in adult); the caudal is pointed, the median rays longest, the upper lobe slightly lunate, and the lower lobe straight or slightly rounded; with age the median rays become shorter until in specimens about 10 cm. long the caudal is truncate and in the adult distinctly concave. The gill rakers are longer and more slender than in *Cynoscion nebulosus* and remarkably uniform in number at all ages, 6+11, the longest about two-thirds the diameter of the eye.

GROWTH.

The growth of the young of *Cynoscion regalis* is rapid, but not to the degree surmised by Eigenmann (1901, p. 47), who states that "it seems very probable that the fish reaches marketable size in about a year from birth." Eigenmann's conclusions were based on observations of growth in July and August, at which period he found the young to double their length in about 30 days.

Measurements of 10 large samples of young fish, taken at various times from July to March, have since been made by us. These show a rapid growth until September, when the rate begins to decrease, growth practically ceasing in November and beginning again the following spring. July and August are the months of most rapid growth. Fish hatched on June 1 should average as follows in total length, according to our calculations:

July 1	3 cm. (1¼ inches).
Aug. 1	8 cm. (3⅛ inches).
Sept. 1	13 cm. (5⅛ inches).
Oct. 1	17 cm. (6¾ inches).
Nov. 1	18 cm. (7⅛ inches).

Tracy (1908) made some tentative deductions as to the rate of growth in the early stages, and his conclusions agree surprisingly well with the figures given above. An analysis of his results indicates that an average length of about 1.75 cm. (¾ inch) is reached on the fifteenth day after hatching. Our list suggests an average length at 15 days after hatching not far from this figure, for since fish hatched June 1 reach a length of 3 cm. (1¼ inches) by the end of the month it would appear that halfway through that month, or on the fifteenth day after hatching, they reach a length of about 1.5 cm. As this interpolation is made for the month of June and Tracy's work was done in July, when growth is known to be more rapid, the agreement is particularly close.

Owing to the extended spawning season and the consequent wide variation in length of the fish in their first winter, it is difficult to follow the subsequent growth by measurement of specimens, as the year classes overlap each other in size. The best method of determining age after the first year is by examination of the scales, but this also presents some difficulties, chief among which is the absence of a first winter ring in the scales of the smaller fish of any one year.

The following is a summary of calculations as to estimated average lengths for the first five years made from a sample of 74 fish taken on the spawning grounds

at Cape May, N. J., in 1919. The largest fish in the sample was 49 cm. (19¼ inches) long and had apparently attained an age of 9 years.

	Estimated average length.
First winter	10–13 cm. (4–5½ inches).
Second winter	21 cm. (8¼ inches).
Third winter	28 cm. (11 inches).
Fourth winter	33 cm. (13 inches).
Fifth winter	36 cm. (14⅛ inches).

These figures differ from those obtained by Taylor (1916). Taylor overlooked the frequent absence of the first winter ring on the scales, and most of his "first year" fish really represent the second year. With this exception his results compare fairly well with the above.

AGE AT MATURITY.

The first spawning occurs at an age of 3 to 4 years for the females and 2 to 3 years for the males. Subsequent spawning occurs annually throughout life. In the sample of fish from the Cape May spawning grounds the majority were from 4 to 6 years old and the 5-year-old fish were the most numerous.

SIZE AND WEIGHT ATTAINED.

The average weight of *Cynoscion regalis*, as marketed, is from 1 to 2 pounds, but fish weighing 10 to 15 pounds are not uncommon, and a weight of 30 pounds has been recorded.

The correlation of weight and length in this species has been studied by Crozier and Hecht (1914), who found that the weight of fish taken in the summer months might be expressed by the equation: Weight in grams = (0.00877) × (length in cm.)^3.

The following list gives average length and corresponding average weights of summer-caught fish:

Length.	Weight.
30–35 cm. (12–14 inches)	300– 450 g. (⅔–1 pound).
35–40 cm. (14–15¾ inches)	450– 600 g. (1–1⅓ pounds).
40–45 cm. (15¾–17¾ inches)	600– 750 g. (1⅓–1⅔ pounds).
45–50 cm. (17¾–19¾ inches)	750–1,050 g. (1⅔–2⅓ pounds).
50–55 cm. (19¾–21¾ inches)	1,050–1,500 g. (2⅓–3⅓ pounds).
55–60 cm. (21¾–23½ inches)	1,500–1,950 g. (3⅓–4⅓ pounds).
60–65 cm. (23½–25½ inches)	1,950–2,250 g. (4⅓–5 pounds).
65–70 cm. (25½–27½ inches)	2,250–2,700 g. (5–6 pounds).

MOVEMENTS AND SEASONAL DISTRIBUTION.

Very little is known regarding the migrations of *Cynoscion regalis*. The fish are generally found in schools, usually small, but sometimes of great size. In the Chesapeake and Delaware regions the fish first appear late in April; in Buzzards Bay, early in May. In the Delaware and Chesapeake the schools first move up the bays until water of a low salinity is encountered, when they turn back and move seaward, spawning just within or near the mouths of the larger estuaries. After spawning the fish return to the ocean, remaining near the coast until July or August, when they again seek the bays and sounds. These remarks apply to the main body of fish. Many small schools seem not to join in the general movement but to remain in the bays and sounds throughout the summer, and it seems

probable from observations made in the summer of 1920 that these schools are chiefly composed of fish that do not spawn until September. In October the adults disappear and are not seen again until the following spring. Although it has been supposed by many that these fish migrate to the southward, proof of such migration is lacking. It is known that the species is very sensitive to sudden reductions in water temperature, and this fact gives reason to suppose that the fish seek regions of warm water in the winter months, but whether the movement is southward or eastward to the warm and deep waters on the inner edge of the Gulf Stream remains to be determined.

During their first summer the young remain in or near the waters in which they were hatched and move off to sea in the early fall. At Fernandina, Fla., the young are found throughout the winter in from 3 to 5 fathoms of water, on the bottom, and large numbers are taken in the trawls of the shrimp fishermen at that place.

FOOD.

The food of *Cynoscion regalis* reflects the rapacious and free-ranging nature of this species in that most of it was found to be typical of the plankton of regions from which taken. The itemized lists and tables below give in detail the results obtained from examination of the stomachs of 313 examples, ranging in size from 2.6 to 39 cm. (1 to 15½ inches) in standard lengths, that were taken at various points from Massachusetts to Florida. These lists indicate the types of food taken, with their relative amounts expressed in volumetric percentages. All measurements of specimens indicate the standard length.

Head of the Acushnet River, Mass., September 8, 1882.—Of 28 examples, 7 to 11 cm. long, 5 were empty. Of the remaining 23 all but 2 had gorged themselves on either shrimps or fish.

	Volumetric percentage.
Shrimps	47.0
Isopods	.5
Polychæt worms	.5
Fish	48.0
Unidentified material	4.0

Most of the material was in an undigested state and therefore readily identifiable. The following list gives in detail the fishes encountered in the stomach contents, together with the standard lengths of the examples of squeteague from which taken:

TABLE 4.—*Fish remains in stomach contents of squeteague from Acushnet River, Mass., 1882.*

Standard length of example in centimeters.	Fish remains.		Standard length of example in centimeters.	Fish remains.	
	Description.	Length in centimeters.		Description.	Length in centimeters.
9	Fundulus heteroclitus (Walbaum).	2.8	9	Pomolobus æstivalis (Mitchill).	4.1
7	do	2.5	9	do	4.1
7	do	2.3	9	do	3.2
11	Pomolobus æstivalis (Mitchill)	3.7	9	do	3.1
10	do	3.8	8	do	3.6
10	do	3.6	10	Vertebræ only	
10	do	3.5			

A secondary examination showed the Fundulus to have fed on insects only and the Pomolobus to contain material greatly resembling mud.

Cape May, N. J., May 22, 1919.—Of 30 examples (breeding), 24 to 39 cm. long, 9 were empty. The remaining 21 were quite full.

	Volumetric percentage.
Shrimps	7
Schizopodous forms	49
Unidentified crustaceans	33
Fish	1
Unidentified material	10

The remains of fish consisted simply of a few fragments from the stomach of an example 32 cm. long.

Cape May, N. J., August 8, 1916.—At a depth of from 0 to 5 m., 32 examples, 2.6 to 7.8 cm. long, were taken in a seine.

	Volumetric percentage.
Shrimps	19.0
Schizopodous forms	61.0
Amphipods	.5
Isopods	.5
Unidentified crustaceans	11.0
Fish	8.0

The remains of fish are tabulated below with the standard lengths of the individuals from which they were taken. In all except the specimen containing the 1.6-cm. clupeoid other food was found along with the fish remains.

TABLE 5.—*Fish remains in stomach contents of squeteague from Cape May, N. J., 1916.*

Standard length of example in centimeters.	Fish remains.	
	Description.	Length in centimeters.
7.0	Vertebræ only	
3.3	Post-larval clupeoid	1.6
3.1	do	1.5
3.1	Mangled clupeoid remains	

Cape Charles, Va., September 12, 1916.—There were taken 45 examples, 4.3 to 11.5 cm. long.

	Volumetric percentage.
Schizopodous forms	91.0
Amphipods	3.0
Copepods	3.5
Larval crustaceans	.5
Fish	2.0

The larval crustacean remains consisted of a single crab in the zoëa stage. The fish present consisted of the mangled remains of what appeared to be a clupeoid, taken from a 9.2-cm. individual that had also eaten some schizopods or schizopodous larvæ.

Southport, N. C., December 10, 1919.—Of five examples, 12 to 21 cm. long, four were empty. The fifth contained shrimps.

Cape Lookout Bight, N. C., December 13, 1919.—Of two examples, 13 and 14 cm. long, one was empty, and the other, the larger, contained schizopodous crustaceans.

Winyah Bay, S. C., July 10, 1915.—Of 34 examples, 2.8 to 6.2 cm. long, five were empty. Most of the remaining 29 had fed well, and in some cases a great distention of the abdomen was apparent.

	Volumetric percentage.
Schizopodous forms	83
Isopods	6
Copepods	2
Fish	9

The remains of fish in all cases were beyond identification, as only bits of bone and pieces of flesh remained. No examples smaller than 4.4 cm. in standard length were found to have ingested any fish. All had fed on schizopods or schizopodous larvæ, but none longer than 3.6 cm. had taken copepods.

Fernandina, Fla., March, 1920.—Of 105 examples, 5 to 17 cm. long, taken in a shrimp trawl, 74 were empty. Of the remaining 31 only 3 contained more than a mere trace of food.

	Volumetric percentage.
Shrimp	46
Schizopodous forms	18
Fish	18
Débris	18

There was no especial correlation between size of fish and food taken, although apparently two year classes were present, the division appearing between 10 and 11 cm. However, no individuals larger than 8 cm. had taken any schizopodous forms. The fish remains for most part were simply mangled pieces, although from one individual 9 cm. long a fish 1.9 cm. long was taken that was very probably a young *Micropogon undulatus*. A piece of wood was among the débris taken from a 17-cm. example.

Fernandina, Fla., December 6, 1919.—Of 32 examples, 6 to 21 cm. long, taken in a shrimp trawl, 16 were empty. The stomach walls were entirely clean, and in most cases that organ was shriveled to a very small size. No food was found in the intestines of those individuals either, which suggests that they had not eaten for some time. The remaining 16 were found to be well filled with food, and in some cases the stomach was distended to such an extent that it filled the major portion of the visceral cavity. There appeared to be no correlation between size of the individuals and condition of digestive tract.

	Volumetric percentage.
Fish	38
Shrimps	19
Schizopodous forms	31
Unidentified crustaceans	12

Two fish were identified as *Opisthonema oglinum* (LeSueur). They were both about 8 cm. long and were removed from fishes 16 and 17 cm. in length. The rest of the fish remains were beyond identification. The two smallest specimens had eaten only schizopodous forms. In all cases only one kind of food was found in a stomach.

The following discussion of the food of the squeteague is taken from an unpublished report, "The Food of the Squeteague, *Cynoscion regalis* (B. and S.), at Beaufort, N. C.," by Selig Hecht and William J. Crozier.

This study of the food of the squeteague was made at the laboratory of the United States Bureau of Fisheries, at Beaufort, N. C., during July and August, 1912. Eigenmann (1901, p. 45) and Peck (1896, p. 351), writing from Woods Hole, Mass., describe the food of young squeteague as consisting entirely of shrimp and young fish (silversides, alewives, etc.). Peck tabulates the stomach contents of squeteague taken from the fish traps, showing that fishes, especially menhaden (*Brevoortia tyrannus*), butterfish (*Poronotus triacanthus*), and herring are its staple articles of diet and that scup, squid, and shrimp are also eaten. Tracy (1910, p. 132) notes that squeteague taken in traps in Narragansett Bay had Fundulus and small shore fishes in their stomachs. Linton (1905, p. 384) examined the stomachs of 45 squeteague taken at Beaufort and reports the finding of shrimp, fish, and annelids in 3 small specimens, and a preponderance of fish, together with large shrimp, crabs, seaweed, broken shells, and lamellibranchs, in the larger ones.

Table 6 contains the results of the examination of the stomachs of 382 squeteague taken from the pound net operated by the laboratory. It may be objected that when confined in a net in company with numerous other fishes the squeteague are subjected to abnormal feeding conditions. Although it is true that many menhaden, for example, were found in the net at times when menhaden were found in the stomachs of certain squeteague, there were, however, always numbers of the hairy-back (*Opisthonema oglinum*) and of other species of a size, at least, appropriate to the requirements of the squeteague. Yet, only a single hairy-back was taken from the stomach of a weakfish during the entire season. In addition to this, it may be pointed out that the remains of various fishes were identified among stomach contents in such a state of digestion as to make it almost a certainty that the meal had been ingested previous to the capture of the fish in the pound, at most 24 hours previously. As Riddle (1909, p. 447) has shown for Amiatus, and as Weinland (1901) found for the dogfish, torpedo, and ray, digestion is an extremely prolonged process in fishes. Van Slyke and White (1911), in a study of protein digestion in the smooth dogfish, *Mustelus canis*, report that between two and three days are required for the complete digestion of a meal of finely chopped beef, which presents no such obstacles to digestion as scales, bones, etc. There is no reason to suppose that the process is much faster in teleosts. We infer, therefore, that the fishes examined represent as close an approximation to the normal as is possible under working conditions.

TABLE 6.—*Food of 382 squeteague, Cynoscion regalis, at Beaufort, N. C.*

[Roman figures outside parentheses indicate the number of *Cynoscion regalis*. Figures within parentheses indicate the number of animals eaten. Figures in italics indicate percentages. For explanation see text.]

Squeteague examined.			Food in stomach contents.				
Length in centimeters.	Total number.	Number empty.	Menhaden.	Anchovy.	Shrimp.	Unidentifiable fish.	Miscellaneous.
20–25	41	25	0 *0*	9(16) *56.2*	2(7) *12.5*	6(7)	1(1) squid. 1(1) isopod.
25–30	88	44	8(11) *18.2*	19(53) *43.2*	9(9) *20.5*	2(3)	1(2) amphipods. 1(1) isopod.
30–35	70	36	2(3) *6.9*	20(43) *58.8*	12(12) *35.3*	2(2)	
35–40	49	16	18(26) *54.5*	7(9) *21.2*	8(20) *24.2*	5(7)	1(1) hairy-back. 1(1) squid.
40–45	53	6	37(62) *78.7*	3(4) *6.4*	8(14) *17.0*	1(1)	
45–50	38	6	29(55) *76.4*	1(3) *3.1*	3(3) *9.4*	2(3)	
50–55	21	3	16(34) *76.2*	0 *0*	1(2) *5.6*	1(2)	
55–60	17	6	11(33) *64.7*	0 *0*	0 *0*	2(3)	
60–65	5	0	4(17) *80.0*	0 *0*	0 *0*	1(1)	1(4) Menidia.

Of the 382 stomachs 240, or 62.8 per cent, contained food. By far the greatest number (52.2 per cent) of those containing food had in them menhaden (*Brevoortia tyrannus*); 20.8 per cent, *Stolephorus brownii;* 17.9 per cent, shrimp (*Pinæus brasiliensis* or *P. setiferus*, in proportions depending on the relative abundance of these two species); and 8.2 per cent, fish in such a state of decomposition that they could not be identified; the remainder contained the miscellaneous food indicated in the table.

The relation of the squeteague to his food is not quite as simple as these figures might indicate. Besides the food data, a record was made of the length of each squeteague, and in Table 6 the specimens have been arranged according to size, grouped into classes of 5 cm. range, and the food of each of these classes has been entered separately. The significance of the numbers in the columns headed "Menhaden," "Anchovy," "Shrimp" may best be illustrated by an example. In the first item under "Anchovy" the figures indicate that nine squeteague between 20 and 25 cm. in length were found to contain 16 anchovies, and that these nine fish represent 56.2 per cent of the total number of squeteague of this length class in whose stomachs food was found.

Considering the "Menhaden" column, it is clear that but a small percentage of squeteague between 20 and 35 cm. in length eats manhaden, but that the percentage of squeteague over 35 cm. in length that eats them rises very quickly until in the case of those 60 cm. long 80 per cent eat menhaden. This is brought out in a more striking manner when we consider the "Anchovy" column. More than half of the squeteague between 20 and 35 cm. in length eat anchovies; but in the group between 35 and 40 cm. in length, correlated with the rise in the percentage of fish that eat menhaden, there is a drop to 21 per cent, then in the 40 to 45 cm. group to 6 per cent, and finally no squeteagues over 50 cm. long eat anchovies. Inspection of the figures in the "Shrimp" column shows that the number of sque-

teague that eat shrimp increases with length until a maximum is reached at about 35 cm. In the groups containing squeteague over 35 cm. in length the percentage of shrimps eaten gradually decreases until after the 55 cm. group none is eaten.

Among the factors that determine the food of fish of a given size within a geographical region may be considered the "preference" of the fish, its energy requirements, and the size and abundance of its prey. Since we find the food of the squeteague to be limited to a few species, we may draw the preliminary conclusion that variations in the food of the squeteague are due, in part at least, to mechanical circumstances, such as the size of the fish and its prey. It is impossible for a 20-cm. squeteague to swallow a 10 or 15 cm. menhaden, which is the smallest size found at this time of the year. The squeteague up to 25 cm. eats no menhaden. All of the menhaden eaten by the 25–30 cm. group ranged from 10 to 12 cm. in length. As the squeteague increases in size he can readily swallow a 15-cm. menhaden, and in the 35 to 40 cm. group menhaden are found abundantly in the stomach contents. There is no doubt, from the number of weakfish that eat menhaden and from the total number consumed, that menhaden is their staple food. The smaller squeteague eat anchovies and shrimp. *Stolephorus brownii* is small, rarely exceeding 7 or 8 cm., and is found in large schools in Beaufort Harbor; but as soon as the squeteague becomes large enough to eat menhaden the consumption of anchovies falls very quickly. All of the shrimp eaten by the younger squeteague are small, but the larger fish frequently swallow as many as five or six of the large shrimp.[8] With increasing length fewer shrimp are found, until in the largest specimens the stomachs contain no shrimp.

In summarizing the results of this investigation as to the food of *Cynoscion regalis* at Beaufort, N. C., it may be stated that—

1. The food of the adult *Cynoscion regalis* varies with locality.

2. At Beaufort the food consists mainly of menhaden, anchovies, and shrimp—menhaden constituting the staple article of diet.

3. The relative proportions of menhaden, anchovies, and shrimp consumed depend on the size of the squeteague.

The foregoing data obtained by students at Beaufort agree well with those found by the junior writer in examining fish from widely scattered points. The larger amount of small invertebrates found by the latter, however, appears to be correlated with the fact that most of the fish he examined were immature and of small size, which mechanically, if in no other way, precluded the possibility of their negotiating the larger forms. A notable exception is that of the breeding fish taken at Cape May, N. J., which had eaten mostly of small schizopodous forms.

Cynoscion nebulosus (Cuvier and Valenciennes). SPOTTED SQUETEAGUE, SOUTHERN SQUETEAGUE, SPOTTED WEAKFISH, TROUT, SEA TROUT, SPOTTED TROUT, BLACK TROUT, SPECKLED TROUT, SALMON TROUT, SALMON.

Cynoscion nebulosus (fig. 20) ranges from New York to Texas but is rare north of Delaware Bay. Little is known of the habits of the species, the consensus of opinion being that schools migrate to the northward in the spring or late winter

[8] It is interesting to note that the shrimp are swallowed in a doubled-up condition, with the head and tail close together, so that, since the animal is swallowed with the bend first, it is impossible for the sharp rostral spine to injure the wall of the gut.

and to the southward in the fall. It is more active, wary, more difficult to surround with a net, and more highly prized as food than the squeteague (*Cynoscion regalis*). Its average weight is given variously as from 2 to 4 pounds; the maximum as about 16.5.

In North Carolina the species is quite abundant, and greater numbers are taken from October to May than during the summer months, when because of its wariness Beaufort (N. C.) fishermen take most of their fish at night. Some of the fishermen state that they can detect the presence of the fish by the sound of the flipping of the fins at the surface as it feeds and take advantage of this habit by lying in wait on the feeding grounds and then quietly running the seine around the fish when their presence is detected. An indication of the wariness of this species is shown by the rarity with which it is taken in pound nets. In the pound net of the Bureau of Fisheries laboratory at Beaufort, N. C., from June 10 to August 30, 1912, when large numbers were about, only five examples were taken, while during the same period several thousand squeteague (*Cynoscion regalis*) were caught.

As the water cools off in the late fall the fish appear to school up in creeks and deeper holes and become less active. In the northern part of its range there is evidence of a definite migration in the summer to Delaware Bay. The supposed migration in June, July, and August in the southern States may be only a movement out of the rivers and bays into the ocean for the purpose of spawning, as is the case with *Cynoscion regalis*. Although the statement has been made that this species spawns in bays and sounds in spring and summer, no authentic data to support this contention are available. The only young examples on record as being taken at Beaufort, N. C., are the three small ones described in the present paper, and the scarcity of small fish from this locality and from Chesapeake Bay indicates that they were only stragglers. The young, unlike those of *C. regalis*, have not been taken off the mouths of the rivers and inlets on the North Carolina coast.

So far as known spawning occurs in May and June. The eggs, larvæ, and early post-larval stages have not been studied, the smallest example yet observed having a length of 2.8 cm. (fig. 15). Measurements of the few specimens at hand, taken in July (Beaufort, N. C.) and December (Chesapeake Bay), indicate that the growth of the young the first year is approximately the same as that of *Cynoscion regalis* for the same age.

Examination of the scales of 20 fish from Punta Gorda, Fla., the largest of which was 55 cm. (21¾ inches) long and apparently 8 years old, indicates that the estimated average length for the first six years is approximately as follows:

	Estimated average length.
First winter	11–12 cm. (4½–5 inches).
Second winter	23 cm. (9 inches).
Third winter	31 cm. (12¼ inches).
Fourth winter	36 cm. (14 inches).
Fifth winter	40 cm. (15¾ inches).
Sixth winter	43 cm. (17 inches).

The young of *Cynoscion nebulosus* differ markedly in color and form from the adults and from the young of *C. regalis*. The main differences are in the color pattern, the shape of the caudal fin, the general form, the proportionate length of

the head, the depth and the diameter of the eye, and the position of the hinder edge of the maxillary in relation to the eye.

In a specimen 4.1 cm. long from Pivers Island, Beaufort, N. C., taken July 22, 1913 (fig. 16), the ground color of the body is light, tinged with yellowish above and with a silvery sheen below the lateral line. An interrupted lateral stripe of brownish pigment, slightly narrower than the eye, extends along the middle of the side; on the opercle and caudal fin the pigment is darker, almost black; a broken stripe of similar-color extends along each side of the median line of the back from tip of snout to base of caudal, with interspaces between the broken portions widest below; the tip of the lower jaw is brownsh; the first dorsal fin is dusky, the second translucent, with a narrow median stripe of brown; the blackish area on the caudal is triangular, its apex near the tip of fin; the anal and paired fins are translucent.

A specimen 2.8 cm. long, taken at Beaufort, N. C., July 15, 1913 (fig. 15), agrees closely in form and coloration with the preceding, except that the lateral stripe is continuous and proportionately wider and that portion on the caudal is black. In a specimen 5.8 cm. long (fig. 17), taken with the first, the form and color pattern is similar except that the stripes are slightly more diffuse and less interrupted and the markings on the caudal more broken and of a lighter shade and that two dark narrow stripes appear on the second dorsal.

In these examples the body is deeper than in the adult, about 3.75 in standard length; the head proportionately longer, about 3 in standard length; the eye larger, 4.25 to 4.75 in head; the maxillary shorter, 2 in head, its hinder edge reaching to hinder edge of pupil; the caudal pointed, its median rays longest; the gill rakers, 4+8, shorter and stouter than in *Cynoscion regalis*.

Five specimens of *Cynoscion nebulosus*, 11 to 12.5 cm. long, taken in Chesapeake Bay in December, 1915, represent various stages in transition to color of adult. In an example 11 cm. long (*Fish Hawk*, station 8381, 1¼ miles SSE. of Smith Point Lighthouse off the mouth of the Potomac River, in 25 fathoms, taken December 5, 1915, fig. 18), the ground color above the lateral line is yellowish, tinged with silver, below the lateral line silvery white; the stripes are darker, almost black, and more broken than in smaller examples, their broken portions tending to form irregular blotches, which later develop into round black spots; the lateral stripe is absent from the caudal, and the fin is blotched with dusky spots. In an example 11.2 cm. long from same station the spots are slightly more distinct, the lateral stripe being broken up with two rows of roundish blotches one above the other, below the lateral line; the dorsal stripe is beginning to show a similar separation into blotches. In an example 12 cm. long (from *Fish Hawk*, station 8366, one-half mile W. by S. of Thimble Shoal Lighthouse in 14 fathoms) the spots are more distinct and have encroached on the portion of the side that formerly separated the stripes (fig. 19). In form these specimens are more slender, the depth being about 4 in standard length; the eye is smaller, 5 in head; the maxillary is 2.2 in head, extending nearly to the hinder edge of the orbit; and the median lobe of the caudal is shorter.

In an example 24 cm. long the round black spots are confined to that portion of the back behind the middle of the first dorsal and above the lateral line, with a few exceptions on the middle of the side, to the second dorsal and caudal fins. The spots are about the size of the pupil or smaller; on the second dorsal they are in

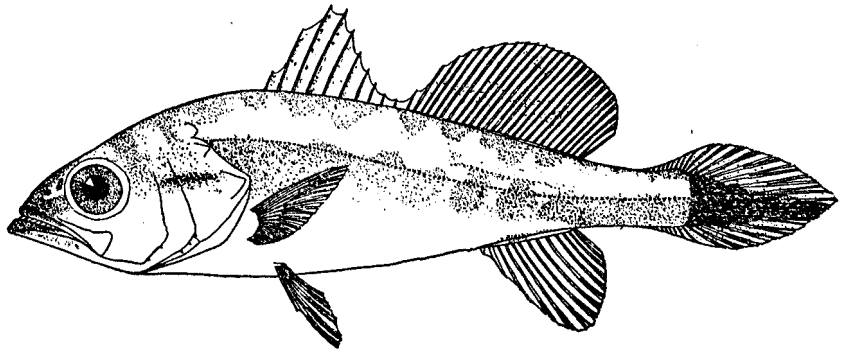

FIG. 15.—Young fish; actual length, 2.8 cm.

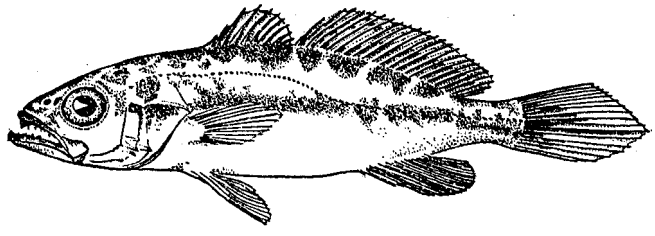

FIG. 16.—Young fish; actual length, 4.1 cm.

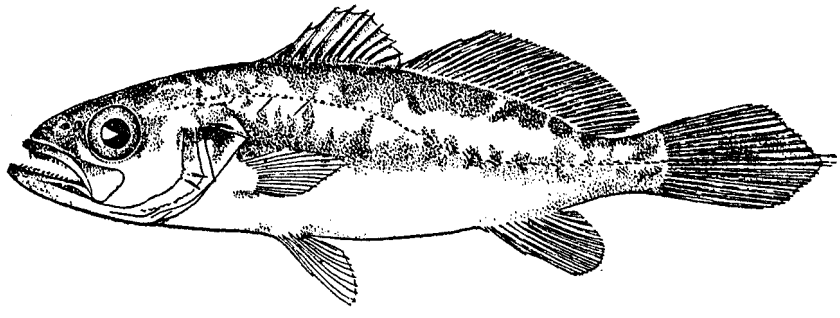

FIG. 17.—Young fish; actual length, 5.8 cm.

CYNOSCION NEBULOSUS.

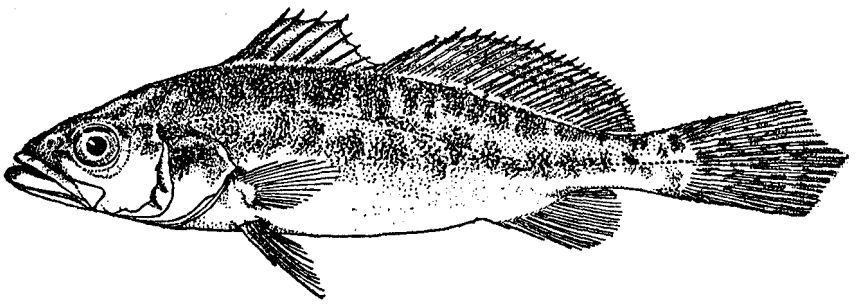

FIG. 18.—Young fish; actual length, 11 cm.

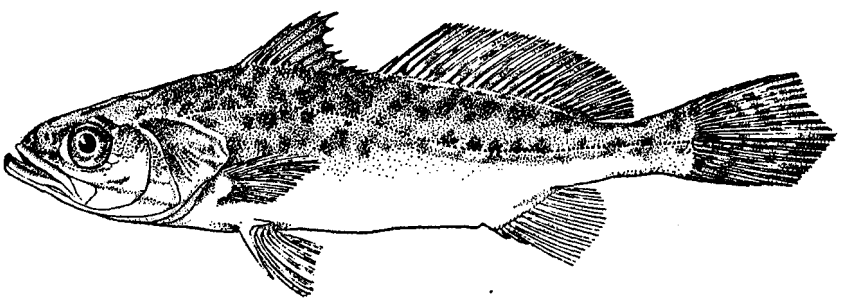

FIG. 19.—Young fish; actual length, 12 cm.

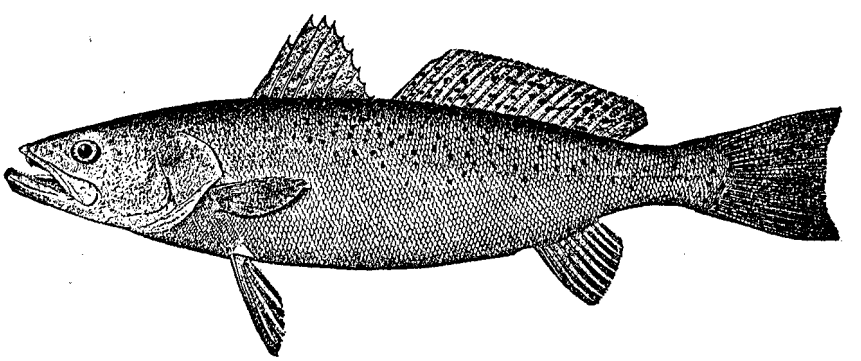

FIG. 20.—Adult fish.

CYNOSCION NEBULOSUS.

two longitudinal rows. In this example the body is more cylindrical, the depth 4.1 and the head 3.3 in standard length; the eye is 5.5 in head; the maxillary reaches the hinder edge of orbit; and the tail has the median rays only slightly produced.

In adult examples (fig. 20) the spots on the fins are smaller, those on the second dorsal being scattered irregularly over that fin. The depth is from 4 to 4.5 and the head about 3.5 in length; the snout 3.75 in head (3.33 in young), long, acute; the eye 6 to 7 and the maxillary about 2.2 in head, extending to the posterior edge of orbit; the first dorsal higher and more angular; the caudal slightly concave. The gill rakers, 4+8, are rather short and stout, very uniform in number at all ages.

The food of *Cynoscion nebulosus* is in all probability rather similar if not identical to that of *C. regalis*, but, owing to the rarity of large numbers of this fish in collections, we had no opportunity to examine any stomachs with a view to answering that question.

Cynoscion nothus (Holbrook). SILVER SQUETEAGUE, BASTARD TROUT, GRAY TROUT, SAND TROUT.

Cynoscion nothus (fig. 21) is the least abundant of the squeteagues on the Atlantic coast of the United States. It was first described by Holbrook (1860,

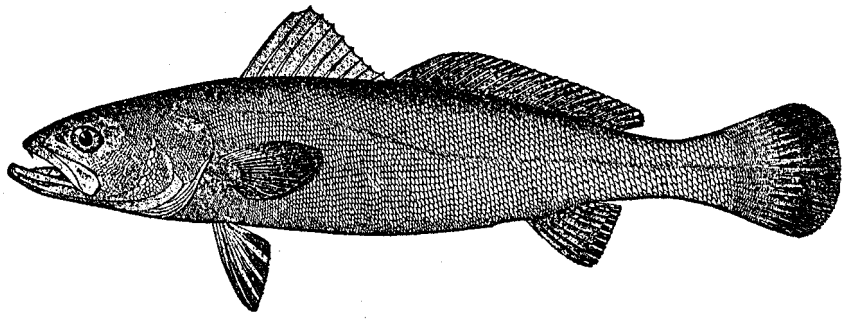

FIG. 21.—*Cynoscion nothus*, adult fish.

p. 134, pl. 19, fig. 1) in 1860 from examples taken in South Carolina waters. Although unfrequently taken on the Atlantic coast it is the most abundant species of the genus in the outside waters of the Gulf States, from Florida to Texas. Examination of a large series of specimens taken by the Fisheries schooner *Grampus* in Gulf waters indicates that the species is very close to *Cynoscion regalis*, and that its claim to specific rank is at least doubtful. Although an apparently well-marked variety, further study may show complete intergradation of characters with the latter species. R. J. Coles (1916) considers it simply a color variation of *C. regalis*.

Comparison of eight examples of *Cynoscion nothus* from the Texas coast with the same number of examples of *C. regalis* from Beaufort, N. C., of approximately the same size (from 11 to 19 cm. in length) shows the following differences:

1. The head of *nothus* is slightly longer than that of *regalis* (2.9 in *nothus*, 3.1 in *regalis*, in standard length).

2. The snout of *nothus* is slightly longer than that of *regalis*, and much longer as compared with the diameter of the eye. (In *nothus* the snout is 3.5 to 3.75 in head, the eye 3.9 to 5 in head. In *regalis* the snout is almost equal to the eye, or very slightly longer.)

3. The pectoral is longer than the ventral in *nothus;* equal to the ventral in *regalis*.

4. Soft dorsal, *nothus*, 26 to 29, usually 26; *regalis*, 26 to 29, usually 27 or 28.

5. Anal, *nothus*, 9 to 11, usually 10 or 11; *regalis*, 11 to 13, usually 12 or 13.

6. Gill rakers, *nothus*, 4+9; *regalis*, 5+11.

7. The typical color of *nothus* is silvery, with the tip of mandible, axillary spot, tip of spinous dorsal, and margin of caudal black or dusky. In many individuals, however, the coloring approaches that of *regalis*, although in all such cases the markings are fainter and paler.

Very little is known concerning the habits of the silver squeteague. It appears to be chiefly confined to open waters and does not run into the bays, sounds, and thoroughfares of the coast, as do *regalis* and *nebulosus*. In size attained it is inferior to these species, the fish marketed at Corpus Christi, Tex., averaging less than three-fourths of a pound in weight. During the winter months these fish are abundant off the coast of Alabama, Louisiana, and Texas at depths of from 3 to 10 fathoms.

The spawning season is not definitely known, but from measurements of a large series of young fish taken on the Gulf coast during the winter months it would appear to occur in the autumn. The eggs, larvæ, and early post-larval stages have not been studied. Young of 6 cm. and upward are quite similar in appearance to the young of *Cynoscion regalis*.

As stated for *Cynoscion nebulosus*, the food of *C. nothus* also is probably similar to if not the same as that of *C. regalis*, but the lack of large numbers of specimens prevented an examination of stomach contents.

Larimus fasciatus (Holbrook). BULLHEAD, CHUB, BANDED DRUM, BANDED CROAKER, BANDED LARIMUS.

The range of *Larimus fasciatus* (fig. 22) is from Chesapeake Bay to Texas, but although stragglers have been taken as far north as Woods Hole, it is not found in abundance north of Cape Hatteras. South of this point and on the shores of the Gulf of Mexico it is one of the most abundant fishes, being taken in large numbers in the trawls of the shrimp fishermen.

The average length of fish of this species taken in the shrimp trawls is about 11 cm. (4½ inches), and individuals exceeding 20 cm. (8 inches) in length are rare. Because of its small size, the species is of little or no economic importance.

The eggs and larval and post-larval stages of *Larimus fasciatus* have not been studied, and little or nothing is definitely known concerning the habits or life history, which, however, are probably very similar to those of *Stellifer lanceolatus*.

Young fish 4 cm. (1½ inches) in length closely resemble the adult both in form and color pattern.

From specimens of *Larimus fasciatus* taken by the *Grampus* on the winter cruise of 1916–17 the following information as to their feeding habits was secured:

Off Gulfport, Miss., Station 10455, February 9, 1917.—Taken from a depth of 13 m., one example, 5 cm. in standard length, contained one post-larval clupeoid 2 cm. long, probably Brevoortia.

Off Galveston, Tex., Station 10469, February 27, 1917.—Of two examples, 8 and 9 cm. in standard length, one was empty. The larger one had eaten only of schizopodous forms.

Off Aransas Pass, Tex., Station 10476, March 5, 1917.—One example, 11 cm. in standard length, was empty.

In all cases the body cavity contained large numbers of small parasitic worms.

As might be expected from the appearance of this species (fig. 22), it apparently pursues its food in the open water with considerable agility, although the paucity of material prevents any definite statement.

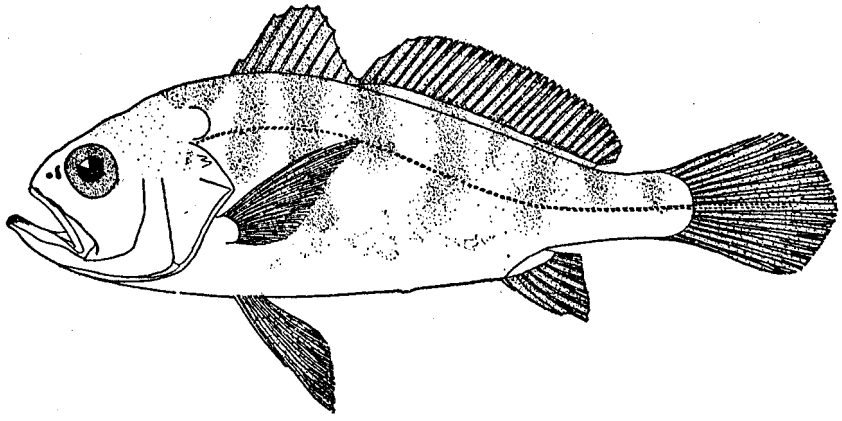

FIG. 22.—*Larimus, fasciatus*, adult fish; actual length, 19 cm.

Bairdiella chrysura (Lacépède). SILVER PERCH, WHITE PERCH, PERCH, SAND PERCH, YELLOW-FINNED PERCH, YELLOW-TAIL.

Bairdiella chrysura (fig. 34) is found on the Atlantic and Gulf coasts, ranging north to the vicinity of New York. It is abundant in New Jersey during the summer and early fall, spawning in June, July, and August. The height of the spawning season in New Jersey waters is reached in June and in North Carolina waters in May.

The embryology and larval development of this species have been fully described by Kuntz (1914) from material obtained at Beaufort, N. C., and further observations by the writers at Atlantic City, N. J., have confirmed his account. The eggs are spherical, transparent, slightly yellowish in color, and buoyant, with a faintly reticulated surface. In diameter they range from 0.7 to 0.75 mm. (to 0.8 mm., Kuntz). The yolk contains a single, relatively large, colorless oil globule, from 0.16 to 0.18 mm. in diameter. The period of incubation is from 40 to 50 hours

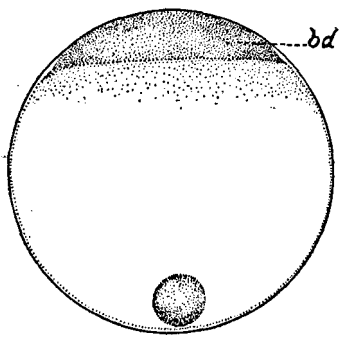

FIG. 23.—Egg with fully developed blastodisc.

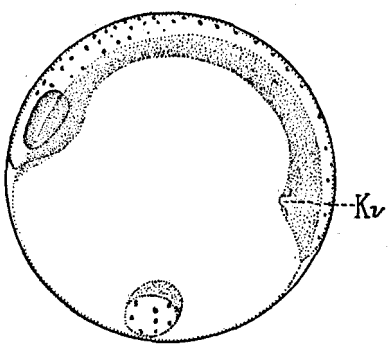

FIG. 24.—Early embryo showing distribution of chromatophores.

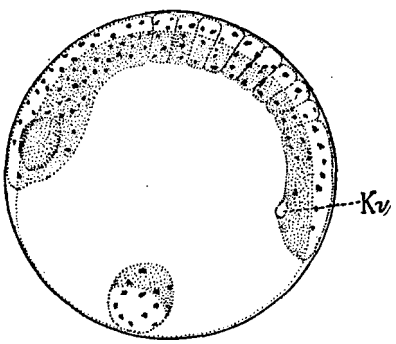

FIG. 25.—Egg with embryo showing 10 somites.

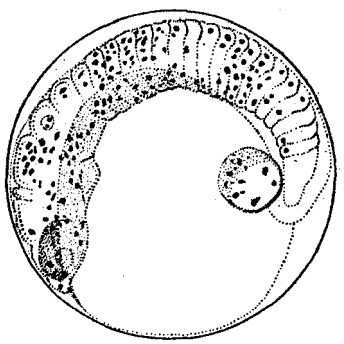

FIG. 26.—Egg with advanced embryo.

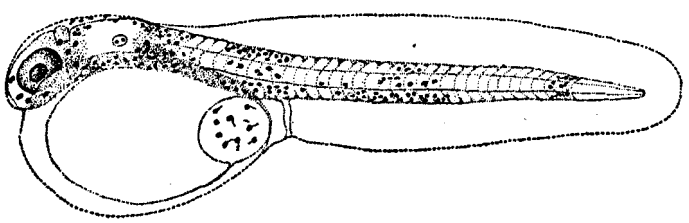

FIG. 27.—Newly hatched fish; actual length, 1.8 mm.

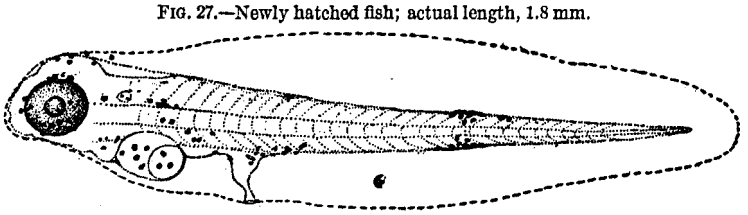

FIG. 28.—Larval fish one day after hatching; actual length, 2.5 mm.

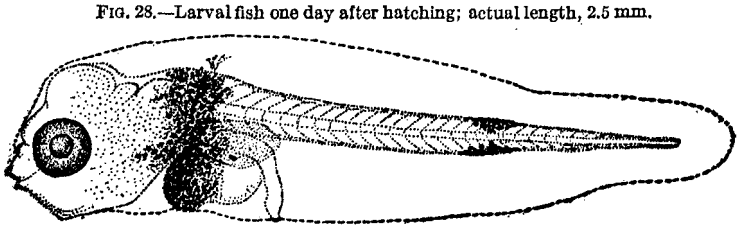

FIG. 29.—Larval fish two days after hatching; actual length, 2.6 mm.

BAIRDIELLA CHRYSURA.

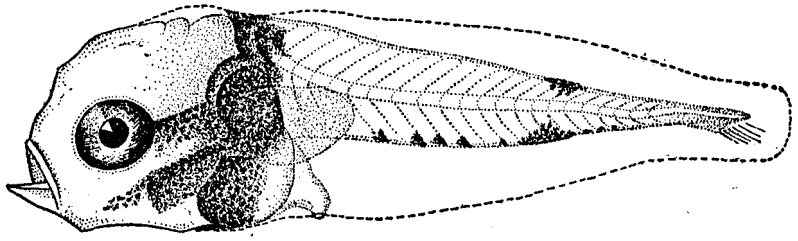

FIG. 30.—Larval fish; actual length, 3.5 mm.

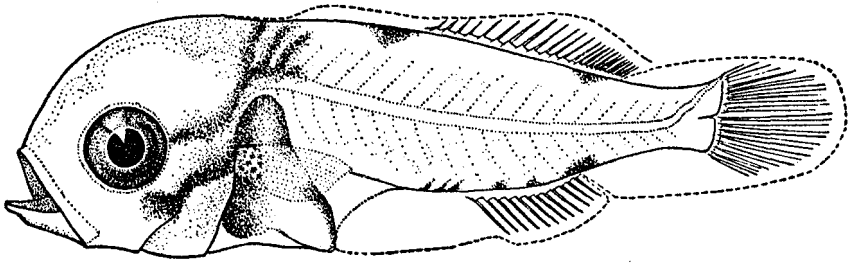

FIG. 31.—Larval fish; actual length, 7.5 mm.

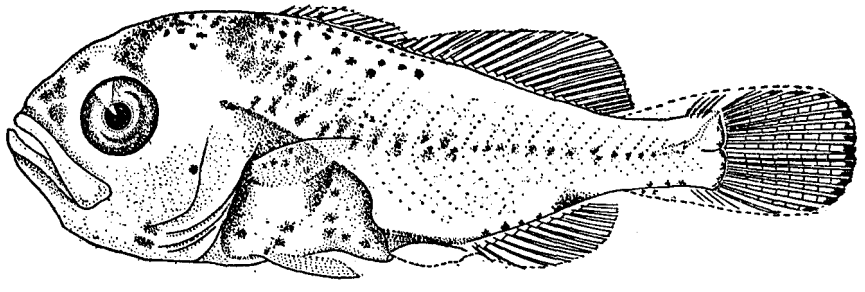

FIG. 32.—Larval fish; actual length, 11 mm.

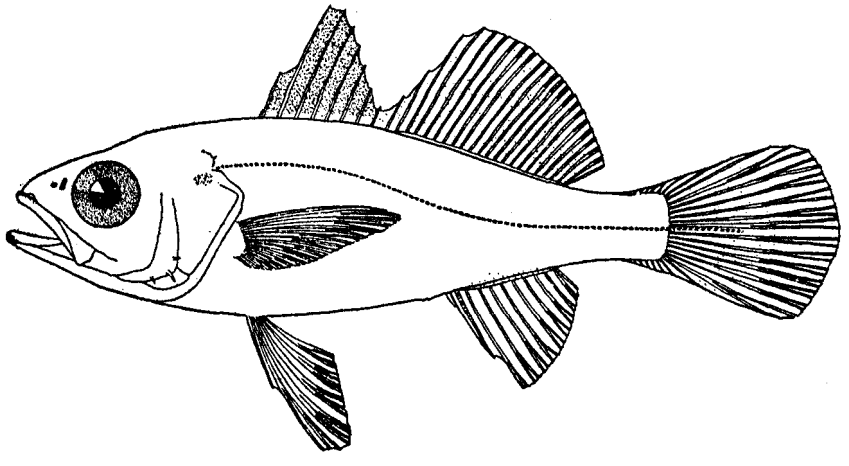

FIG. 33.—Young fish; actual length, 33 mm.

BAIRDIELLA CHRYSURA.

at a temperature of from 66 to 70° F. When hatched, the fry are from 1.5 to 1.9 mm. in length and are marked by five vertical bands of yellow chromatophores—one on the head, one behind the head, one in advance of the vent, and two on the caudal portion of the body. The yolk sac is absorbed in about two days, at which time the general color of the body is light brownish yellow, marked by two vertical bands, the first (behind the head) blackish and the second (about two-thirds the distance from the vent to the tip of the tail) yellowish. Various changes in form and color pattern occur with further growth, until at a length of about 1 cm. the spines and fin rays are distinct and the young may be easily identified by their counts. At a length of 3 cm. the young resemble the adult in all essential features, although the head and eye are still relatively larger and the vertical fins relatively higher than in the adult form. Figures 23 to 34 show the complete development of this species.

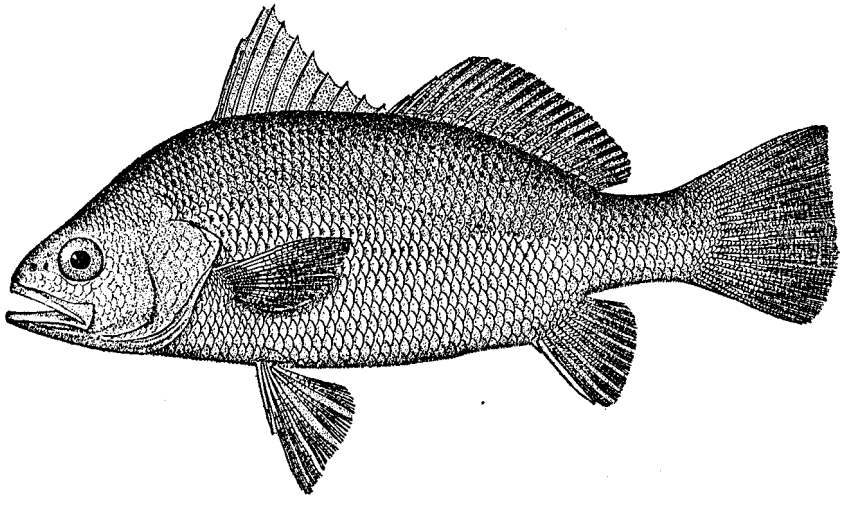

FIG. 34.—*Bairdiella chrysura*, adult fish; actual length, 21 cm.

In 1912 and 1913 Radcliffe (MSS.) measured several hundred silver perch at Beaufort, N. C., and from these data and further measurements of fish from Chesapeake Bay, confirmed by examination of the scales, it is possible to throw some light on the subsequent growth. By the first winter a length of from 6 to 14 cm. (2½ to 5½ inches) is attained, depending on the time of hatching, the average length for May-hatched fish being about 12 cm. (4¾ inches) and for June-hatched fish about 10 cm. (4 inches). During the winter months growth practically stops. The average increment of growth the second season is about 6 cm. (2⅜ inches), with a length for the second winter of from 12 to 20 cm. (4¾ to 8 inches). The first spawning occurs in the third season, when the fish are 2 years old and between 15 and 21 cm. in length (6 to 8¼ inches). After the first spawning the growth is slow, the largest fish of which scales were examined having reached a length of 23 cm. (9 inches) at the age of 6 years. The species seldom, if ever, exceeds a length of 24 cm. (9½ inches).

Cape Charles, Va., September 12, 1916.—The *Fish Hawk* took 21 specimens of *Bairdiella chrysura* that ranged in standard lengths from 6 to 8.2 cm.

	Volumetric percentage.
Schizopodous forms	86
Isopods	5
Amphipods	5
Unidentified crustaceans	1
Polychæt worms	2
Fish	1

A single specimen 7.6 cm. long had taken a small fish of 1.1 cm. in length, but it was too mutilated to identify further.

Stellifer lanceolatus (Holbrook). BULLHEAD, STAR DRUM.

Stellifer lanceolatus (fig. 36) is one of the most abundant fishes on the South Atlantic and Gulf coasts. It is found on sandy or muddy bottom in from 2 to 10 fathoms of water and is taken in vast numbers in the trawls of the shrimp fishermen, but, being small and bony, is not utilized. It rarely exceeds 16 cm. (6¼ inches) in length, and the average adult size taken by the shrimp trawlers is about 10 to 13 cm. (4 to 5¼ inches).

Spawning occurs in late spring or early summer, May and June being the principal months on the Atlantic coast. The eggs and larval and early post-larval stages have not been studied.

Examples 1.5 cm. in length already have the general form of the adult, but the head is proportionately much larger. The spines and fin rays are well developed, as is also the bony armature of the head, and the body is scaled. The color is pale (preserved specimens), with a few small black punctulations on the top of head and nape, a patch of blackish chromatophores on the opercular flap, a similar patch on the side beneath the spinous dorsal, and three or four single black chromatophores on the ventral line of the caudal peduncle.

At a length of from 2.5 to 3 cm. (fig. 35) a dark band or series of blotches appears on the body just below the dorsal fins; the membrane of the spinous dorsal is punctulate with brown; the premaxillary and mandible are edged with blackish; the opercular spot is conspicuous, and behind it lie a few groups of small black chromatophores; there is a dark vertical bar at the base of the caudal rays, and a row of black chromatophores appears on the ventral side of the caudal peduncle. This coloration and form soon gives place to that of the adult (fig. 36).

In general appearance the young of *Stellifer lanceolatus* resemble those of Micropogon and Leiostomus, but can be distinguished at once by the large head and strongly oblique mouth.

On July 10, 1915, the steamer *Fish Hawk* took large numbers of this species in Winyah Bay, S. C. Two very distinct year classes were then present, the young of the year showing a length of from 1 to 4 cm., with a mode of 3 cm., and the 1-year-old fish measuring from 7 to 10 cm., with a mode of 9 cm. Scale examination of fish from Fernandina, Fla., supplemented by actual measurement of large numbers of individuals, shows that a length of from 5 to 9 cm. is reached the first winter and from 8 to 14 cm. the second winter. Maturity is reached at the age of 1 year,

at a length of 8 cm. and upward. The largest fish examined had reached a length of 16 cm. at the age of 2½ years.

The results of the examination of the stomach contents of 84 examples ranging from 2.1 to 12 cm. (¾ to 4¾ inches) in standard lengths are listed below. The various items of food are given with their relative proportions represented in percentages by volume.

Winyah Bay, S. C., July 10, 1915.—Among 50 examples (a sample from a large catch), 2.1 to 8 cm. long, there appeared to be no differentiation of food cor-

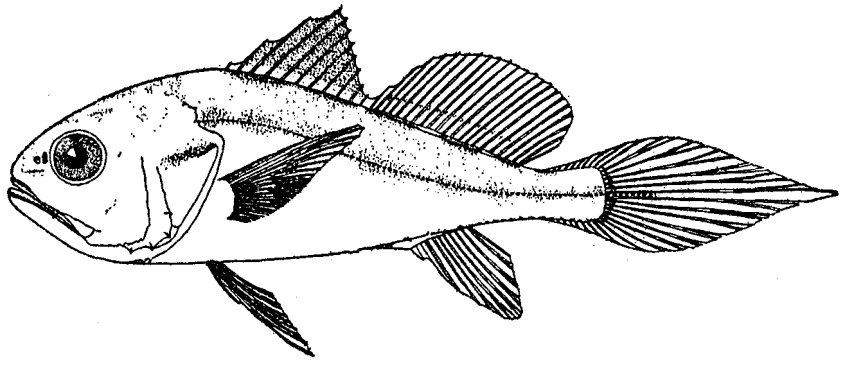

FIG. 35.—Young fish; actual length, 2.9 cm.

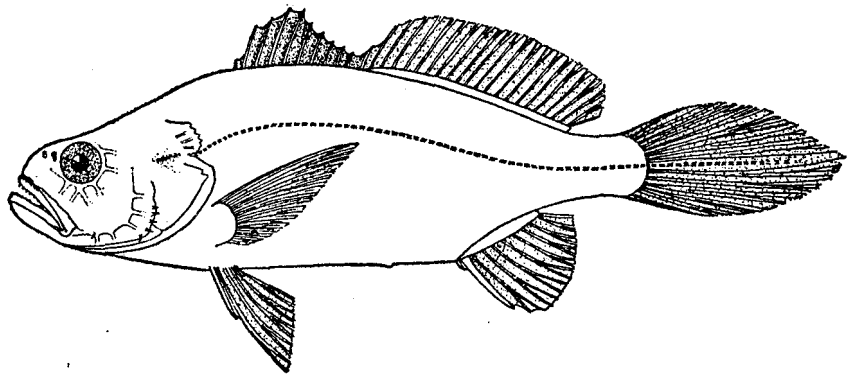

FIG. 36.—Adult fish; actual length, 16.4 cm.

STELLIFER LANCEOLATUS.

responding to the various sizes of fish examined. The following list shows the amount of each item of food in volumetric percentage:

	Volumetric percentage.	
Fish	9	
Decapod (shrimplike)	2	
Copepods	26	
Schizopodous forms	43	
Ostracods	2	
Amphipods	2	
Crustacean larvæ	9	
Total Crustacea		93
Unidentified débris	7	

From this list it is evident that by far the most important items of food are the various crustaceans, the schizopodous forms amounting to nearly one-half. The crustacean larvæ encountered were young crabs in the zoëa and megalops stages. In one case a specimen 3 cm. long had eaten an unidentifiable fish 1.8 cm. in length as well as some schizopodous forms. In another of the same size that had fed equally on copepods and schizopodous forms three small grains of sand were found.

Fernandina, Fla., December 8, 1919.—Of seven examples 4 to 10 cm. long, the food, given in volumetric percentages, was as follows: Copepods, 14; crustacean remains (probably), 86.

Fernandina, Fla., March, 1917.—Of a series of five individuals, ranging from 9 to 11 cm. in length, one was empty and the rest contained polychæt worms and crustacean remains in equal parts by volume.

During the winter of 1916–17 the *Grampus* took specimens of this species off Aransas Pass, San Luis, and Galveston, Tex., from which the following analyses of stomach contents were made.

Off Aransas Pass, Tex., Station 10476, March 5, 1917.—Of three examples 11 to 12 cm. in standard lengths, taken by a trawl, two were empty. The largest individual contained unidentified material.

Off San Luis, Tex., Station 10478, March 9, 1917.—From a depth of from 5 to 10 fathoms eight examples, 4 to 9 cm. in standard lengths, were taken, two of which were empty.

	Volumetric percentage.
Schizopodous forms	8
Copepods	75
Unidentified material	17

Off Galveston, Tex., Station 10480, March 20, 1917.—Of 11 examples, 7 to 9 cm. in standard lengths, 2 were empty.

	Volumetric percentage.
Schizopodous forms	11
Copepods	28
Unidentified material	61

From these analyses it might be inferred that *Stellifer lanceolatus* is rather indiscriminate in its feeding habits, taking food both in the open water and near or at the bottom.

Leiostomus xanthurus (Lacépède). Spot, Norfolk Spot, Goody, Cape May Goody, Lafayette, Roach, Chub, Jimmy.

Leiostomus xanthurus (fig. 38) is found on the Atlantic and Gulf coasts from Massachusetts to Texas, being abundant in the sounds and estuaries and occasionally running up into brackish or even fresh water.

The spawning time is in late fall or early winter and appears to be the same in both Atlantic and Gulf waters. The eggs and larval stages have not yet been studied, but post-larval stages of from 1.9 to 3.7 cm. in length (fig. 37) have been taken from January to April, in Chesapeake Bay and in Florida waters in St. Vincents Sound, St. Josephs Bay, and Charlotte Harbor. One example, 5.2 cm. in

length, was taken at Woods Hole, Mass., on July 20, 1915, but there are no other records from north of Chesapeake Bay for post-larval examples. The species will probably be found to spawn regularly as far north as Delaware Bay, for although spawning specimens have not been observed in New Jersey by the writers the young of the previous winter are found in abundance in the surf during the summer months, and it seems hardly probable that these fish have migrated from southern spawning grounds. These young fish were abundant in the pound net on Youngs

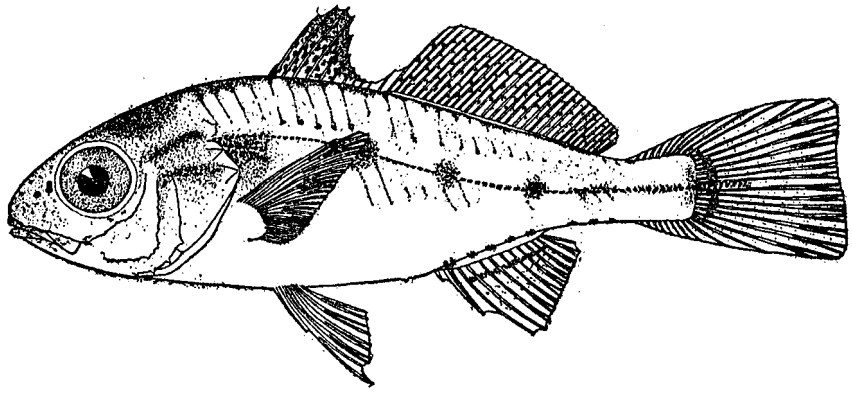

FIG. 37.—Young fish; actual length, 2.9 cm.

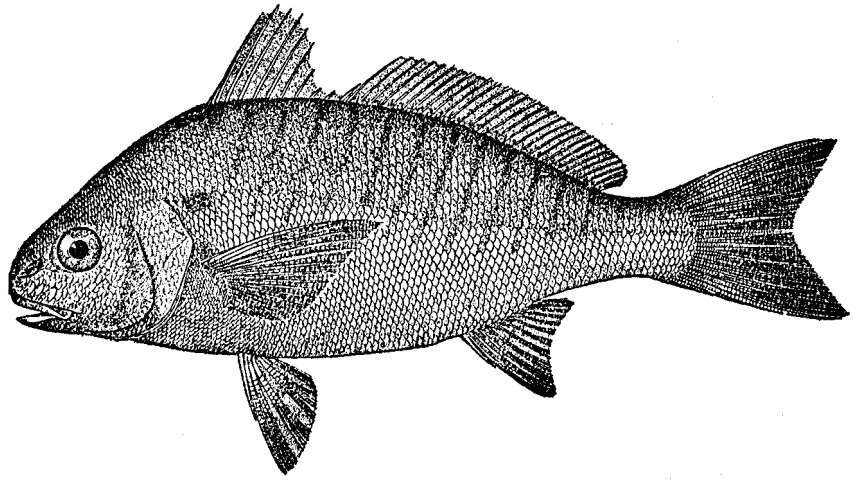

FIG. 38.—Adult fish; actual length, 16.4 cm.

LEIOSTOMUS XANTHURUS.

Pier, Atlantic City, N. J., during August, 1920, the great majority of them passing through the meshes when the net was raised. A few of the larger individuals were taken, none of them exceeding 10 cm. (4 inches) in total length, while the length of the smallest was estimated at about 6 cm. (2½ inches), and the modal length in August may be put at about 8 cm. (3⅛ inches). At the same time large numbers of the previous year class were taken, varying from 11 to 16 cm. (4¼ to 6¼ inches) in length, with a modal length of 14 cm. (5½ inches). These measurements indicate

that the increment in length in New Jersey waters between the first and second summers is about 6 cm. (2½ inches).

As might be expected, growth in southern waters is more rapid, the modal length attained by the second winter being 14 cm. (5½ inches) at Fernandina, Fla. Smith (1907) surmises that spawning size may be reached within a year after hatching, but examination of large numbers of 1-year-old fish at Fernandina indicates that these fish are quite immature and that spawning does not occur until the second year at the earliest.

Growth during the winter months, even in southern waters, appears to be retarded or altogether lacking. Post-larval examples taken in Florida showed no increase in length between January and April, and large series of 1-year-old fish taken at Fernandina in December and March showed no increase in length during the period between observations.

Determination of age by scale examination is difficult owing to the faintness of the winter rings, but examination of the scales of a few New Jersey examples indicates that growth in northern waters for the first three years is approximately as shown in the following estimated lengths:

	Estimated length.
1-year-old	8 to 10 cm. (3 to 4¾ inches).
2-year-old	17 to 22 cm. (6¾ to 8¾ inches).
3-year-old	24 to 29 cm. (9½ to 11½ inches).

The largest example examined at Atlantic City in the summer of 1920 was 30 cm. (11¾ inches) in length, and the scales indicated an age of 4½ years. Specimens from 26 to 28 cm. (10 to 11 inches) long were taken in abundance. The maximum length recorded of this species is 33 cm. (13 inches), but such examples are unusual.

The post-larval stages of *Leiostomus xanthurus* somewhat resemble the young of *Micropogon undulatus* but can easily be recognized by the squarely truncate caudal fin, as compared with the produced and pointed caudal of the latter species.

Examination of the stomach contents of 107 examples ranging in standard lengths from 2.1 to 13 cm. showed them to have been feeding on a variety of invertebrates. The following lists give the kinds of food present, together with the proportions of the various organisms expressed in volumetric percentage.

St. Vincent Sound, Apalachicola, Fla., April 7, 1915.—Of 50 examples (a sample from a large collection), 2.1 to 3.5 cm. long, all individuals had been feeding rather heavily, and in all but 15 specimens a considerable amount of fine sand was present. This suggested that they had been feeding near the bottom and accidentally ingested the grains, as none of the organisms on which they had fed were necessarily pelagic.

	Volumetric percentage.	
Ostracods	72.0	
Copepods	8.0	
Amphipods	2.0	
Unidentified crustaceans	1.0	
Total crustaceans		83
Polychæt worms	1.0	
Foraminifera	.5	
Dipterous larva	1.5	
Unidentified débris	14.0	

Crustaceans form the bulk of food for this species at this size, and almost nine-tenths of that consists of ostracods. The presence of insect remains suggests the proximity of fresh water, as the species represented was referable to the genus Chironomus. The tests of Foraminifera might have been taken with the sand grains in a similar incidental manner.

Fernandina, Fla., March 8, 1920.—Much of the food of 57 examples, 8 to 13 cm. in length, taken in a shrimp trawl, was macerated to such an extent as to be totally beyond identification.

	Volumetric percentage.
Crustaceans	36.0
Mollusks	18.0
Polychæt worms	2.0
Echinoderms	.5
Fish	.5
Unidentified material	43.0

A few crustaceans were probably copepods, and one was definitely an amphipod. Most of the rest of the crustacean remains were fragments of what were also evidently small individuals. All the mollusks were small bivalves, most of which were less than 2 mm. across the greatest width of shell, except a single gastropod of small size. A single small brittle-star made up the echinoderm food. Fish were represented by some remains of a single individual partly digested. Amongst the unidentified material were found a few small tubes consisting of sand grains cemented together, which were possibly formed by some marine worm.

The small inferior mouth of *Leiostomus xanthurus* at once marks it as a bottom feeder. This is well supported by contents of the stomachs, which, although not consisting entirely of benthose, contain a considerable portion of organisms found only resting on the sea floor. This form might well be considered one of the species connecting the pelagic with the typical bottom forms.

Micropogon undulatus (Linnæus). CROAKER, CROCUS, HARDHEAD.

Micropogon undulatus (fig. 41) is one of the commonest food fishes of the Atlantic and Gulf coasts. It is occasionally taken as far north as Cape Cod but is seldom found in abundance north of New Jersey, where it occurs during the spring, summer, and autumn months.

The spawning season is a long one, extending from August to December, and possibly later in southern waters. Ripe males, with running milt, have been taken at Atlantic City, N. J., early in July, and although no ripe females have been recorded earlier than September, the size of fry taken in Chesapeake Bay on September 12, 1916 (3.2, 3.6, and 4.1 cm.), and in New York Bay, N. Y., September 7 to 21, 1922 (2.25, 2.8, and 2.9 cm.), indicates that some spawning must occur in August. Post-larval stages of less than 4 cm. in length have been taken in Chesapeake Bay from September to March, inclusive, and examples of only 1 cm. have been taken in the middle of January. Spawning takes place in the larger estuaries, such as Delaware and Chesapeake Bays. The eggs and larval stages have not yet been studied, the smallest post-larval examples recorded having a length of about 1 cm.

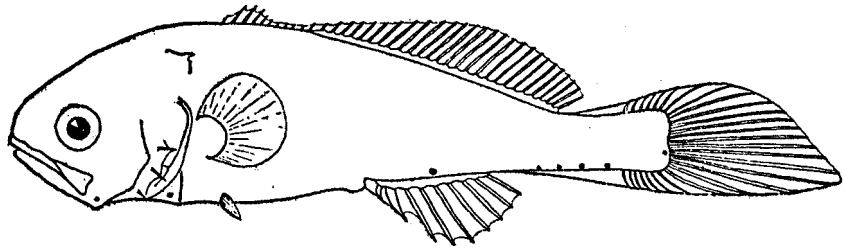

FIG. 39.—Larval fish; actual length, 1.225 cm.

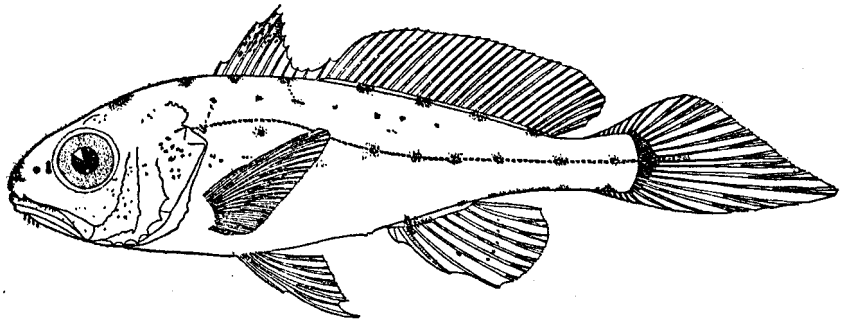

FIG. 40.—Young fish; actual length, 3.4 cm.

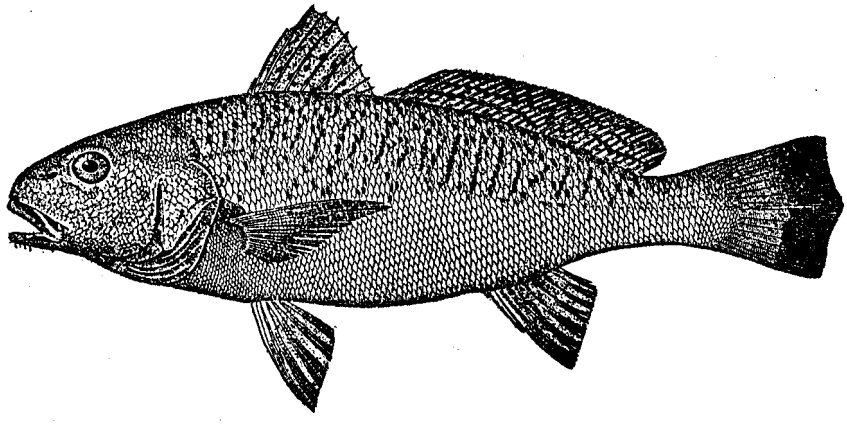

FIG. 41.—Adult fish.

MICROPOGON UNDULATUS.

In post-larval examples 1.1 cm. long the soft rays of the dorsal and anal are already formed; the anal spines are prominent and the dorsal spines and ventral fins are beginning to appear (fig. 39). The pectoral fin is inconspicuous. A membrane extends from the vent to the anal spine, and membranous folds are present both dorsally and ventrally on the caudal peduncle. The caudal is considerably produced, its longest ray about equaling length of head. The mouth is large and prominent, and the suprascapular ridge is already formed. The eye is pigmented, but the only other pigment (in preserved specimens) is in a row of five or six black chromatophores ventrally on the caudal peduncle and two similar ones on the isthmus.

In specimens of 3 cm. in length the spiny armature of the head is strongly developed, the mandibular barbels are in evidence, and the shape of the body approaches that of the adult; the head is large, about 3 in standard length; eye 3 to 3½ in head; the spinous dorsal and pectoral as in the adult, but the soft dorsal and anal proportionately much higher, ventrals long, the first ray reaching to or beyond vent; caudal with a flowing extension of the lower rays, the longest ray about equal to length of head. Scales are present but difficult to distinguish (fig. 40). Color (preserved examples) pale throughout, punctulated with groups of brownish chromatophores in regular rows, 8 on the dorsal line from head to base of caudal, 8 to 10 on a line from opercular flap to caudal, a less distinct row lying between these; snout, premaxillary, and tip of spinous dorsal, base of anal, and base of caudal rays punctulate with brownish.

Examples of 7 to 8 cm. in length are in most respects similar to the adult (fig. 41), the chief differences being in the greatly prolonged caudal rays and the higher anal fin of the young.

The young of *Micropogon undulatus* appear to spend the first winter in the deeper waters of the larger bays and in the ocean about the vicinity of inlets. In the late fall they are often found in waters that are practically fresh. In Chesapeake Bay in January they occur from the Severn River to Hampton Roads and Cape Charles but are most abundant in the deep water (100 to 160 feet) between the mouths of the Potomac and Choptank Rivers.

On December 9, 1915, numerous young fish were taken by the steamer *Fish Hawk* in Chesapeake Bay, near Sharps Island Light, at a depth of 126 feet. These fish were in a post-larval stage and measured in length from 2 to 6 cm., with a mode of 3 cm. From the conformation of the curve of measurements it appears that smaller examples were present but escaped capture. On January 22, 1914, in about 100 feet of water off Cove Point, Chesapeake Bay, the same vessel took in a single haul 5 quarts of post-larval specimens, of which 64 taken at random from the catch showed a length of from 3 to 10 cm., with a mode of 5 cm. During the same month post-larval specimens were taken in the bay at 22 other stations, the extreme lengths observed being 1 and 10 cm. The modal length for January 1 in Chesapeake Bay can thus be put at about 4 cm. (1½ inches), with extremes of 1 and 10 cm. (½ to 3¾ inches).

Actual measurements of 704 examples in their second winter (December 4, 1919) taken in a shrimp trawl by steamer *Albatross* (Station 20032) at Cape Canaveral Bight, Fla., show a clearly cut year class with a mode of 15 cm. (6 inches) and

extremes of 12 and 20 cm. (4¾ and 8 inches). An examination of the scales of a small series of New Jersey examples indicates that growth in northern waters is about the same. The average increment for the third year, as shown by the scales, is about 7 cm., and for the fourth year about 4.5 cm. Thus, the average length for the first four winters for this species may be approximated as follows:

	Average length.
First winter	4 cm. (1½ inches).
Second winter	15 cm. (6 inches).
Third winter	22 cm. (8¾ inches).
Fourth winter	26.5 cm. (10½ inches).

Maturity is reached at the age of 3 or 4 years.

The lists presented below represent the results from the stomach examination of 145 examples of *Micropogon undulatus* ranging in standard length from 1.7 to 17 cm. The foods are shown in their relative proportions according to volumetric percentages.

Cape Canaveral Bight, Fla., December 4, 1919.—Of 24 examples, 9 to 17 cm. in length, taken at a depth of from 4 to 6 fathoms, 6 were empty.

	Volumetric percentage.
Shrimps	24
Echinoderms	25
Polychæt worms	3
Unidentified material	48

The echinoderms were composed of the dismembered arms of brittle stars.

Cape Lookout Bight, N. C., December 13, 1919.—There were taken eight examples, 12 to 16 cm. long.

	Volumetric percentage.
Mollusks	20
Polychæt worms	40
Unidentified material	40

The mollusks were all small bivalves, mostly of the genus Mya. Probably a large part of the unidentified material consisted of the easily disintegrated soft bodies of the polychæt worms.

Southport, N. C., December 10, 1919.—Of 31 examples, 12 to 15 cm. in standard length, that were taken all were found to be completely empty.

Chesapeake Bay, Md., December 9, 1915.—There were taken 45 examples, 1.7 to 4.2 cm. in length.

	Volumetric percentage.
Copepods	17
Ostracods	22
Fish	2
Mollusks	28
Polychæt worms	9
Unidentified material	22

The remains of fish consisted only of a few vertebræ found in one example of 3.9 cm. in length. The mollusks were all small bivalves. Judging from this analysis it might be inferred that these fish are chiefly bottom feeders.

Winyah Bay, S. C., July 10, 1915.—There were taken 37 examples, 4.2 to 6.2 cm. long.

	Volumetric percentage.
Crabs	18.0
Amphipods	20.0
Schizopodous forms	7.0
Shrimps	2.0
Larval crustaceans	.3
Polychæt worms	29.0
Bivalves	1.0
Fish	.7
Unidentified	22.0

The inference is taken from this analysis that these fish were bottom feeders at this time, as the small nonswimming grapsoid crabs and other organisms encountered would be expected in greater numbers on the sea floor than elsewhere.

The remains of fish consisted of simply the caudal half of some small individual. The polychæt worms were represented by several forms of small size. Two small mussel-like bivalves made up the molluscan food. The crustacean larvæ consisted of a crab in the megalops stage. Two specimens contained small quantities of sand.

Micropogon undulatus appears to be comparable with *Leisotomus xanthurus* in regard to feeding habits but is still nearer to the typical bottom forms, in that it has developed sensitive pendent barbels.

Sciænops ocellatus (Linnæus). RED DRUM, DRUM, BRANDED DRUM, CHANNEL BASS, REDFISH, SPOTTED BASS, PUPPY DRUM (YOUNG).

The range of Sciænops (fig. 43) is from New Jersey to Texas, and stragglers have been taken as far north as Cape Cod. It is one of the largest species of the family, attaining a weight of 75 pounds and a length of about 152 cm. (5 feet). In the south the smaller fish are esteemed for the table, but in the northern part of its range the species is looked upon principally as a game fish of interest to surf anglers.

There appears to be a regular summer migration of large fish from southern waters to the coast of New Jersey, the fish appearing in late May or early June and remaining until October. Fish of less than 20 pounds in weight are rare among these migrants, and their average weight is about 30 pounds. Small fish are rarely seen north of the Chesapeake capes, and the species is not known to breed north of Chesapeake Bay.

Spawning occurs chiefly in the late fall or early winter, although from the size of some young fish taken in Florida waters in January it is probable that some spawning may take place as early as September. The eggs and larval stages have not been studied. The smallest examples that have been examined are six from Chesapeake Bay, 4, 4.2, 5, 5.1, 5.8, and 6.3 cm. long, respectively, and one from Pensacola, Fla., 5.8 cm. long. (See fig. 42.)

The specimen 4 cm. in length already shows the general form of the adult, and the scales are well developed. The color pattern is distinctive. In preserved examples the ground color of the head and body is pale brownish, somewhat silvery on the opercle and sides below the lateral line. A series of five or six irregular dark

brown blotches, somewhat smaller than the eye, lies below the lateral line, one behind the opercle, one under the afterpart of the spinous dorsal, two or three under the soft dorsal, and one on the caudal peduncle. There is a large irregular blotch of brown on the nape and a number of smaller ones along the bases of the dorsal fins and on the caudal peduncle. The membrane of the spinous dorsal is punctulated with dark brown, and similar, smaller punctulations appear on the soft dorsal

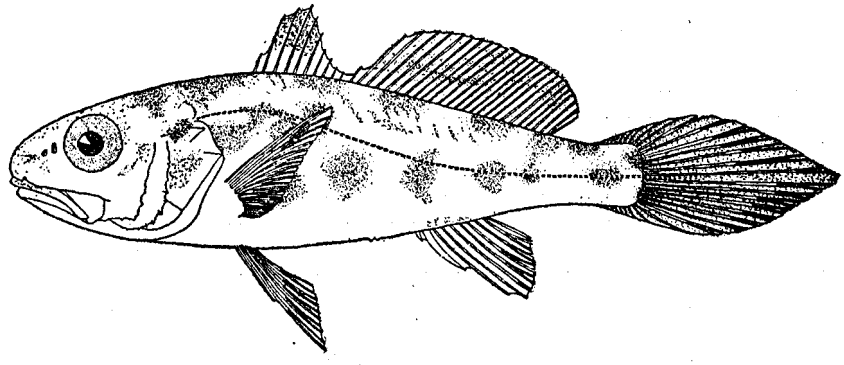

FIG. 42—Young fish; actual length, 4.2 cm.

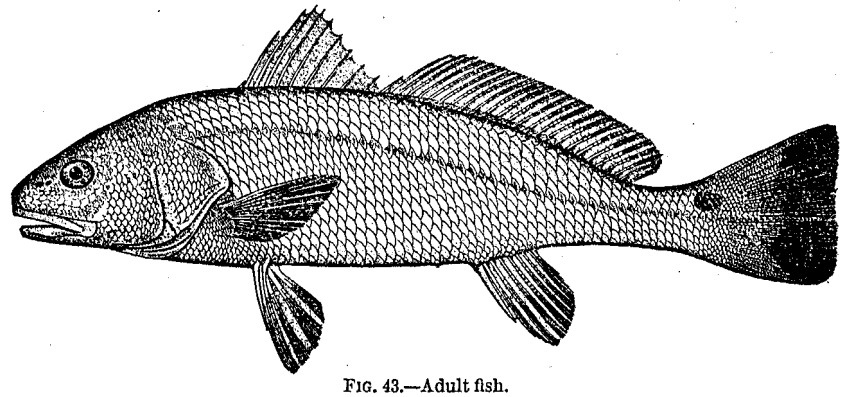

FIG. 43.—Adult fish.

SCIÆNOPS OCELLATUS.

distally and on the produced median portion of the caudal fin. The pectorals, ventrals, and anal are hyaline.

An example 6.3 cm. in length is quite similar, except in the presence of a dark brown blotch at the base of the upper caudal rays. This blotch appears to be the first phase of the ocellated caudal spot of the adult.

In a specimen 12 cm. long the color is paler and the blotches, with the exception of the caudal spot, are less distinct.

The growth of the young of *Sciænops ocellatus* during their first winter is slow. From measurement of the few examples available, it appears that in Chesapeake Bay a length of about 5 cm. (2 inches) is reached by the middle of March. Eight examples taken at Beaufort, N. C., on June 22, 1914, show an average length of about 16 cm. (6¼ inches). with extremes of 13 and 18 cm. (5⅛ and 7⅛ inches). The material at hand is insufficient for a study of further growth. Examination of the

scales of 21 examples from Fernandina, Fla., taken March 6, 1920, would seem to indicate that 3-year-old fish may range in length from 39 to 59 cm. (15½ to 23¼ inches) and of one from Sandy Hook Bay, N. J., on September 14, 1921, that a fish of about 6 years may measure 82.6 cm. (32½ inches), but as the markings on the scales are obscure, further studies are required to confirm this estimate, which shows a remarkably slow rate of growth for a species reaching such a large size.

The following comparison of weight and length of the smaller fish is taken from the same sample of 21 fish from Fernandina.

Length.	Weight.
40 cm. (15.7 inches)	650 g. (1.43 pounds).
45 cm. (17.7 inches)	950 g. (2.09 pounds).
50 cm. (19.7 inches)	1,300 g. (2.86 pounds).
55 cm. (21.7 inches)	1,700 g. (3.75 pounds).
60 cm. (23.6 inches)	2,250 g. (4.96 pounds).
65 cm. (25.6 inches)	2,800 g. (6.17 pounds).
70 cm. (27.6 inches)	3,400 g. (7.50 pounds).
75 cm. (29.5 inches)	4,150 g. (9.15 pounds).

From the above figures a formula for the calculation of weight from length can be drawn, as follows: $\frac{L^3}{98} = W$, where L = length in centimeters, and W = the weight in grams. The formula $\frac{L^3}{2,717} = W$, where L = length in inches, and W = weight in pounds avoirdupois. These formulæ will give approximately correct results with fish under 75 cm. (30 inches) in length.

According to R. H. Corson, the well-known New Jersey angler, Sciænops has extraordinary tenacity. He has seen specimens left out of water for at least 45 minutes roll on hot midsummer beaches and states that at the end of the time they were able to swim away apparently unharmed.

Menticirrhus americanus (Linnæus). WHITING, KING WHITING, SEA MINK, HAKE, SEA MULLET, VIRGINIA MULLET, KINGFISH, ROUNDHEAD, CAROLINA WHITING.

Menticirrhus americanus (fig. 45) is the most abundant species of its genus from the Chesapeake capes to Texas, its range extending northward to New York. On the New Jersey coast, where it appears in late summer, it is found in company with *M. saxatilis* and is not always recognized by fishermen as distinct from that species. In the northern part of its range it disappears from the inshore waters in autumn, but in Florida waters many are taken by the shrimp fishermen throughout the winter months.

The spawning season of this species appears to be later than that of *Menticirrhus saxatilis*, but its duration is not exactly known. Smith (1907) gives June as the spawning season at Beaufort, N. C.; but many females were examined in August, 1920, at Atlantic City, N. J., and the eggs in all of them, although well developed, were hard, and no spent fish were taken. Also 66 young examples of from 2 to 7 cm. (¾–2¾ inches),[9] with a modal length of 4 cm. (1½ inches), were taken at Boca Grande, Fla., on April 2, 1917 (fig. 44), which would indicate that in the

[9] The stomach of one of these contained an example of the same species 1.2 cm. (one-half inch) in total length.

Gulf of Mexico the species spawned in late fall or early winter, at about the same time as *Leiostomus xanthurus*, young of which were taken with them. The eggs and larval stages have not yet been studied.

Measurements of 58 young examples taken at Fernandina, Fla., December 8, 1919, seem to indicate that there may be *two* spawning seasons. Of these fish, 52 examples showed a length of from 14 to 24 cm. ($5\frac{1}{2}$ to $9\frac{1}{2}$ inches), with a mode of

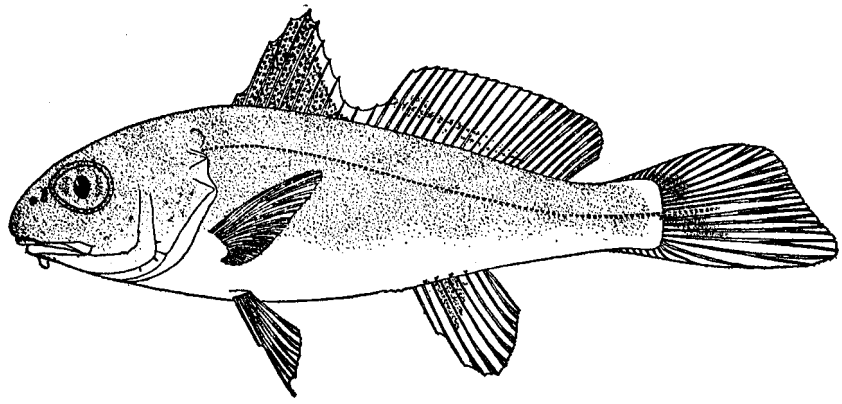

FIG. 44.—Young fish; actual length, 2.6 cm.

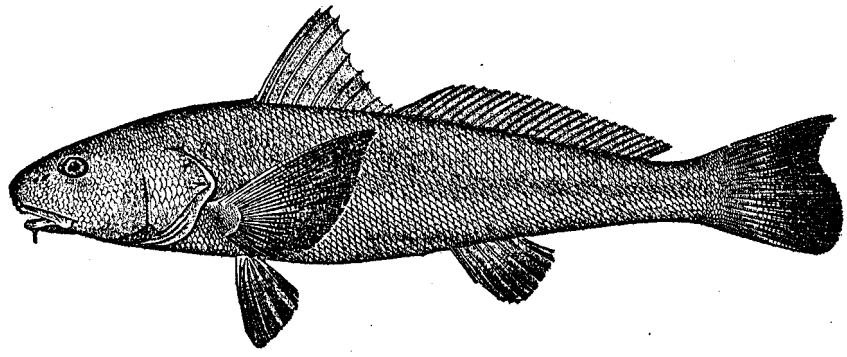

FIG. 45.—Adult fish.
MENTICIRRHUS AMERICAUS.

17 cm. ($6\frac{3}{8}$ inches). This group was in its second winter and was comparable to the young taken at Boca Grande in April. A smaller group, of six fish, was composed of individuals from 8 to 11 cm. ($3\frac{1}{8}$ to $4\frac{1}{4}$ inches) in length. These fish were in their first winter, and there is reason to believe that they had been spawned the previous spring. It is possible that they were the product of the spawning stated by Smith to occur in June.

The smallest post-larval examples examined (Boca Grande, Fla., April 2, 1917) are between 2 and 3 cm. ($\frac{3}{4}$ and $1\frac{1}{16}$ inches) in length,[10] and at this size (fig. 44) the

[10] The example of 1.2 cm. taken from the stomach of a larger individual has been omitted from this discussion, as it possibly has been modified by the action of gastric juices. Briefly, the form of the body and fins are similar to the larger ones described in detail, but the pigmentation does not resemble that of the adults so closely, neither is it so dark, the chromatophores being fewer and more scattered. Three rows of them above the lateral line and parallel to the back are the most prominent, but we can not be sure just how much has been effaced. Probably a considerable change has been effected, however, by the processes of digestion.

resemblance to the adult (fig. 45) is already striking, both in form and color. The form is quite similar to that of *Menticirrhus saxatilis* of the same size, but the ventral fins are somewhat shorter, not reaching to vent. The coloration is much paler than in *M. saxatilis*. In preserved specimens the general ground color of the body and head is silvery, with brownish chromatophores forming a pattern of cloudy bands similar to that of the adult. The membrane of the spinous dorsal is sparsely punctulate with brownish; that of the soft dorsal has a group of dusky punctulations basally about the middle of the fin, as has also the anal; the pectorals are hyaline; ventrals white with a few punctulations of dusky on the membrane; caudal hyaline, with a group of dusky chromatophores at the base of the median rays. Specimens 2.5 cm. (1 inch) in length possess well-developed ctenoid scales. Specimens of 5 to 6 cm. (2 to 2⅜ inches) in length show little change. A group of dark punctulations has appeared on the base of the upper caudal rays, and the membrane of the soft dorsal is punctulate basally for its entire length.

Measurements of two large samples of young fish, taken at Fernandina, Fla., on December 8, 1919, and March 8, 1920, indicate that there is no perceptible growth during the winter months, even in southern waters, and that the modal length attained by the second winter is about 17 cm. (6¾ inches), with extremes of from 14 to 24 cm. (5½ to 9½ inches).

Examination of the scales of a small series of New Jersey examples tends to confirm the hypothesis that they were spawned in the late fall, passing the first winter in the post-larval stage at a length of about 4 cm. (1½ inches) and attaining a length of about 16 cm. (6¼ inches) the second, and of about 25 cm. (9¾ inches) the third winter. Maturity is reached at the age of 3 years. This growth is somewhat less than that shown for *Menticirrhus saxatilis* in the same region, but the fact that New Jersey is about the northern limit of the range of this species must be considered. Examples from Florida show, as might be expected, a somewhat faster rate of growth.

Considerable agility on the part of the younger examples of *Menticirrhus americanus* is indicated by the larval and post-larval fishes that have been found in their stomach contents. The lists below give the foods with their proportions expressed in volumetric percentages. Sizes of examples are given in standard length.

Boca Grande, Fla., April 2, 1917.—Of 50 examples, 2.8 to 5.8 cm. in length, all had full digestive tracts.

	Volumetric percentage.
Schizopodous forms	85
Polychæt worms	2
Fish	6
Unidentified material	7

The schizopodous forms formed by far the greater bulk. The individuals averaged about 6 mm. in length and were probably of the genus Mysis. In two specimens a few sand grains were noted. The fish remains are tabulated below, together with the lengths of the individuals from which they were taken.

TABLE 7.—*Fish remains in stomach contents of whiting from Boca Grande, Fla., 1917.*

Standard length of example in centimeters.	Fish remains.	
	Description.	Length in centimeters.
4.0	Menticirrhus americanus	1.1
3.5	Caudal half of a post-larval fish	
3.6	Unidentifiable fish	1.5
3.6	Two post-larval clupeoids	[1] 1.3
3.4	Vertebral columns of three individuals	
3.7	Vertebral columns of two individuals	
3.2	Caudal half of a post-larval fish	

[1] Each.

During the winter cruise of 1916–17 the *Grampus* took the following three catches:

Off Fernandina, Fla., January 10, 1917.—Of six examples, 7 to 13 cm. long, taken in a shrimp trawl one was empty.

	Volumetric percentage.
Shrimps	40
Unidentified crustaceans	20
Polychæt worms	20
Fish (fragments)	20

Off San Luis, Tex., Station 10478, March 9, 1917.—At a depth of from 5 to 10 fathoms seven examples, 9 to 18 cm. long, were taken.

	Volumetric percentage.
Crabs	7
Shrimps	7
Unidentified crustaceans	29
Unidentified material	57

Off Texas coast, no label.—Of eight examples, 8 to 14 cm. long, three were empty. The food of the remainder, given in volumetric percentages, was as follows: Crabs, 10; polychæt worms, 90.

Fernandina, Fla., March, 1920.—The 47 examples, 12 to 25 cm. long, taken in a shrimp trawl had apparently been feeding lightly, although none of the digestive tracts was found completely empty. Only a single stomach was found distended with food.

	Volumetric percentage.
Shrimps	20
Small crabs	7
Polychæt worms	24
Fish	6
Unidentified material	43

The results indicate that their food is about equally divided between crustaceans and polychæt worms (possibly Nerius) with occasional slight quantities of small fish. A considerable portion of the food had been reduced to a homogeneous paste that defied analysis. About one-sixth of the unidentified material can probably be referred to various small invertebrates; the remainder was distinctly past identification.

Menticirrhus americanus is at once seen to be a bottom form, both from its food and its anatomical characters—sensitive barbels and flattened ventral profile. The same is true of *M. saxatilis*. The young, however, judging from their food, are less given to keeping to the bottom and exercise considerably more agility.

Menticirrhus saxatilis (Bloch and Schneider). KINGFISH, KING WHITING, HAKE, BARB, WHITING, SEA MINK, SEA MULLET.

Menticirrhus saxatilis (fig. 55) is found from Cape Cod to Florida but attains its greatest abundance north of Chesapeake Bay and is far more abundant in New Jersey waters than *M. americanus*, which species it closely resembles. It can be readily distinguished from *M. americanus* by the presence of an elongated dorsal spine (which extends far beyond the anterior rays of the soft dorsal when depressed) and the average number of soft rays in the anal fin (eight or nine in *saxatilis*, seven or eight in *americanus*). These fish usually appear in the shore waters in May and remain until autumn, frequenting sandy bottoms just outside the surf and sandy channels in the vicinity of inlets. Spawning commences in June and continues until August, reaching its maximum in late June or early July.

A study of the eggs and larval development was made at Atlantic City, N. J., during the summer of 1920. The material used was obtained from the pound nets on Young's Million Dollar Pier, where excellent working facilities were provided by the owner, Capt. E. L. Young.

When ripe, the eggs flow freely under slight pressure, the fertilized eggs floating immediately. The eggs are spherical, 0.76 to 0.92 mm. in diameter, averaging about 0.80 to 0.85 mm., and are almost colorless, some showing a faint yellowish tinge. The yolk contains one or more refractive oil globules, the number varying greatly in the eggs of different individual fish. The eggs from some fish show from 1 to 6 globules, averaging 3 to 4, while in others the number may be from 9 to 18, averaging 13 or 14. When only one globule is present, its diameter is from 0.19 to 0.26 mm. When many are present, they are irregular in size, ranging from about 0.14 to 0.02 mm. in diameter. As development proceeds these globules become amalgamated until at the time of hatching only one is present.

In still water, at a temperature of 68 to 70° F., the period of incubation is from 46 to 50 hours. Segmentation and development proceed as in Bairdiella (Kuntz, 1914). About 18 hours after fertilization grayish chromatophores become distributed over the dorso-lateral aspects of the embryo and on the surface of the oil globule. At 24 hours the chromatophores on the globule have become black and stellate and the embryo is dotted with black punctulations. A number of scattered small black chromatophores also appear on the dorsal surface of the yolk sac. Figures 46 to 49 illustrate the embryological development.

Upon hatching, the larva of *Menticirrhus saxatilis* is from 2 to 2.5 mm. in length. The head is slightly deflected, and the globule lies in the posterior portion of the yolk sac. The pigmentation consists of three vertical bands of black and dull gold chromatophores, one above the anus and two posterior to it, dividing the caudal region into three nearly equal parts. A patch of black and dull gold pigment lies in the dorsal fin fold anteriorly, and similar chromatophores are scattered over

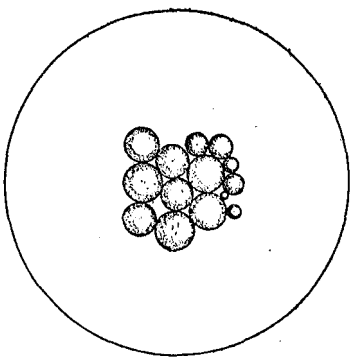

FIG. 46.—Newly fertilized egg.

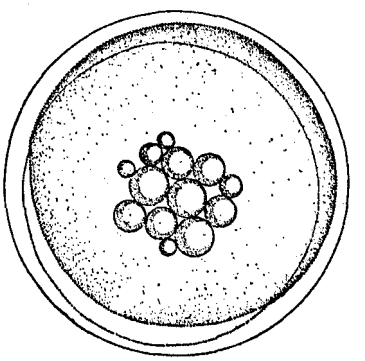

FIG. 47.—Egg of 17½ hours' incubation.

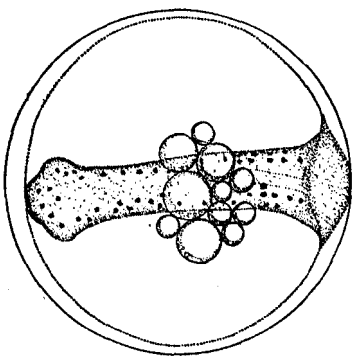

FIG. 48.—Egg of 24 hours' incubation.

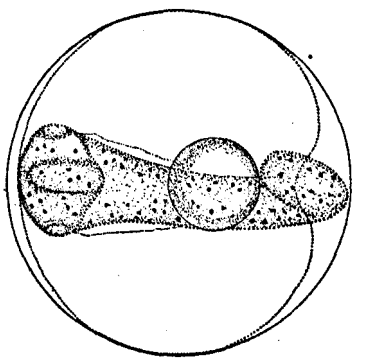

FIG. 49.—Egg of 27½ hours' incubation.

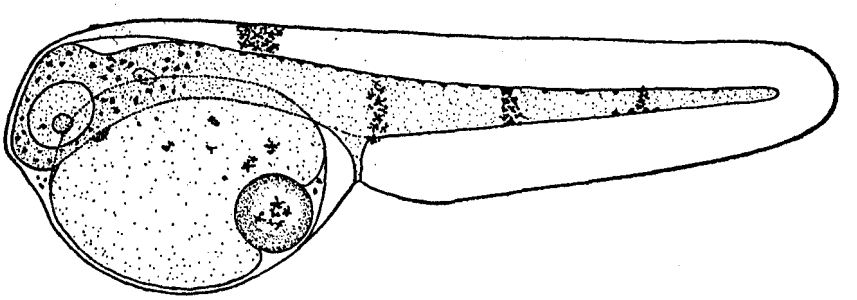

FIG. 50.—Newly hatched larval fish; actual length, 2.2 mm.

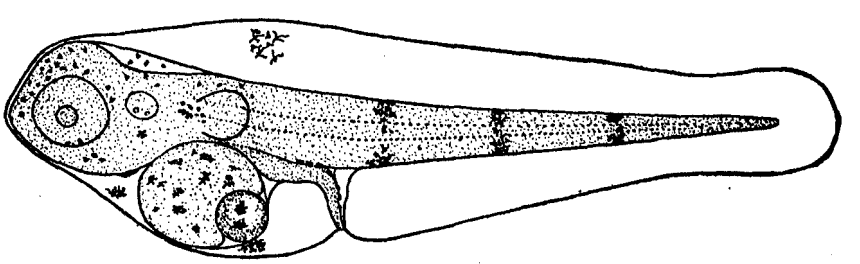

FIG. 51.—Larval fish one day after hatching; actual length, 2.5 mm.

MENTICIRRHUS SAXATILIS.

the yolk sac. The larva floats in an inverted position, tail inclined upward, every little while making short wriggling dashes, which bring it momentarily into what is to be its normal position after the yolk sac is absorbed. The three bars on the tail and the patch on the dorsal fin fold are the most conspicuous markings to the unaided eye.

On the second day after hatching the posterior caudal band loses its gold pigment and all the markings are less conspicuous. The yolk sac is considerably reduced, but little growth in length occurs. The pectorals are faintly visible. On the third day the yolk sac is still further reduced, and the bands, especially the anterior ones, are becoming faint. On the fourth day only traces of the caudal bands are visible, and a row of black chromatophores appears along the ventral surface posterior to the vent, extending to the location of the middle band. The blotch in the dorsal fin fold is still conspicuous; the eye is pigmented; pectorals are pigmented with black and gold chromatophores; mouth is open and functioning; abdomen with a golden tinge, and yolk sac is almost completely absorbed. On the fifth day the normal position when at rest is floating head downward, but the fry are very quick in action when disturbed. To the unaided eye the color effect is that of a dark brown head and body as far as vent; tail transparent. Growth in length up to this time is negligible. On the sixth day the eye shows a steel-blue luster. No trace of rudimentary fins is visible. By the seventh day a few fry attain a length of 2.8 mm., but all are becoming weak, none surviving until the eighth day after hatching. Figures 50 to 53 illustrate the larval growth of this species.

The later larval and early post-larval stages are not known, the smallest examples that have been taken being about 2.5 cm. (1 inch) in length.

Young fish between 3 and 4 cm. ($1\frac{1}{8}$ and $1\frac{1}{2}$ inches) in length (fig. 54) already strongly resemble the adult (fig. 55), but the head and eyes are larger, the body deeper, and the soft dorsal and anal fins much higher; the third dorsal spine is not produced, and the lower lobe of the caudal is much more prolonged than in the adult. The color varies greatly both in pattern and intensity, ranging from the characteristic markings of the adult to an almost uniform blackish brown. Certain markings that appear to be constant in preserved specimens are as follows: Membrane of spinous dorsal dusky, posterior portion edged with lighter; soft dorsal and anal blackish at base, or with a dark band near base, rest of fin hyaline; caudal hyaline, with one or two irregular dark blotches at base; pectoral hyaline, its axil blackish; ventrals brownish or blackish, the rays and outer margin white. Scales are present and well developed in examples 3 cm. ($1\frac{1}{8}$ inches) in length.

The growth of *Menticirrhus saxatilis* the first summer is exceedingly rapid. Measurements of a large number of young taken at Woods Hole, Mass., during July and August in various years show that fish hatched early in June may attain a length of 2 cm. ($\frac{3}{4}$ inch) by July 1, 8 cm. ($3\frac{1}{8}$inches) by August 1, and over 15 cm. ($5\frac{7}{8}$ inches) by September 1, but this is a maximum, and the modal length of fish hatched in late June and early July is about 5 cm. (2 inches) for August 1 and 10 cm. (4 inches) for September 1. These observations are confirmed by measurement of smaller samples of fish from more southern points. A lot of 21 fish taken at Cape

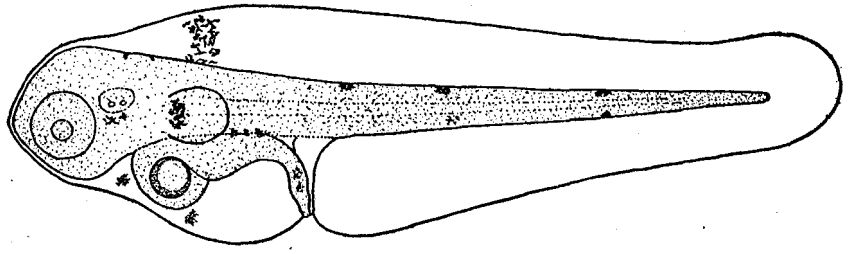

FIG. 52.—Larval fish two days after hatching; actual length, 2.65 mm.

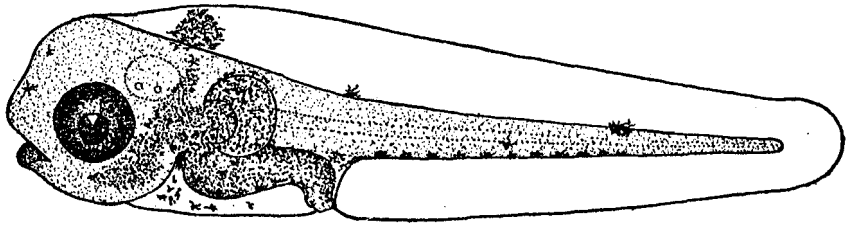

FIG. 53.—Larval fish four days after hatching; actual length, 2.7 mm.

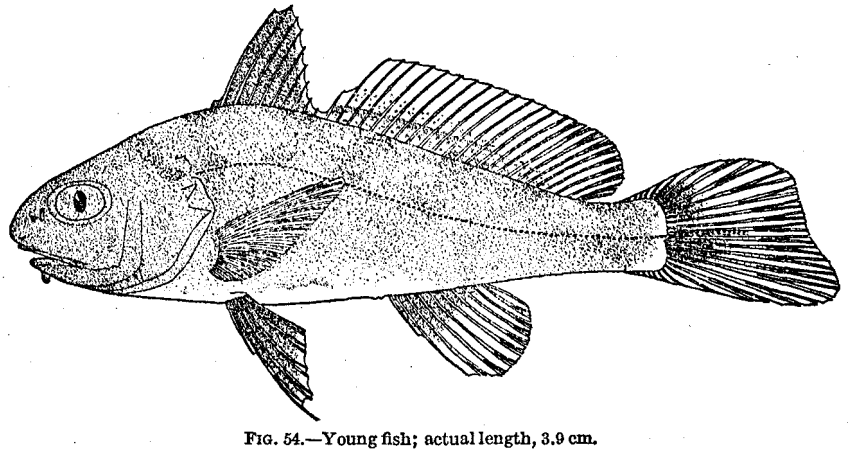

FIG. 54.—Young fish; actual length, 3.9 cm.

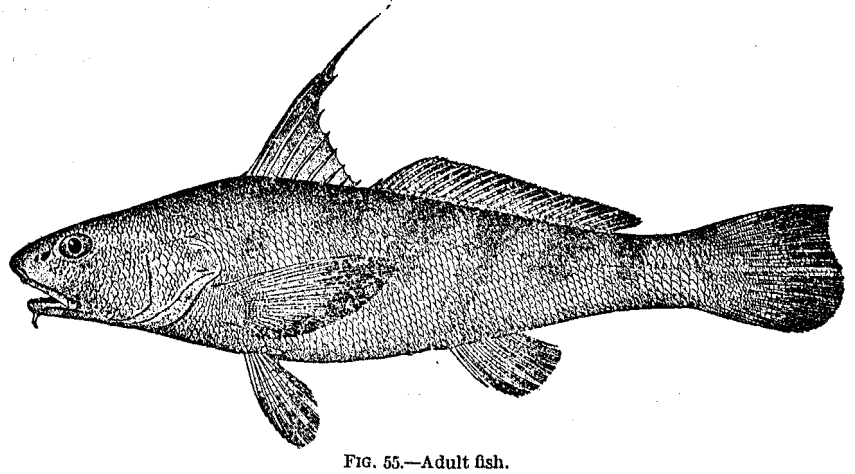

FIG. 55.—Adult fish.

MENTICIRRHUS AMERICANUS.

May, N. J., on August 8, 1916, shows a modal length of 4 cm. (1½ inches), with extremes of 2.5 and 9 cm., and seven samples from Chesapeake Bay, September 12, 1916, range in length from 9 to 14 cm.

Growth falls off rapidly in the autumn and practically ceases during the winter. From examination of the scales of a small series of New Jersey examples it appears that the species attains a modal length of about 12 cm. (4¾ inches) the first winter, the majority being between 10 and 15 cm. (4 and 6 inches) in length. In the second winter the modal length is about 25 cm. (10 inches), and in the third winter about 35 cm. (13¾ inches). Maturity is reached during the third or fourth summer; that is, at the age of 2 or 3 years. The males appear to mature earlier than the females, and while many ripe males 2 years old are taken, it is probable that the females seldom spawn until 3 years old.

The following four lists of the food of *Menticirrhus saxatilis* give the various items in terms of volumetric percentage. The range of standard lengths of the individuals is given in all cases.

Atlantic City, N. J., August, 1920.—Of nine samples, 20 to 24 cm. in length, taken in a pound net five were empty.

	Volumetric percentage.
Shrimps	81
Amphipods	6
Polychæt worms	13

Sewell's Point, Cape May, N. J., August 8, 1916.—There were taken along the beach in a seine 21 examples, 1.9 to 7.2 cm. in standard length.

	Volumetric percentage.	
Shrimps	9	
Amphipods	30	
Schizopodous forms	9	
Isopods	5	
Larval crustaceans	2	
Total crustaceans		55
Polychaet worms	19	
Unidentified material	26	

The two largest individuals that contained identifiable material (5.6 and 7.2 cm.) had fed entirely on shrimps and none was found in any of the others. This correlation of type of food and size of individual is, apparently, merely a case of the larger fish being able to negotiate more bulky organisms. The larval crustacean was probably the megalops of some crab. A few grains of sand were found in the stomachs of two examples.

Davis Neck Beach, Falmouth, Mass., August 3, 1892.—Of 17 examples, 2.4 to 7.4 cm. long, 4 were empty.

	Volumetric percentage.
Shrimps	42
Schizopodous forms	42
Unidentified material	16

Probably most, if not all, of the unidentified crustacean remains, on which the digestive fluids had acted to such an extent as to make positive identification impossible, consisted of either or both of the other two entries.

Nobska Beach, Woods Hole, Mass., July 20, 1915.—Of 25 examples, 1.9 to 3 cm. long, the food, given in volumetric percentages, was as follows: Amphipods, 85; isopods, 15. All the stomachs were full, and one contained a few grains of sand.

Menticirrhus littoralis (Holbrook). SEA MULLET, WHITING, SURF WHITING, SILVER WHITING.

Menticirrhus littoralis (fig. 57) occurs on the South Atlantic and Gulf coasts rarely if ever being found north of North Carolina. Little is recorded of its life

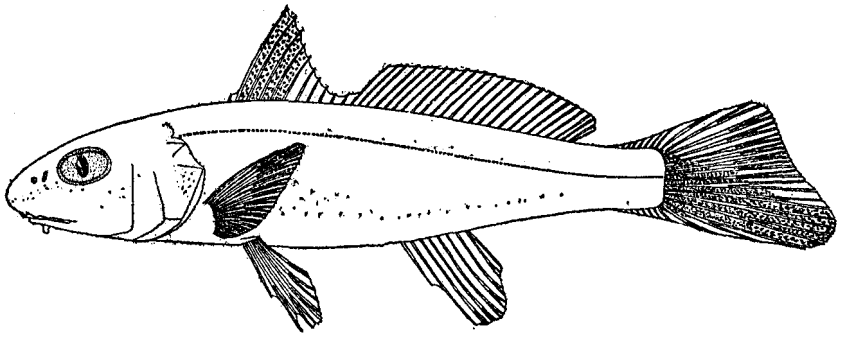

FIG. 56.—Young fish; actual length, 5 cm.

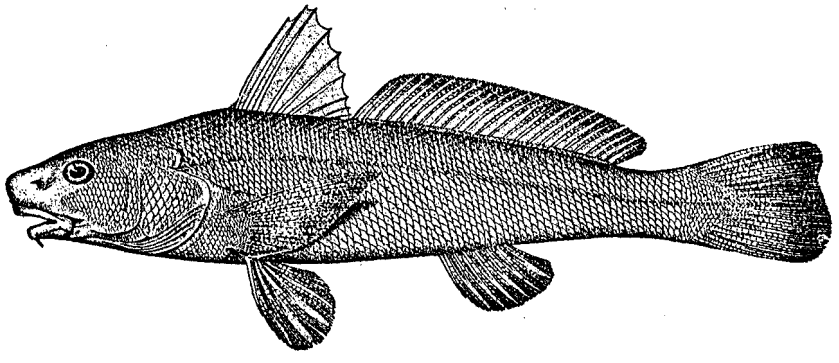

FIG. 57.—Adult fish.

MENTICIRRHUS LITTORALIS.

history. Smith (1907) states that spawning fish have been taken at Beaufort, N. C., in June.

The eggs and larval stages have not been studied. Three examples, 3.8, 5, and 5.1 cm. long, respectively, seined on the beach at Fort Macon, Beaufort, N. C., August 18, 1913 (fig. 56), are the only specimens of the young that have been examined. In these the body is less compressed and less deep than in young of *Menticirrhus saxatilis* and *M. americanus* of the same size, and the color more uniform. The ventrals, which are long, reaching to or beyond the vent, have the

second and third rays longest, instead of the first, as in the other species. Color of head and body (preserved specimens) is an almost uniform grayish brown, somewhat lighter beneath and finely punctulate with darker; membrane of spinous dorsal with small brown punctulations between second and fifth spines; soft dorsal similarly marked along outer margin and along the middle third of its width; caudal

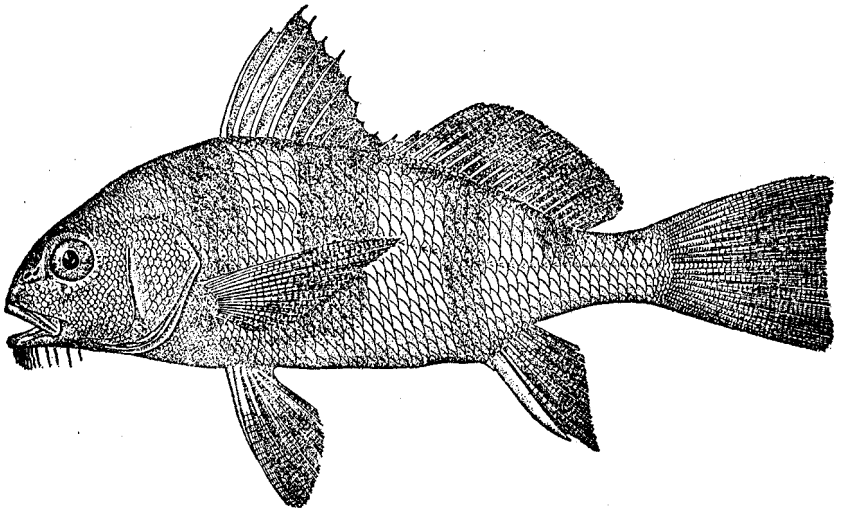

FIG. 58.—Young fish; actual length, 23.1 cm.

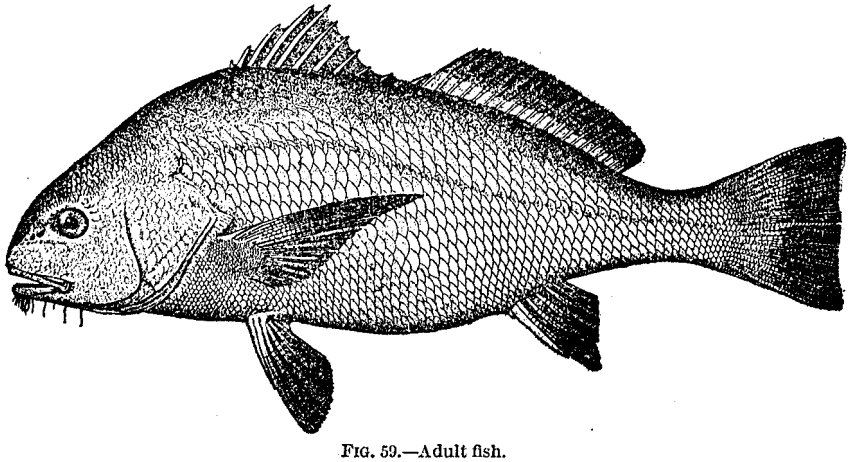

FIG. 59.—Adult fish.

POGONIAS CROMIS.

punctulate at base and on the prolonged lower lobe; other fins hyaline. The scales on the smallest example are quite distinct.

Pogonias cromis (Linnæus). BLACK DRUM, SEA DRUM, DRUM, BIG DRUM, BANDED DRUM, GRAY DRUM, DRUMFISH, PUPPY DRUM (YOUNG).

Pogonias cromis (fig. 59) is found along the Atlantic coast from New England to Argentina but is more plentiful on the Florida coast than northward.

The eggs and larvæ are unrecorded, and little is known of the life history. Inquiries at several institutions devoted to the study of natural science failed to reveal specimens of less than 8 cm. (3 inches) in their collections. At this size they are marked with five more or less complete vertical bars. Figure 58 illustrates the markings of an example 23.1 cm. (8.9 inches) long. As they become older and larger these markings finally fade out completely, until they become uniformly dusky. A confusion of names has arisen on the north Jersey coast in which this species is split in two by local anglers, who differentiate between a red drum and a black drum. J. T. Nichols, of the American Museum of Natural History, New York City, called the writers' attention to this, and it was personally noted at Atlantic City, N. J., in 1920.

The so-called "black drum" is more chunky forward and of a dark grayish color, whereas the "red drum" is slimmer and somewhat reddish brown in hue. With just what this variation may be correlated is not known, but the very largest examples we examined were all of the dark type. On the other hand, all small examples just out of the banded stage are as far as known likewise of this type. Fishes in the red phase seem to be known only from the New Jersey coast. South of Atlantic City—that is, at Cape May—there is no such confusion, Pogonias having but one name—"black drum"—and "red drum" referring to Sciænops. In localities where the confusion is common Sciænops is known as "channel bass." At no place are professional fishermen known to recognize more than one name for Pogonias, this simply being an angler's distinction, which at present, at least, has no scientific recognition.

There appears to be a regular summer migration of large examples of Pogonias to the New Jersey coast. Specimens of less than 20 pounds in weight are decidedly rare thereabouts, although surf fishermen take small banded examples weighing about 12 pounds occasionally.

This species attains the greatest size of any of the Sciænidæ. A record from St. Augustine, Fla., gives 146 pounds as a maximum weight, and examples up to 60 pounds are not rare.

The food of these fish consists chiefly of various mollusks, for which their heavily paved phyrangeal teeth are admirably adapted. They have from time to time been accused of committing depredations on oyster beds, having been known to completely annihilate small plants of that mollusk in a single raid.

Eques acuminatus (Bloch and Schneider). RIBBON FISH, CUBBYU.

Eques acuminatus has been recorded as ranging from North Carolina to Brazil. Little is known of its habits, and it appears to be a straggler on our coast but is not rare about the West Indies. Most records mention small examples, 7.5 to 12.5 cm. (3 to 5 inches). The form is rather similar to that of *E. lanceolatus*, but the markings are very different, consisting of seven wide longitudinal light bands. In older specimens the light bands become narrower, and the junior writer has seen a series that connects it with *Eques acuminatus umbrosus* (Jordan and Eigenmann), which as Smith (1907) has shown is no longer tenable.

Eques pulcher (Steindachner). RIBBON FISH.

L. L. Mowbray, of the New York Aquarium, states that *Eques pulcher* is not especially uncommon about the coral heads located on sandy bottoms among the keys of the east coast of Florida. The first record of *E. pulcher* for the United States was made by him at Key West in the summer of 1917, and the specimen was given to the American Museum of Natural History. Through the clear waters that these ribbon fish inhabit he has often seen them feeding on small crustaceans, as the latter would hazard a journey through the open waters from one coral snag to another.

Eques lanceolatus (Linnæus). RIBBON FISH.

Eques lanceolatus ranges from Pensacola to the West Indies and is rather common southward. In contrast to *E. pulcher* it inhabits the outer coral reefs and is usually

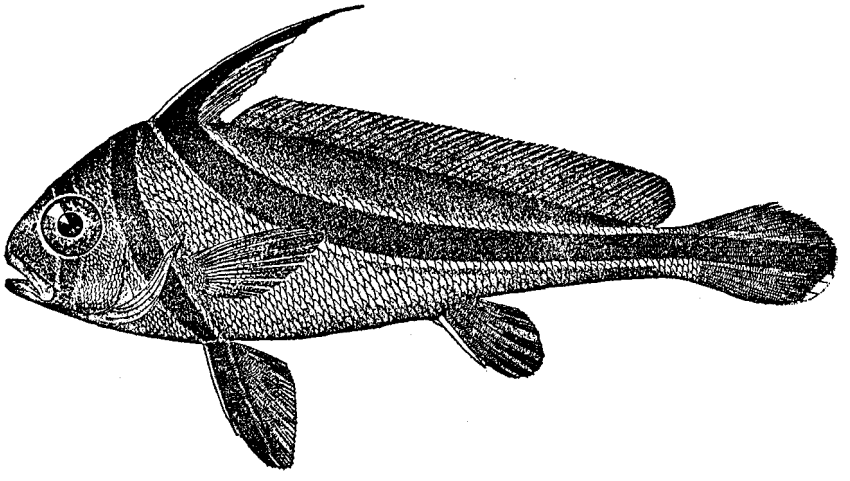

FIG. 60.—*Eques lanceolatus*, adult fish.

seen singly, although it is rather rare on the Florida coast according to Mowbray. Figure 60 illustrates the adult of this species.

Umbrina coroides (Cuvier and Valenciennes).

Umbrina coroides is recorded twice by Jordon (1880) from the Indian River, Fla. It is close to *Umbrina broussonnetii* described from Jamaica, a doubtful species. If they are synonymous, *broussonnetii* should be retained. In systematic treatment *U. coroides* should precede Menticirrhus, but because of the lack of knowledge concerning it it was given this place.

Corvula sialis (Jordan and Eigenmann).

Corvula sialis is described by Jordan and Eigenmann (1889) from Key West, based on a single specimen. It is a rare form of which little is known and precedes Bairdiella in systematic position.

GENERAL REMARKS ON FOOD OF ATLANTIC COAST SCIÆNIDÆ.

The feeding habits of the Sciænidæ can be correlated directly with their physical characters and habitat. The fast-swimming species of open waters, such as *Cynoscion regalis*, have been found to feed chiefly on organisms of pelagic regions, which in many cases necessitated considerable pursuit on the part of the feeder; the slower moving species, such as *Micropogon undulatus*, on organisms found on or near the bottom. This is brought out by a comparison of the lists of food for *Cynoscion regalis* taken at Cape May, August 8, 1916 (p. 160) with that for *Menticirrhus saxatilis* of about the same size taken at the same place on the same date (p. 194). The latter, a comparatively sluggish fish, had taken a considerable quantity of polychæt worms and no fish; the opposite was true of the former.

Again, on July 10, 1915, in Winyah Bay, specimens of *Cynoscion regalis*, *Stellifer lanceolatus*, and *Micropogon undulatus* were taken. Comparing the stomach contents of *Stellifer lanceolatus* and *Micropogon undulatus*, the former's pelagic habitat was reflected in its food as well as the latter's bottom-feeding habits in its food. A similar comparison might be made between Stellifer and *Menticirrhus americanus* taken on March 9, 1917, at San Luis, Tex. *Bairdiella chrysura* taken near Cape Charles on September 12, 1916, had fed in a manner similar to Cynoscion taken at the same time. Bairdiella is also a free-ranging fish, but not to such an extent as Cynoscion. The examination of specimens of *Menticirrhus americanus*, *Leiostomus xanthurus*, and *Cynoscion regalis*, taken in March, 1920, at Fernandina, Fla., showed the first two to have been feeding on the bottom, which fact could be inferred from their inferior mouths, and Cynoscion with its large terminal gape to have been pursuing the organisms of the open water.

A very fine gradation in the modification of body form is correlated with the bathymetrical distribution of this family. At one end are found the more generalized forms; for example, Cynoscion, the central habitat of which is slightly below mid-water. These grade down through such intermediate forms as Bairdiella, Sciænops, and Leiostomus to the typical bottom forms with well-flattened profiles and mandibulary barbels, such as Micropogon, Menticirrhus, and Pogonias. As a whole, the family is generally considered as inhabiting the sandy shores of the warmer seas, and from this typical habitat there are comparatively few important digressions.

SUMMARY.

1. As far as is known, species of the family Sciænidæ develop from comparatively small pelagic eggs.

2. Development is rapid, incubation lasting but a few days, and the larvæ grow rapidly.

3. In most cases the post-larval fishes acquire the diagnostic characters of the adults in a few months.

4. Maturity is reached in from one to four years, depending upon the species.

5. The males of several species are known to mature a year earlier than females of the same age.

6. One species or another can be found spawning at any time during the greater part of the year at various places along the Atlantic coast.

7. All of the species appear to have rather protracted spawning seasons. In the case of some it extends practically over the entire warm half of the year.

8. There appear to be no very great differences in the dates of spawning to be correlated with latitude. Such differences as do exist can likely be directly correlated with water temperature.

9. Although the species studied have pelagic eggs, all known spawning grounds are at no great distance from shore, and probably the ova are extruded near the bottom, although in no great depth of water.

10. The entire family, as represented in this region, shows well-defined migratory movements, which are evidenced annually by a disappearance of these fishes from inshore waters in winter.

11. The food of this family is made up chiefly of crustaceans, annelids, mollusks, and fish. The less active species feed chiefly on the more sedentary forms; the very active members pursue the more lively foods.

12. The availability of the foods appears to be the most prominent factor in the selection of diet, thus throwing the determination of it largely on the geographical and bathymetrical distribution.

13. The feeding habits and bathymetrical distribution are well reflected in the physical characteristics of the various species.

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