NATURAL HISTORY AND CONSERVATION OF REDFISH AND OTHER COMMERCIAL SCIÆNIDS ON THE TEXAS COAST

By JOHN C. PEARSON

Temporary assistant, United States Bureau of Fisheries

CONTENTS

INTRODUCTION

GENERAL PROBLEM

In the summer of 1925 the United States Bureau of Fisheries, heeding a demand from Texans for more specific information as to the actual status of their coastal marine fisheries, conducted a short survey of those fisheries. The results of the study were presented in a Preliminary Report on the Marine Fisheries of Texas, by Higgins and Lord (1926), in which the character of the fisheries was discussed in the light of their past and present yields. A logical recommendation given in this report was for the immediate initiation of biological investigations that would include primarily extended study of the life histories of various marine food fishes of the State.

Having complete control of its commercial fisheries, Texas has been alarmed for some time as to the possibility that serious depletion of its shore fisheries would occur before any steps could be taken to insure a permanent supply of food fish. Many prohibitive laws have been passed, unfortunately, without sufficient knowledge of the life histories of the fish to allow rational conservation of the fish stock as well as intelligent utilization and development of the fisheries. The people most interested in the future welfare of the marine resources of Texas are beginning to realize that a fundamental prerequisite for adequate fisheries legislation is an accurate, unbiased knowledge of the life histories of the food fish entering into the fisheries.

AIM OF THE INVESTIGATION [1]

The natural histories of the three leading food fishes of coastal Texas—the redfish (*Sciænops ocellatus*), the black drum (*Pogonias cromis*), and the spotted sea trout (*Cynoscion nebulosus*)—have been little understood in any section of the distribution of these species. Along the Texas coast serious debates often arise as to the habits of the redfish, drum, and spotted trout, with special reference to the location of spawning areas and the distribution of young and adult fish. Reliable information concerning the life histories of these most valued shore fishes is of much interest, both from a popular standpoint and the point of view of those individuals that are intrusted with the conservation of the natural resources of Texas. To furnish this sound basis for conservation, the first of a series of scientific fishery investigations was undertaken to ascertain, primarily, the location of the spawning grounds, rate of growth, seasonal distribution, and movements of the redfish, black drum, and spotted sea trout.

As a result of the support of the Texas game, fish, and oyster commission, which consisted in furnishing a fishing boat and crew, various launches, as well as other equipment and services, the bureau is able to present the following paper, embodying the results and conclusions of 14 months' field observations and collections along the coast of Texas. These observations, conducted continuously from April, 1926, to June, 1927, included studies on the natural history of the croaker (*Micropogon undulatus*) and the spot (*Leiostomus xenthurus*), fishes of secondary commercial importance in Texas but of considerable value along the Atlantic coast.

DESCRIPTION OF TEXAS COAST

The entire coast line of Texas, from the mouth of the Sabine River in the north to the mouth of the Rio Grande in the south, extends along the Gulf of Mexico for nearly 400 miles. The greater portion of the coast is bordered by a chain of low, sandy barrier islands, which separate the many coastal bays and lagoons from the Gulf of Mexico and through which run the various passes that connect the inland waters with the Gulf. The coast line following the winding shores of these many bays, lagoons, and coves extends about 2,000 miles along the mainland.

A central coastal section, extending, roughly, from Copano Bay on the north to Baffin Bay on the south, provides an extremely diverse system of intercoastal and Gulf waters. Many types of marine environment are to be found within this general area, in which the greater part of the field work centered and which, for the purposes of the investigation, appeared to satisfy the demand for an area of observation that would be representative of the entire coast line.

---

[1] Appreciation and thanks are due to the following individuals for assistance and advice, which enabled the investigator to progress in his task more rapidly than would have been possible if their interest and help had been lacking: Turner E. Hubby, former commissioner of the Texas game, fish, and oyster commission; William J. Tucker, present commissioner of the State commission; C. W. Gibson, of the Lone Star Fish & Oyster Co., Corpus Christi, Tex.; Robert E. Farley, deputy of the Texas game, fish, and oyster commission; Lawrence Gates of Corpus Christi, Tex. Special thanks are due to the city of Corpus Christi for the extended use of one of the rooms in the city hall as an office and laboratory. Many individuals and fish companies in the vicinity of Corpus Christi contributed greatly to the success of the investigation by their willingness to give advice and information.

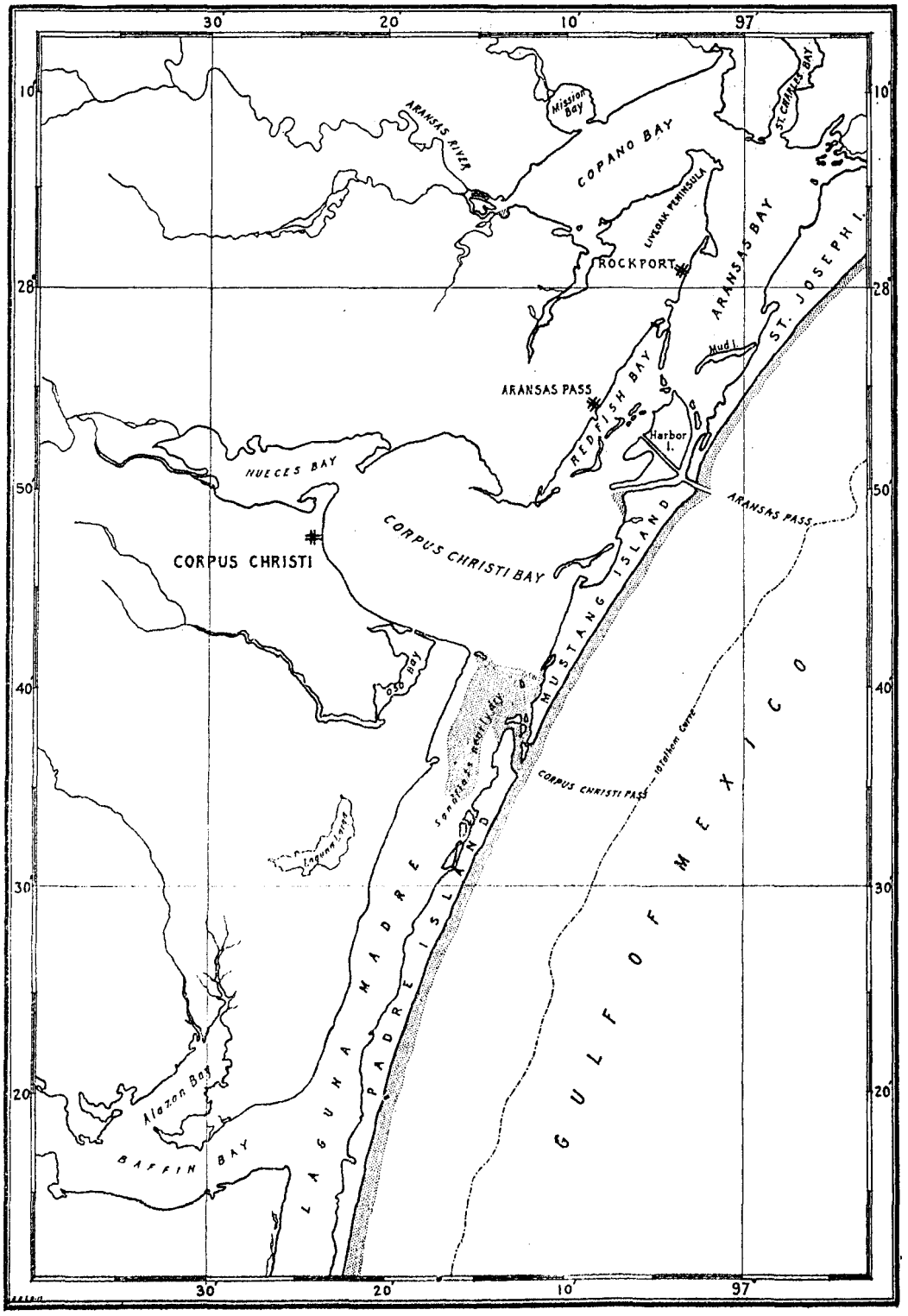

FIG. 1.—Section of the Texas coast covered by the investigation

The Gulf of Mexico is the fundamental source of all the marine life found within the intercoastal waters. Without the incoming tides the shallow bays and lagoons would be subject to such extreme temperatures and salinities as to render the existence of much marine life highly improbable. At the present time Laguna Madre, a long, narrow lagoon having poor circulation of water with the Gulf of Mexico, often reaches such high salinity through excessive evaporation in summer as to kill thousands of fish trapped in the lagoon by shallow water. In spring large quantities of Gulf water pour into the bays, bringing along a new supply of marine organisms, which usually linger within the intercoastal waters until the approach of cold weather.

Water from the Gulf enters the bays by the passes or inlets through the barrier islands. Because of the relatively slight tidal action, many of the more remote bays and lagoons do not attain a salinity equal to that of the Gulf and approach the character of brackish water. Two passes—Aransas and Corpus Christi—are included in the section of Texas coast represented in Figure 1.

Aransas Pass is an artificial or dredged channel, which has been enlarged from a relatively shallow, natural inlet to a deep, jettied pass, through which merchant ships go on their way to the inland port of Corpus Christi. The pass is about 2 miles long, 1,000 feet wide, 30 feet deep, and is protected against erosion by a pair of rock jetties stretching out into the Gulf about a mile from the shore line. Many observers believe that natural entrance of schools of fish into the bays is hindered by these barriers along the shore line. While no data exist to support or deny this contention, the writer found that the rocks at Aransas Pass had a decided tendency to impede the entrance of many larval and young croakers and spots into the bays. The deepened condition of the pass, resulting from continual dredging, allows more water to enter than would be possible if the pass were continually filled with sand, such as is the case with most of the natural passes along the coast. The effect of the dredging in the pass, however, could hardly be called beneficial to the particular species of fish found to spawn at the mouths of the passes.

Corpus Christi Pass, lying at the head of Laguna Madre and about 20 miles south of Aransas Pass, is a small, natural channel through which not even a small power boat can navigate on account of the ever-present sand bars in and about the pass. At the time of the investigation in 1926 and 1927 this pass was about 1,000 feet long, 100 feet wide, and about 6 feet deep in the middle of the channel. It may change its shape and depth after each severe storm and at times may be almost closed by sand bars.

Tidal action usually gives the passes along the coast but one strong incoming tide a day, and little or no water enters if the tide is opposed by strong winds. With the passes serving as main highways between the Gulf and the intercoastal waters, their condition is of the utmost importance if a continual interchange of water is to be maintained.[2]

[2] According to Marmer (1927, p. 434), the range of the tide at Galveston, Tex., averages but 1 foot, as compared with 4½ feet at New York and 9 feet at Portland, Me. On the Atlantic coast the two high waters and also the two low waters of a day are approximately the same, the morning and afternoon tides resembling each other in all respects. In the Gulf of Mexico, however, the two high waters do not differ much, but morning and afternoon low waters are so strikingly different that frequently the higher of the two low waters merges with one of the high waters, and at such times there is but one high water and one low water in a day.

The largest as well as the deepest of the intercoastal waters included in the general area of study comprised three main bays: Corpus Christi Bay, with its tributaries covering about 185 square miles, and Aransas and Copano Bays, covering with their tributaries about 163 square miles. The depth of water in these bays scarcely exceeds 15 feet, and numerous oyster reefs make much of the total area unnavigable to all but boats of the shallowest draft. The bottoms generally consist of hard sand with soft mud present in the vicinity of river mouths, and the water is often turbid, due to the heavy winds that sweep the coast.

Protected indentations of these larger bays, commonly called coves, are interesting in that generally they are preferred by fish to the more open, larger bays on account of the quiet, shallow water, well supplied with aquatic vegetation and organisms suitable for fish food.

A unique system of smaller bays tributary to the larger ones is common along certain sections of the coast. These smaller bays, typified by Oso and Nueces Bays, which empty into Corpus Christi Bay, are extremely shallow and muddy and inci-

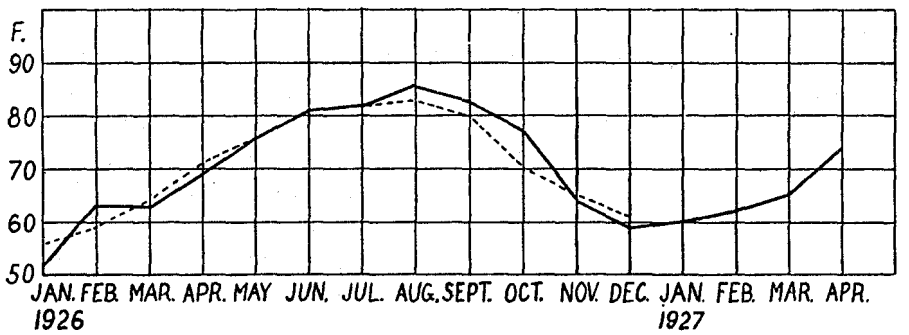

FIG. 2.—Mean air temperature at Corpus Christi, Tex. Solid line, January, 1926, to May, 1927; dotted line represents the averaged monthly mean temperature from 1888 to 1926. (From U. S. Weather Bureau records)

dentally harbor the bulk of the black-drum population. Their average depth is rarely over 3 feet, and excessive turbidity prevails on account of the quantity of silt brought down by the fresh-water rivers and creeks that empty into these bays.

Stretching from the southeast corner of Corpus Christi Bay to the mouth of the Rio Grande, a distance of over 180 miles, is the tortuous, extremely shallow Laguna Madre. This lagoon, except in the vicinity of Baffin Bay, has a depth rarely over 2 to 4 feet, with a grassy or mud bottom, according to the proximity of sediment-laden rivers or creeks. The northern half of the lagoon reaching from Corpus Christi Bay to Penascal Point in Baffin Bay (an enlarged and deeper portion of Laguna Madre), provides a fine foraging ground as well as a natural trap for the fish that frequent this body of water; while the general inaccessibility of the region allows the fish considerable protection from fishing activities. This portion of the lagoon has long been a problem to conservationists, since a heavy mortality of fish life often occurs during the summer months from the excessive salinity of the water, resulting from evaporation and lack of rain.

From Corpus Christi Bay to Baffin Bay the lagoon generally is open to navigation of shallow-draft sailboats; but below Baffin Bay it becomes nothing more than a

semidry mud or sand flat, which extends south to a point about 30 miles above Point Isobel, Tex. Consequently, very little circulation of water occurs in the vicinity of Baffin Bay. The only sources of fresh water are the small creeks emptying into the bay, and of salt water, the drift of sea water from Corpus Christi Pass and Bay southward. With little rainfall on this particular section of the coast, the salt water predominates nearly all the year in and about Baffin Bay as well as in the more northern portions of the lagoon.

During the summer of 1925 a period of excessive salinity (indicated by high specific gravity of the water) occurred in Laguna Madre, which caused severe mortality of fish trapped within the lagoon on account of the nearly dry areas between the section of high salinity (Baffin Bay) and the deeper, less saline waters of Corpus Christi Bay and the Gulf of Mexico. Table 1 presents a series of specific-gravity determinations within the particular area of high salinity as well as within other bodies of coastal water not affected. In all, 185 determinations were made throughout the area covered in Figure 1, but only the major stations have been given in Table 1. Waters with a low saline content are denoted by low specific gravity (Nueces and Copano Bays), while waters with a high content of salts are indicated by high specific gravities (Baffin Bay and Laguna Madre). Ordinary Gulf water found about the passes has generally a specific gravity of about 1.026. During July and August, 1925, the specific gravity of the water in Baffin Bay and lower Laguna Madre reached 1.055—twice that of normal Gulf water near the passes.

TABLE 1.—*Excessive salinity of the water in the vicinity of Baffin Bay and Laguna Madre, Tex., during the summer of 1925*

[The specific gravities indicate the relative salinity in various coastal waters. Ordinary Gulf water has a specific gravity of about 1.026. Consult text for details. Determinations by H. F. Prytherch]

Date	Locality	Specific gravity, 17.5° C.	Water temperature° F.	Air temperature °F.	Date	Locality	Specific gravity, 17.5° C.	Water temperature °F.	Air temperature°F.
July 29	Baffin Bay	1.055	87.0	86.0	Sept. 4	Corpus Christi Bay by Oso	1.029	80.0	83.0
30	Laguna Madre	1.055	87.0	84.5	5	Nueces Bay	1.023	84.0	82.0
31	Corpus Christi	1.029	84.0	84.0	5	Aransas Pass	1.027	84.0	83.0
31	Corpus Christi Pass	1.027	85.2	82.6	6	Aransas Bay	1.027	80.0	78.0
31	Corpus Christi Bay by Oso	1.028	86.0	85.0	6	Copano Bay	1.023	84.0	90.0
Aug. 4	Corpus Christi Bay	1.028	83.0	82.5	19	Baffin Bay	1.055	84.0	83.0
5	Aransas Bay	1.025	81.7	81.0	19	Laguna Madre	1.055	85.0	84.0
5	Copano Bay	1.021	82.7	84.0	20	Corpus Christi Pass	1.030	85.0	85.0
12	Baffin Bay	1.055	86.0	88.0	20	Corpus Christi Bay by Oso	1.029	85.0	86.0
12	Laguna Madre	1.060	87.0	84.0	20	Nueces Bay	1.020	87.0	85.0
13	do	1.055	86.0	87.0	21	Aransas Pass	1.027	84.0	80.0
14	Corpus Christi Pass	1.028	87.0	81.0	21	Aransas Bay	1.024	84.0	84.0
14	Corpus Christi Bay by Oso	1.027	86.0	88.0	21	Copano Bay	1.024	84.0	82.5
14	Nueces Bay	1.023	88.0	84.0	Oct. 7	Baffin Bay	1.039	83.0	80.0
14	Aransas Pass	1.028	86.0	83.0	7	Laguna Madre	1.039	85.0	82.0
15	Aransas Bay	1.026	85.0	82.5	8	Corpus Christi Pass	1.025	81.0	84.0
15	Copano Bay	1.023	86.0	85.0	8	Corpus Christi Bay by Oso	1.024	83.0	81.5
Sept. 3	Baffin Bay	1.055	88.5	86.0	8	Nueces Bay	1.017	84.0	82.0
3	Laguna Madre	1.044	88.0	87.0	8	Aransas Pass	1.025	83.5	83.0
4	Corpus Christi Pass	1.029	86.0	83.5	9	Aransas Bay	1.021	81.5	79.0

The average precipitation at Corpus Christi for May, June, July, and August, 1925, was but 1.26 inches, compared with the normal average for these months of 2.38 inches. This reduction of nearly one half of the normal rainfall during the summer of 1925 accounts, at least partially, for the excessive salinities that prevailed in Laguna Madre. Table 1 indicates a falling specific gravity within Baffin Bay and Laguna

Madre during October, 1925, and this was due largely to the rainfall during September, which measured 8.12 inches, compared with the normal for the month of 4 inches.

In the summer of 1926, with the average precipitation during May, June, July, and August at Corpus Christi slightly above normal (2.78 inches), there appeared no evidence of excessive or destructive salinity within Laguna Madre. Obviously, the amount of rain fall during the summer months determines to a great degree the conditions, both physical and biological, that obtain within this unique salt lagoon.

There remains to be mentioned another type among the coastal waters of Texas. This is represented by the bayous or channels running into the mainland and islands from the various bays or connecting the bays with one another. These bayous are generally from 10 to 100 feet long, much less in width, and are generally deep, owing to the action of tidal or wind currents, which keep the water running from one bay to another. Such bayous provide a most important refuge and feeding ground for young fish of many species, which enter from the spawning grounds in deeper areas. Table 2 presents an interesting catch made within a small bayou or creek in one haul with a small minnow seine and illustrates the variety of marine fish that prevails within such an environment.

TABLE 2.—*Young fish taken in one haul of a 50-foot seine in a small creek, 2 to 4 feet deep, off Copano Bay on May 18, 1927*

Common local name of fish	Scientific name	Common local name of fish	Scientific name
Skipjack	Elops saurus.	Anchovy, or "minnow"	Anchovia mitchilli.
Menhaden	Brevoortia patronus (?).	Swellfish	Spheroides nephelus.
Spotted sea trout	Cynoscion nebulosus.	Flounder	Species unknown.
Redfish	Sciænops ocellatus.	Hog choker	Achirus fasciatus.
Black drum	Pogonias cromis.	Mullet	Mugil cephalus.
Sand trout	Cynoscion nothus (?).	Catfish	Galeichthys milberti.
Sand perch	Bairdiella chrysura.	Alligator gar	Lepisosteus tristoechus.
Croaker	Micropogon undulatus.	Goby	Species unknown.
Spot, or flat croaker	Leiostomus xanthurus.	Gizzard shad	Dorosoma sp.
Jackfish	Caranx hippos.	Unknown	Polynemus ostonemus.
Electric fish	Porichthys porosissimus.	Needlefish	Tylosurus marinus.

METHODS

AREA OF STUDY

While the territory encompassed in Figure 1 and briefly described on preceding pages was believed to cover typical environments in which the redfish, black drum, and spotted sea trout occur, it seemed desirable to divide this extensive area into compact units or "key" stations, which could be examined regularly and efficiently for existing fish populations. A careful study of the fish life occurring at these "key" stations should yield a series of facts that finally could be patched together into a life history of the species of fish under consideration.

The greater part of the experimental collecting centered in and about these "key" localities, including the two passes, Aransas and Corpus Christi; adjacent waters to these passes, such as Harbor Island Channel and Bayou, Packery Channel, and the Gulf of Mexico; the more open bays, such as Corpus Christi, Aransas, and Copano, together with various coves (Shamrock and Ingleside) that form restricted portions of these bays; the more remote intercoastal waters, such as Oso and Nueces Bays, with Laguna Madre; and the many brackish rivers and creeks flowing into

the intercoastal bays and lagoons. Incidental but important collecting also was conducted in the waters of Baffin, Alazan, Mesquite, Espiritu Santo, Lavaca, and Matagorda Bays, as well as about Cedar Bayou and Cavallo Passes and along the shores of the Gulf of Mexico from Cedar Bayou Pass to Corpus Christi Pass. Much of the territory fished was closed to all forms of net fishing and consequently provided ideal conditions for an examination of the natural fish populations.

SAMPLING OF FISH POPULATION

A perfect method of sampling an unknown fish population requires in the beginning a perfect knowledge of this population. No detailed observations on the natural abundance and distribution of the redfish, black drum, or spotted sea trout in any particular localities along the Texas coast had ever been recorded, and what information was available was extremely fragmentary and unreliable. The field operations, as a matter of sheer necessity, had to be devoted largely to an effort to secure at definite intervals adequate samples of young and adult fish for data on maturity, time and place of spawning, age, rate of growth, and seasonal distribution and movements. Where and how these fish were to be captured constituted one of the first problems for the investigator to solve.

All catches made by any type of gear were supervised individually by the writer, and the results were tabulated and filed for future compilation and study. Since the investigator was in touch with the collecting operations, he was able to sense, by the changing composition and character of the catch in various localities, any unusual movements of the fish. As a rule, all food fishes captured were measured by the writer for total length from the tip of the snout to the end of the mid-caudal (tail) fin ray, and the sex was determined if the sexual elements were in evidence. All fish above 5 centimeters were measured in centimeters, while those under this length generally were measured in millimeters. Due to the great abundance of larval and young fishes of most species, but a small percentage of the total number secured was measured for consideration in this paper.

Several explanations may be offered for the lack of egg collections, which apparently are the first things to be sought in an attempt to understand the life history of any marine fish. Physical difficulties in employing the typical egg-collecting gear (the fine silk tow nets) were very serious throughout the investigation, owing to the shallow water and to the hordes of Medusæ, or jellyfish, that filled and broke the nets during the warm months of the year. So abundant are these Medusæ that bathing beaches on Corpus Christi Bay must be screened to prevent the bathers from becoming severely poisoned by contact with the pests. Furthermore, the heavy seas, often prevalent at the mouths of the passes in the Gulf of Mexico, prevented the small boat needed for navigation within the shallow bays from operating in the Gulf, where the majority of the marine fishes are believed to spawn.

With the securing of larval and young fish of the species desired, and with the definite indication of the general spawning areas through the nature and distribution of the newly hatched fish as well as the spawning adults, it was not thought practical to seek the fish eggs with the time and resources at hand. In future research, however, an attempt can well be made to collect the eggs of the redfish, black drum, and spotted trout on the basis of the information presented in this paper.

COLLECTING GEAR

Since the fishing gear occasioned the most serious error in obtaining a representative sample from any given locality, strenuous effort was expended constantly to employ nets with a wide range in size of mesh, which would cut this inevitable error to a minimum. Due to the efforts of 4 or 5 experienced fishermen, notable success was had in the operation of the various types of fishing gear. Drag or haul seines of varying sizes were the most practical and effective gear that could be used in the shallow water, while trawls, gill nets, tow nets, trammel nets, and dredges were most applicable in the deeper waters of the bays or the Gulf.

The frequency of use of any particular type of collecting gear was not considered, since all fishing operations were conducted as environmental conditions and scientific needs warranted at the time. Factors such as tides, winds, currents, type of fishing bottom, depth of water, and the kind of material desired were but a few of the limitations influencing the selection of gear. Table 3 presents a list of the types of collecting apparatus most generally used.

TABLE 3.—*Types of collecting gear employed during investigation*

[Several types of dredges and bottom trawl are not included]

Gear	Length, in feet	Depth, in feet	Size of mesh	Size of twine
Experimental seine	450	10	150-foot center, 1 inch square 300-foot ends, 1½ inches square	All No. 9 cotton.
Do	480	12	160-foot center, ¾ inch square 320-foot ends, +¾ inch square	Center No. 9 cotton. Ends No. 6 cotton.
Do	30	4	10-foot center, ¼ inch square 20-foot ends, ¾ inch square	All No. 6 cotton.
Do	50	4	20-foot center, ¼ inch square 30-foot ends, ½ inch square	Center No. 9 cotton. Ends No. 6 cotton.
Do	10	3	38 meshes per linear inch; oxx	Net made of bobbinet lined with silk cloth.
Commercial drag seine	[1] 600	5	100-foot center, 1 inch square 500-foot ends, 1½ inches square	Center No. 24 cotton. Ends No. 18 cotton.
Petersen trawl	29	7X3-2X1	All ¼ inch square	All No. 6 cotton.
Ring tow nets	9	3	38 meshes per linear inch; oxx	Silk bolting cloth.
Gill net	450	6	All 1½ inches square	No. 18/3 linen.
Do	300	5	All 4 inches square	
Trammel net	400	10	Inner net 1½ inches square Outer nets 4 inches square	Inner net No. 20/3 linen. Outer nets No. 12 cotton.
Commercial shrimp trawl	40	[2] About 35.	Bag ¾ inch square Mouth to bag 1 inch square	No. 18 or 21. No. 9.

[1] Bag of commercial drag seine 16 feet long.

[2] Width.

NATURAL HISTORY OF THE REDFISH, SCIÆNOPS OCELLATUS (LINNÆUS)

REDFISH, RED DRUM, CHANNEL BASS

Perca ocellata Linnæus, Syst. Nat., ed. XII, 1766, p. 483; South Carolina.
Sciænops ocellatus Jordan and Evermann, 1896-1900, p. 1453, Pl. CCXXII, fig. 567; Welsh and Breder, 1923, p. 184; Hildebrand and Schroeder, 1928, p. 276.

DESCRIPTION OF ADULT

The adult redfish has an elongate, rather robust body, with a somewhat elevated back. The head is long, rather low, with snout bluntish. The mouth is horizontal and rather large. No barbels are present on the lower jaw. The color is usually silvery reddish, with each scale having a dark center, these marks forming obscure lateral stripes along the rows of scales. A most characteristic marking on all adult redfish is the presence of a jet black spot at the base of the upper caudal or tail fin. Sometimes several of these spots may be present along the sides of the fish, but one on each side of the upper caudal is generally the rule. (See fig. 8.)

DESCRIPTION OF YOUNG

In larval redfish 4 to 5 millimeters in length (0.2 inch) the yolk sac is present and the dorsal and ventral fin folds are continuous to the caudal fin. The latter is fairly well developed, as are the vertical fins, although the rays of both dorsal and anal are indistinct. Ventrals and pectorals are obscure. One or several prominent groups of brown chromatophores or pigmentation areas are present invariably, and these serve, by their approximate location, to help to identity the young fish at this small size. The most pronounced as well as the most constant group lies ventrally along the posterior base of the anal, while the others lie, when present, one under both the spinous and soft dorsals, and one ventral, slightly posterior to the vent. Often a group of chromatophores appears between the anal and soft dorsal along the obscure lateral line and also between the vent and the spinous dorsal. (See figs. 3 and 4.) Redfish lacking vertical fin rays (fish generally under 7 millimeters) usually can be distinguished from larval croakers (*Micropogon undulatus*) through the fact that the latter possess no dorsal chromatophores, and both of the ventral ones lie closer to each other than ever occurs in the redfish. (Compare figs. 3, 4, 33, and 34.) Larval black drum (*Pogonias cromis*) probably will not be found at the time of the year when larval redfish occur. The dorsal chromatophores of the young larval drum tend not to appear until post-larval stages are reached (at about 7 to 10 millimeters). (Compare figs. 3, 4, 13, and 14.) Anal-ray counts usually are possible on young redfish at a length of 6 to 8 millimeters and above. The count of eight soft anal rays distinguishes the fish from other related species, with the exception of the croaker, which has the same anal count although a different soft-dorsal count.

At about 7 millimeters the yolk sac on young redfish has disappeared, and only a small membrane between the vent and the anal fin remains of the larval fin fold. At this length some fish may have portions of the fin fold still remaining along the edges of the caudal peduncle, however. The chromatophores generally are more pronounced, with small markings appearing on the head and along the sides of the body in no definite arrangement than can be discerned. (See fig. 4.)

Young redfish above 10 millimeters (0.4 inch) rapidly take on much pigmentation, and at 25 millimeters (1 inch) the color pattern has become most distinctive. The ground color at about 25 millimeters is a pale brown, somewhat silvery in fresh specimens. A distinct row of five to seven brown blotches, usually smaller than the eye, lies, for the most part, along the lateral line, one on the opercle, one behind, two or three under the soft dorsal and under the spinous dorsal, and one on the caudal peduncle. A fainter row of these blotches extends along the back from the nape to the caudal peduncle, with the number varying both as to size and number, as well as being more indistinct. A series of dark brown pigment dots extends along the base of the caudal fin, and a series of chromatophores runs along the base of the anal fin. The membrane of the spinous dorsal is punctulated with dark brown, and the soft dorsal is marked likewise, to a somewhat less degree however. Scales and teeth are evident. (See figs. 5 and 6.)

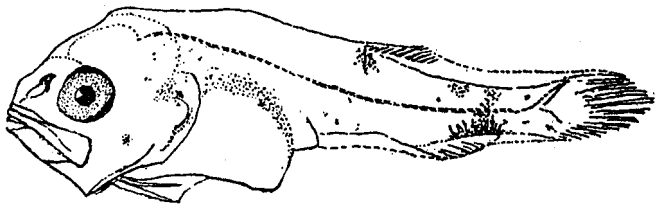

FIG. 3.—Larval redfish. Actual length, 4.5 millimeters

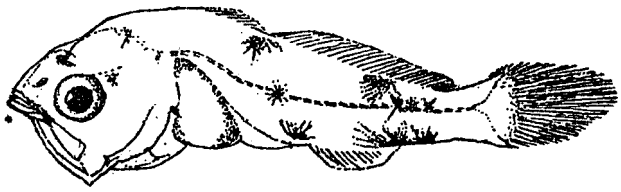

FIG 4.—Young redfish. Actual length, 7 millimeters

At about 36 millimeters (1.5 inches) the color pattern remains generally the same, with the important exception that a pronounced chromatophore enlargement occurs at the base of the upper caudal. This enlargement is the first appearance of the ocellated black spot that is characteristic of the species until death. (See fig. 7.)

The brown lateral blotches enlarge with the fish and generally remain until the latter has reached about 15 centimeters (5.9 inches), when they tend to fade and finally disappear. However, many redfish at 15 centimeters may have lost all traces of the blotches and assumed a dull grayish silver hue with a pronounced bluish iridescence above the lateral line. In a fresh specimen this silvery sheen obscures a mass of finely peppered dots that cover the upper and middle parts of the body and tend to form irregular, undulating, brown stripes along the rows of scales. The anal, pectorals, and pelvics are reddish in cast, with the black ocellated spot on the upper caudal peduncle most distinct.

FIG. 5.—Young redfish. Actual length, 11 millimeters

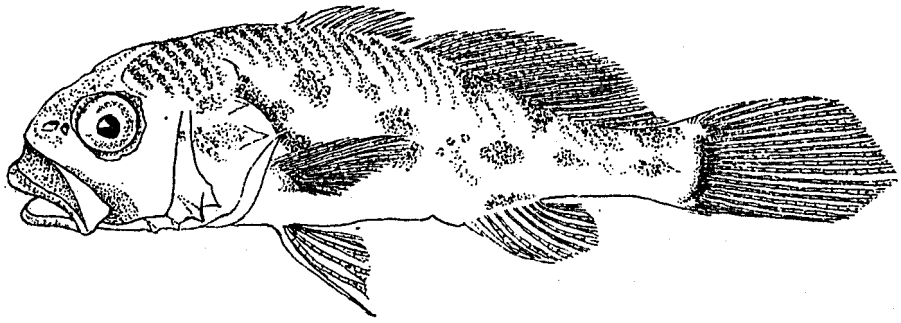

FIG. 6.—Young redfish. Actual length, 24 millimeters

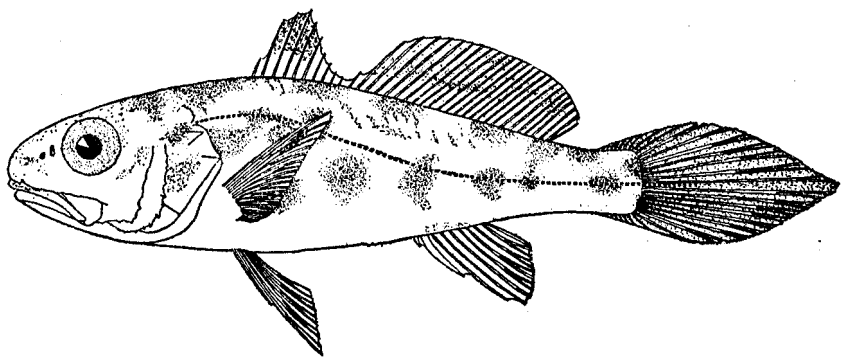

FIG. 7.—Young redfish. Actual length, 4.2 centimeters

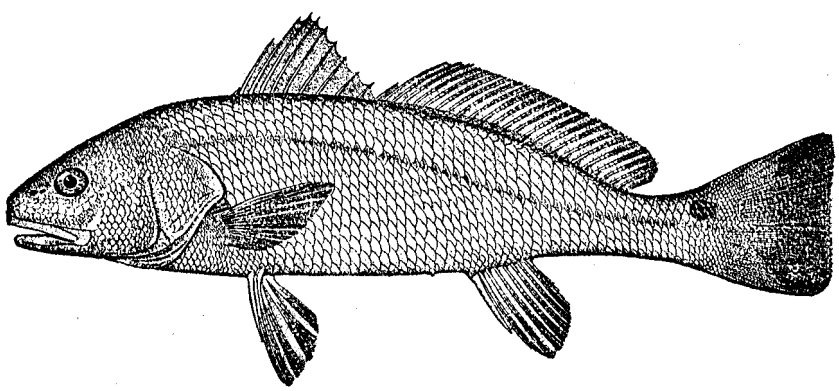

FIG. 8.—Adult redfish

SPAWNING AND EARLY DISTRIBUTION OF YOUNG

In a consideration of the various phases in the life history of the redfish or red drum the spawning habitat of the adult and the distribution of the young fish perhaps are of the most general interest. It has been a subject for much debate in recent years among those who profess an intimate knowledge of Texas coastal waters as to the exact location of the spawning grounds of the redfish, and while the idea is now generally established that the species spawns outside of the barrier islands in the open Gulf of Mexico, no definite observations ever were recorded to support this belief.

From April to September, 1926, a considerable number of redfish, ranging from 4 to 108 centimeters (1.5 to 42.4 inches) in length, were secured from the various bay and Gulf waters (Table 7). Examination of the sexual organs of all fish showed an immature or resting condition. On September 17, however, a large school of adult or "bull" redfish was observed in a regularly fished area in Shamrock Cove off Corpus Christi Bay, and the capture of part of this school revealed, by the presence of well-developed eggs in the ovaries of the females, that spawning time was approaching. Coincidental with the capture of these nearly ripe fish were the reports of fishermen that large numbers of "bull" redfish were traveling along the Gulf beaches and congregating about the mouths of the passes. Intensive fishing in all sections of the coastal area after the capture of these ripening fish failed to reveal any newly-hatched redfish until October 11, when along the shores of Harbor Island, inside of Aransas Pass and near the Gulf of Mexico, several young fish, ranging from 11 to 24 millimeters in length (0.4 to 1 inch), were taken in a few feet of water by a small beach seine. (See Table 4.)

TABLE 4.—*Collections of larval and young redfish (Sciænops ocellatus) during the spawning season of 1926*

Date of capture	Number of fish	Length range, in millimeters	Locality [1]	Miles from nearest pass
Oct. 11	49	11–24	Harbor Island Light	1
Oct. 18	128	6–34	do	½–1
Oct. 20	52	7–21	Lydia Ann Channel	1
	28	13–29	West side, Harbor Island	3–4
Oct. 22	4	23–26	Ingleside Cove	12
Oct. 25	30	10–26	Harbor Island	½–1
Oct. 27	2	25	Corpus Christi Bay by Oso	10
	5	15–29	Shamrock Cove	12
Oct. 28	10	7–18	Laguna Madre	½–1
Oct. 29	63	5–27	do	¼–1
	15	7–26	do	4
	49	5–14	do	1–3
Nov. 4	169	6–40	Harbor Island Light	1
Nov. 9	163	12–50	Harbor Island	1–3
Nov. 15	3	11–15	Laguna Madre	½–1
	15	13–28	Ingleside Cove	12
Nov. 23	132	10–60	Harbor Island	1
Dec. 1	9	17–53	do	1–3

[1] Approximate.

The exact locality where these young redfish were captured is known as Harbor Island Bayou and lies about 1½ miles inside of Aransas Pass. This bayou consists of a small, deepened channel, running from the east shore of the island (Lydia Ann Channel) into the interior of the land for several winding miles. On account of its

suitable depth and sluggish tidal current, the bayou, as well as contributory branches, furnishes an ideal refuge for thousands of larval and young fish. With the incoming tidal current from the Gulf, many marine organisms often are brought into the bayou, voluntarily or otherwise, where they may remain indefinitely or may depart on the next outgoing tide. Many tropical fishes, such as Pterophryne, the sargassum-weed dweller, often frequent Harbor Island Bayou during the height of the tide but generally return to the Gulf during low water.

After a week of seeking the young redfish within many bays with no success another visit to Harbor Island and the adjacent shore lines was made on October 18, when a greater number of larval and young fish were secured than a week previous. Systemic collecting along the grassy shore lines inside of Aransas Pass indicated that areas nearest to and in direct line with the pass yielded the greatest number as well as the smallest size of young. Table 5 illustrates the relative size and abundance of young at various distances from the passes.

TABLE 5.—*Relative size and abundance of young redfish about Corpus Christi and Aransas Passes during October to November, 1926 (from Table 4)*

	Distance, in miles, from nearest pass		
	¼ to 1	2 to 4	5 to 12
Total number of fish taken	636	264	26
Number of fish taken, in percentage	68	29	3
Average minimum and maximum lengths, in millimeters	8-29	11-34	19-28

Corpus Christi Pass, 20 miles south of Aransas Pass, was visited on October 29 to determine whether the newly hatched redfish were coming through the pass into Laguna Madre from the Gulf. The collections obtained were even more extensive than those made at Aransas Pass, for isolated patches of grass bottom in the shallow water immediately inside Corpus Christi Pass offered a temporary refuge for the young fish undoubtedly being brought into the pass from the Gulf of Mexico. Along the sides of the shallow channels radiating from the pass into the waters of Laguna Madre were large quantities of young redfish taken in particular when the tidal current was rushing in from the Gulf.

During the collection of the young fish about the passes (October to November) large numbers of adult redfish were observed milling about at the mouths of the passes. Several fish from these schools captured in the latter part of October showed ovaries with nearly spent roes. In mid-November a considerable number of spent adults was taken along the Gulf beaches in the vicinity of the passes by sport fishermen, all fish showing signs of emaciation due, no doubt, to the spawning activity in the previous weeks.

By the middle of November the numbers of larval and very young redfish commenced to decrease, and with the absence of any young under 10 millimeters (0.4 inch) after the 15th of the month it was believed that the spawning season was virtually at an end.

As shown by Tables 4 and 5, the newly hatched redfish in the younger stages were secured in the greatest abundance only in the immediate vicinity of the passes or along the sides of the channels directly supplied with the tidal waters from the Gulf. The distribution of the young apparently resulted from the action of the tidal currents, which, sweeping in from the Gulf, carried the young, nearly helpless fish to shallow areas covered with characteristic heavy aquatic vegetation.

A complicating factor in the ready identification of the redfish larvæ was the presence during late October and throughout November of great numbers of larval croakers (*Micropogon undulatus*), which were spawned in the Gulf and were coming into the bays in such abundance as to clog the nets and to render the separation of the fish from the closely related redfish most difficult. This confusion probably resulted in many larval and young redfish being missed in the tow-net collections conducted in the passes themselves as well as in the open Gulf. With gallons of the larval croakers being secured, little hope was entertained of finding the less abundant redfish. It was only when the young redfish had reached the more shallow waters that a ready separation of the species generally could be made.

There would appear to be no doubt that the redfish spawn in the Gulf of Mexico, near or at the mouths of the passes, and that the young come into the inland waters after hatching, to be distributed over many square miles of bays and lagoons. No other spawning place, save in the Gulf, would be possible to account for the concentrated numbers of young within and about the passes, together with the schools of spawning adults at the mouths of these passes.

Outside of the knowledge gained during the investigation along the Texas coast, very little definite information is available as to the time and place of spawning in other sections of the range of the species. Welsh and Breder stated (1923, p. 184) that "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."

A series of young-fish collections made by Hildebrand and Schroeder (1928, p. 278) indicates that in Chesapeake Bay spawning occurs slightly earlier in the fall than it does along the Texas coast. The following catches are recorded by Hildebrand and Schroeder from Chesapeake Bay and are presented for comparison with the Texas collections.

TABLE 6.—*Collections of young redfish in Chesapeake Bay in 1921, by Hildebrand and Schroeder*

[Compare with Table 4]

Date	Number of fish	Length range, in millimeters	Date	Number of fish	Length range, in millimeters
Sept. 19	6	24–34	Oct. 15	1	49
Sept. 20	7	20–42	Oct. 26	45	25–49
Oct. 7	6	44–53	Nov. 21	2	48–54
Oct. 11	23	26–46	Nov. 23	28	39–90

GROWTH AND AGE

During the first two years of life the growth of the redfish is very rapid. Spawned about October, 1925, the fish making up the 1925 year class reached a mean total length of 21.5 centimeters (8.4 inches) by the end of May, 1926 (May 30 to June 6). (Consult Table 8 and fig. 9.) Comparably, the succeeding year class, hatched in October or November, 1926, attained approximately the same mean length of 21.5 centimeters by the end of May, 1927 (May 8 to 22). By the 1st of October, 1926 (October 3 to 10), the 1925 year class had grown to a mean length of 33.7 centimeters (13.3 inches). The growth of this class continued rapidly, although becoming reduced during the winter months, and by the end of May, 1927, when about 1½ years of age, the group reached a mean length of 43.6 centimeters (17.1 inches), with a length distribution from 36 to 51 centimeters (14 to 20 inches). This growth during the first year of life may be clearly followed by inspection of Tables 7 and 8 and Figure 9.

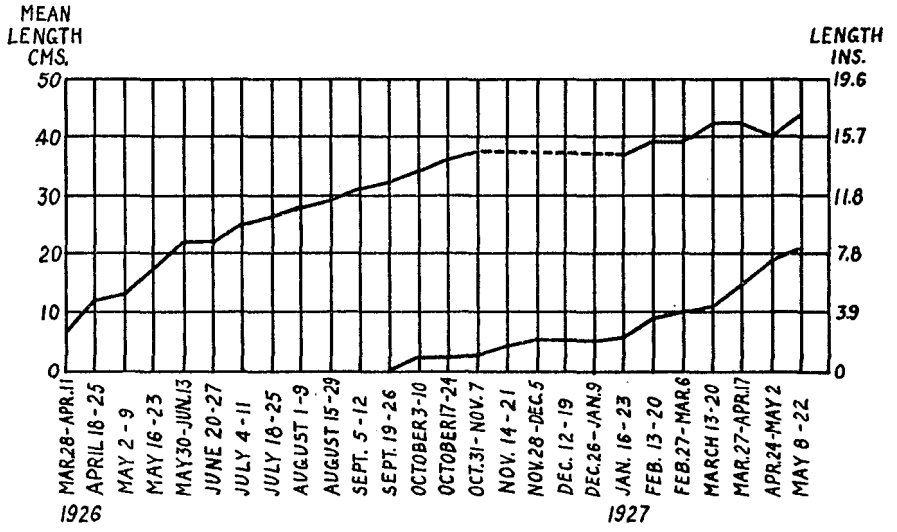

FIG. 9.—Growth of redfish during first 14 months of life. (Based on Table 8)

TABLE 7.—*Length-frequency distribution of redfish taken in Texas, March, 1926, to May, 1927*

[Collections summarized into approximate bimonthly periods]

Centimeters	Mar. 28–Apr. 11	Apr. 18–25	May 2–9	May 16–23	May 30–June 13	June 20–27	July 4–11	July 18–25	Aug. 1–9	Aug. 15–29	Sept. 5–12	Sept. 19–26	Oct. 3–10	Oct. 17–24	Oct. 31–Nov. 7	Nov. 14–Jan. 9	Jan. 16–23	Feb. 13–20	Feb. 27–Mar. 6	Mar. 13–20	Mar. 27–Apr. 17	Apr. 24–May 22
1													26	195	120	8						
2													23	140	112	29						
3														15	70	35	1					
4	13														44	52	9					
5	13														6	41	15	1				
6	6															23	22	7	1	5		
7	1															8	13	17		17		
8	3	1															20	24	3	13		
9	5	5	3															40	4	11		
10	10	5	5															30	3	15	1	

TABLE 7.—*Length-frequency distribution of redfish taken in Texas, March, 1926, to May, 1927*—Contd.

[Collections summarized into approximate bimonthly periods]

Centimeters	Mar. 28–Apr. 11	Apr. 18–25	May 2–9	May 16–23	May 30–June 13	June 20–27	July 4–11	July 18–25	Aug. 1–9	Aug. 15–29	Sept. 5–12	Sept. 19–26	Oct. 3–10	Oct. 17–24	Oct. 31–Nov. 7	Nov. 14–Jan. 9	Jan. 16–23	Feb. 13–20	Feb. 27–Mar. 6	Mar. 13–20	Mar. 27–Apr. 17	Apr. 24–May 22
11	10	4	7															23	1	14	3	1
12	1	2	8															8	1	21	1	
13	1		12	3														7		8		
14		6	10	4		1														2	2	
15		5	1	4		2												1		2	3	1
16		1	7	2	3																7	4
17		1	3	5	3	3															1	2
18		1	2	5	7																4	11
19			1	2	15	6															2	13
20				4	22	2	2	1														14
21				1	30	10	4	2														19
22					34	12	8	3			1		1									13
23					25	13	15		7	2												5
24					13	15	17	4	9	1												5
25					10	9	13	6	14	5												3
26					2	7	12	13	18	9		3										1
27					1	3	5	8	24	12	5	1										1
28						4	3	8	28	16	7	1	1									
29						2	2	4	21	25	9	4					1					
30						1	2	2	20	25	15	17	2									
31						1		1	7	26	16	16	6	1	1							
32									8	18	15	11	4	1			1					
33								1	9	15	5	10	9	2	3	1	3	1	1			
34									2	10	13	12	10	5	2		7	2	4			
35									1	11	6	8	7	2	1	1	12	5	1			
36									1	6	8	4	7	4	7	1	13	4	11		2	4
37									3	2	4	3	3	1	9	1	14	1	14		2	4
38										2	2	2	1	4	10	2	9	2	16	1	2	3
39			1							1	1	1	1		5	1	7	1	19		1	2
40				1		1				1		1	1	1	1		6	3	8	1		4
41														1	4	1	3	1	8		1	3
42		2													2	1	3	3	8		6	7
43		3	5	1		2											1	2	4	1	2	2
44		1	2	2		2					1	1				1		2	2			2
45			1	1	1				1									2	1			2
46			2	2	2	1			1			1					2		1	1	2	3
47			1		1		1														2	3
48			1		3	2			3	1											1	3
49			4	1	1	3	3		1	1												1
50			1	1	2	3	4		2									1				1
51			1	1	2	1			2	7												1
52			1	1	1	2	2		7	9				2								
53		1		1		1	2		2	4	1											
54						3	1		5	5	1	1										
55		1							3	5		4	1				2					
56						1	1		3	1	1	1	2							1		
57				3			1	1	1	1	1		2				1	1	2			
58		1		2					2	1		3	2				3		1			
59							1			1		1	1					3	2			
60					2				1	3		2					4		2			
61									3	4							3		1			
62		1					1		1	5			1				4		1		1	
63							2	1	2	2							5	2				
64		1		1			1		1	4		4			1		2	1	1			
65							4	1		4							1		2		1	1
66				1			1			1			1						1			
67							2			2							2		2	1		
68								2		1		1		1			1		1			
69				1			2	1				1							1			
70			1				1		1		1	2	1						1			
71							1				1	1							1			
72							2	1		3							1					
73							1	1				1					1					
74							1	9			3	1										
75								5			3											
76							2	2			2	2										
77								7														
78								4			6			1								
79								11			7	1							1			
80								2			5						1		1			

TABLE 7.—*Length-frequency distribution of redfish taken in Texas, March, 1926, to May, 1927*—Contd.

[Collections summarized into approximate bimonthly periods]

Centimeters	Mar. 28–Apr. 11	Apr. 18–25	May 2–9	May 16–23	May 30–June 13	June 20–27	July 4–11	July 18–25	Aug. 1–9	Aug. 15–29	Sept. 5–12	Sept. 19–26	Oct. 3–10	Oct. 17–24	Oct. 31–Nov. 7	Nov. 14–Jan. 9	Jan. 16–23	Feb. 13–20	Feb. 27–Mar. 6	Mar. 13–20	Mar. 27–Apr. 17	Apr. 24–May 22
81											4											
82								4			6								1			
83								2			11											
84							1				9								1			
85								2			10											
86							1	2			3											
87								1			4			1								
88								1			8											
89											2											
90								1			1											
91											1											
92											1											
93											2											
94																						
95								1														
96								1			1											
97																						
98																						
99								1														
100																						
107								1														
108								1														
Total	63	42	80	50	180	113	122	119	214	253	203	122	113	377	398	206	193	195	136	113	47	130

TABLE 8.—*Collections and length measurements of redfish taken in Texas, 1926 and 1927, illustrating growth during first year*

[Periods of collection usually in bimonthly summaries. Fish attain suitable market size at 36 centimeters (14 inches)]

Date	Year class 1925				Year class 1926			
	Number of fish	Length distribution, centimeters			Number of fish	Length distribution, centimeters		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Mar. 28–Apr. 11, 1926	63	4	7.4	15				
Apr. 18–25, 1926	31	8	12.3	18				
May 2–9, 1926	59	9	13.2	19				
May 16–23, 1926	30	13	16.7	21				
May 30–June 13, 1926	165	16	21.5	27				
June 20–27, 1926	91	14	22.0	31				
July 4–11, 1926	83	20	24.8	30				
July 18–25, 1926	53	20	26.3	33				
Aug. 1–9, 1926	172	23	28.2	37				
Aug. 15–29, 1926	187	23	29.0	40				
Sept. 5–12, 1926	107	22	31.2	39				
Sept. 19–26, 1926	94	26	32.3	40				
Oct. 3–10, 1926	53	28	33.7	40	49	1	1.9	2
Oct. 17–24, 1926	22	31	35.6	41	350	1	1.5	3
Oct. 31–Nov. 7, 1926	45	31	37.4	42	352	1	2.2	5
Nov. 14–Jan. 9, 1927	10	33	38.3	44	196	1	4.0	7
Jan. 16–23, 1927	82	29	37.1	46	80	3	6.2	8
Feb. 13–20, 1927	29	33	38.6	45	158	5	9.3	15
Feb. 27–Mar. 6, 1927	98	33	38.8	46	13	7	10.2	13
Mar. 13–20, 1927	4	38	41.8	46	108	7	10.9	16
Mar. 27–Apr. 17, 1927	21	36	41.6	48	24	10	15.3	19
Apr. 24–May 2, 1927	19	36	39.9	50	26	11	18.5	23
May 8–22, 1927	25	36	43.6	51	67	15	21.2	27

By a comparison of 1½-year old fish taken during the bimonthly periods of April 18 to 25, May 2 to 9, and May 16 to 23, 1926 (probable length range from 39 to 53 centimeters), and the monthly period of April 24 to May 22, 1927 (probable length range from 36 to 51 centimeters), it is found that the 1926 fish possess a mean total length of 45.8 centimeters (18 inches), while the 1927 group of the same age has a mean total length of 44.1 centimeters (17.3 inches). (See Table 7.)

The May, 1926, 1½-year old redfish, with a length range from 39 to 53 centimeters and a mean total length of 45.8 centimeters (18 inches), appeared to attain an approximate modal length of 52 centimeters (20.5 inches) by September, 1926, on the basis of a collection of fish taken during the period of August 15 to 29, 1926.

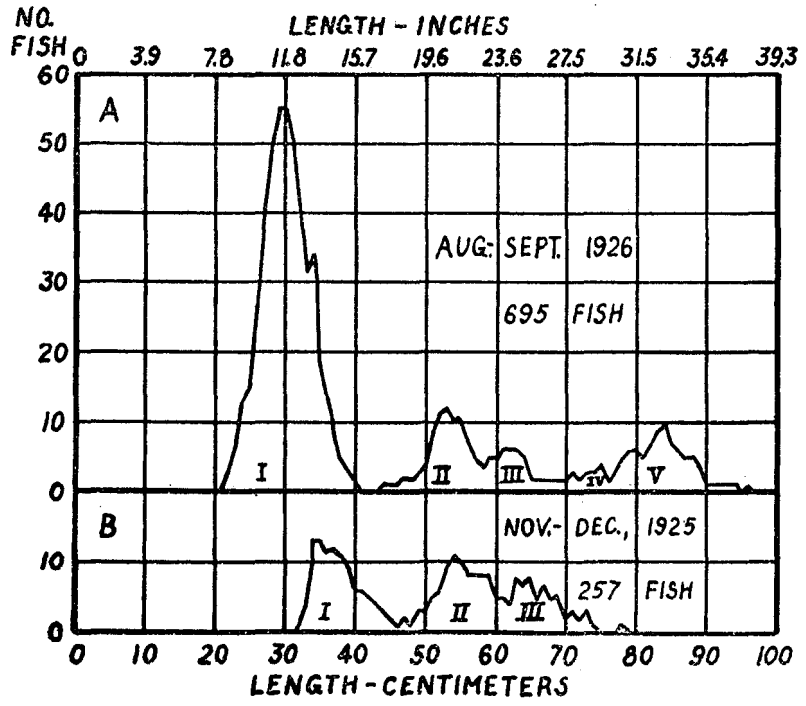

FIG. 10.—**A**—length-frequency distribution of redfish taken in Texas with experimental gear during August and September, 1926. **B**—length-frequency distribution of market redfish taken during November and December, 1925. Actual frequencies in both cases have been smoothed by a moving average of threes. Roman numerals indicate year classes

This collection (Table 7) had a length range from 48 to 68 centimeters, which probably included two year classes, the second with a mode at 52 centimeters and the third with a mode at 62 centimeters.

Collections of redfish above the second year are not numerous, owing mainly to the difficulty experienced in obtaining unselected catches of the larger, more powerful fish. However, by combining all samples of fish secured during August and September, 1926, a fairly well defined series of year groups or classes is discernible by inspection of the modes or humps in the length-frequency distribution. (See Table 9.) An error necessarily is occasioned by this grouping, since fish taken in early August will have grown some by the end of September. This is noticeably true in the case

of the youngest year class by a comparison of the bimonthly samples (Table 7), but for the present purpose of presenting all distinguishable year classes at one time this error may be disregarded.

A smoothed length-frequency distribution of these redfish shows the first three year classes to be marked by modal lengths at 30, 53, and 63 centimeters (11.8, 20.8, and 24.8 inches). (See fig. 10A.) Following these definite year groups, several modes are evident at about 75, 79, and 84 centimeters, and these modes are believed to be composed of fish in the fourth and fifth year classes. The mode at 79 centimeters is probably accidental and made up of fish either in the fourth year and belonging with the 75-centimeter group, or in the fifth year and belonging with the 84-centimeter group. The small number of fish lying within the probable range of the fourth year class magnifies this abnormal or chance mode at 79 centimeters. It must be realized, of course, that a considerable overlapping occurs among the various year classes, particularly as age and size increase.

TABLE 9.—*Length-frequency distribution of redfish collected with experimental gear in August and September, 1926*

Length, centimeters	Frequency	Length, centimeters	Frequency	Length, centimeters	Frequency	Length, centimeters	Frequency	Length, centimeters	Frequency
22	1	38	4	54	12	70	4	86	3
23	9	39	2	55	12	71	2	87	4
24	10	40	1	56	6	72	3	88	8
25	19	41	0	57	3	73	1	89	2
26	27	42	0	58	6	74	4	90	1
27	41	43	0	59	2	75	3	91	1
28	51	44	2	60	6	76	4	92	1
29	55	45	1	61	7	77	0	93	2
30	62	46	2	62	6	78	6	94	0
31	49	47	0	63	4	79	8	95	0
32	41	48	4	64	9	80	5	96	1
33	29	49	2	65	4	81	4		
34	25	50	2	66	1	82	6	Total	695
35	18	51	9	67	2	83	11		
36	15	52	16	68	2	84	9		
37	9	53	7	69	1	85	10		

In a consideration of the reliability of the above age estimates, it should be recognized that the redfish attains an extremely large size. While a length of only 105 centimeters (42.5 inches) was the largest size secured during the past investigation along the Texas coast, many fish reach a much larger size, with the maximum length of the species recorded by Welsh and Breder (1923, p. 184) at 152 centimeters, or about 5 feet. With the increment in length for Texas fish during the first year about 34 cemtimeters (13.4 inches), during the second year about 20 centimeters (7.8 inches), and during the third and fourth years about 10 centimeters each (4 inches), it is most likely that the growth increment during the fifth year would be but little less, causing the fish to have a general average length of about 83 to 85 centimeters (33 inches) at the end of its fifth year of life.

A series of measurements made upon 257 market redfish caught in a commercial seine during November and December, 1925, is presented by Table 10 and illustrated graphically by Figure 10B. A smoothed length-frequency distribution (fig. 10B) shows the presence of the first three year classes (I, II, and III) with length modes existing at 35, 54, and 64 centimeters (13.7, 21.2, and 25.2 inches) and with a slight mode at 74 centimeters (29.1 inches), and probably representing fish

in the IV-year class. The youngest or 0-year class (a few weeks old) is not represented, of course, in the commercial catch. The abrupt curve at about 32 to 33 centimeters (12.6 to 12.9 inches) results from the selection of the gear as well as a legal minimum-size market limit at 36 centimeters (14 inches).

TABLE 10.—*Length-frequency distribution of 257 market redfish taken in Laguna Madre, Tex., November to December, 1925, by commercial seines*

Length, centimeters	Frequency	Length, centimeters	Frequency	Length, centimeters	Frequency	Length, centimeters	Frequency	Length, centimeters	Frequency
33	4	42	4	51	3	60	8	69	3
34	14	43	4	52	6	61	3	70	2
35	17	44	3	53	10	62	3	71	1
36	8	45	1	54	12	63	6	72	5
37	12	46	2	55	11	64	14	73	0
38	15	47	1	56	6	65	2	74	3
39	6	48	2	57	7	66	9	78	1
40	6	49	0	58	12	67	3		
41	7	50	7	59	4	68	10	Total	257

A study of the annual winter growth check, as indicated on the scales of the redfish, afforded verification of the age estimates made from the length frequency. The redfish spawned in the late fall rarely show, on the scale structure, any evidence of a reduced growth rate during the first winter, but after the first winter definite changes occur in the scale pattern during the cold months of the year, which enable the age of the fish to be determined with some degree of accuracy. The scales of the species become heavily calcified and opaque after the second or third year, and it is necessary to treat them with a weak solution of hydrochloric acid in order to make them transparent.

The nature of the redfish scale is similar to that of the black drum, and the winter growth check in both species essentially consists of a break or interruption in the pattern of the circuli on the scale, particularly along the lateral terminals of the circuli. These breaks or irregularities probably are produced by the greatly accelerated growth of the fish and its scale in the early spring after a winter period of retarded growth. Closer approximations of the circuli along the radii during the winter season are evident on the scales from the younger fish, with these approximations forming so-called "bands," ending along the lateral terminals in pronounced breaks in the circuli arrangement.

The abundance of scale material allowed the fact to be proved that these scale checks were formed annually during the winter season, with, however, the first winter's check usually absent or faint, owing probably to the small size of the fish during the first winter. Measurements of these annual checks for the purpose of calculating the average growth were not deemed practical, since the decalcification of the scales caused the latter to change their size.

The ages of 300 unselected redfish were obtained by counting the number of winter scale checks, including any check that may or may not have formed during the first winter, when the fish were but a few months old. Thus, in the case of a collection of fish taken during April and May, 1926 (fig. 11), 35 redfish, ranging from 8 to 21 centimeters in length (3.1 to 8.2 inches), were found to be in their first year (having been spawned the October or November previous and in most cases not showing a winter check on the scales); 22 redfish, ranging from 40 to 51 centimeters (15.7 to 20 inches), were found to be in their second year (possessing, in all cases, one

definite scale check usually near the periphery of the scale and indicating a check in growth during the second winter of life); 6 redfish, ranging from 53 to 57 centimeters (20.8 to 22.4 inches), showed two definite winter checks; and 7 redfish, ranging from

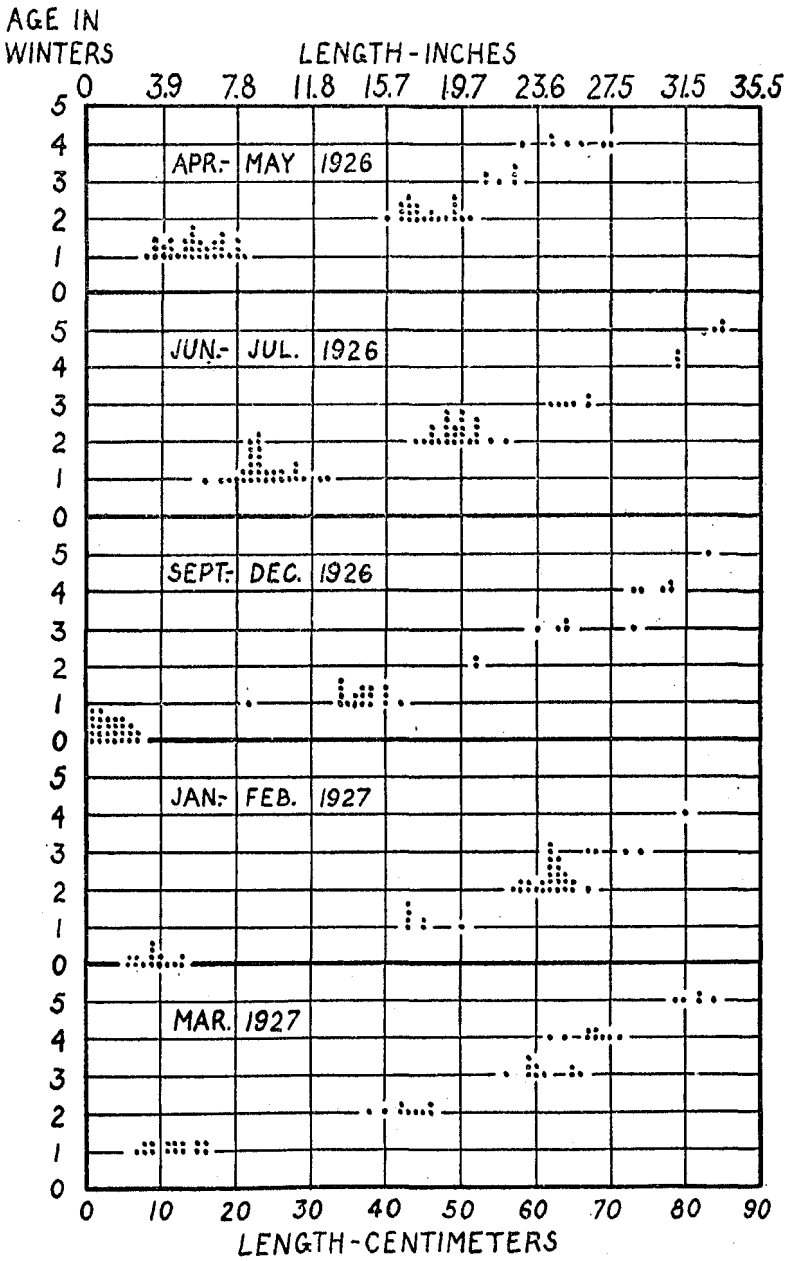

FIG. 11.—Age of redfish according to length, as indicated by winter growth checks on scales

58 to 70 centimeters (22.8 to 27.5 inches), possessed three definite annual scale checks. Hence, the approximate actual age, in years, of the redfish as represented in winters by Figure 11, is one less than the number of winters recorded.

For the first three years little doubt exists as to the verity of these age determinations by the scale method, but it may be said that after the third winter some errors may occur in the age determinations, due both to the extreme difficulty in examining the large scales and to the personal judgment of the writer in counting the annual breaks or "checks" in the annuli of the scales. It would appear, however, on the basis of both scale and length-frequency studies, that the redfish reach a total length of about 80 to 85 centimeters (31.5 to 33.2 inches) by the end of the fourth year or the fifth winter of life.

SEASONAL DISTRIBUTION AND MOVEMENTS

The larval and young redfish, after entering the bays and lagoons from the Gulf spawning grounds, tend to distribute themselves rapidly. While assisted in the early stages of distribution mainly by the tidal currents, the young fish soon is able to use its own power of locomotion to take it to places of safety. By October 27, 1926, several small redfish 25 millimeters long (0.6 inch) were taken along the shores of Corpus Christi Bay near the entrance into Oso Bay, while a collection of young 15 to 29 millimeters long (under 1 inch) was secured in Shamrock Cove, a sheltered indentation of Corpus Christi Bay some 12 miles or more from Corpus Christi Pass.

The young seek the more grassy and quiet coves and lagoons during the early part of life, rarely being found on bare, sandy bottom or in rough water. This preference for shallow tidal flats was most noticeable in the vicinity of the passes. A serious destruction of many small redfish consequently may have resulted in October, 1926, when an extremely low tide occurred in the vicinity of Aransas Pass, which caused large areas of the shallow flats in and about Harbor Island to become dry. Many small mullet and top minnows were observed in a dying or dead condition as a result of being unable to reach the deeper channels when the water drained off from the flats. Many young redfish known to be on such areas were either killed likewise or forced to enter the channels that did not appear suited to the normal requirements of the fish.

With the coming of cold weather during the first winter, the young redfish, ranging in length from 5 to 15 centimeters (2 to 5.9 inches), work into the deeper bayous from the more shallow coves and flats. During the spring following hatching many wander out into the Gulf of Mexico, but apparently they occur only in moderate numbers along the shore lines in the surf, since none ever are caught in the shrimp trawls, which operate from 1 to 10 miles offshore. In less than a year after hatching young redfish may be found within the bays and lagoons, 75 miles or more from the nearest pass, as collections of fish in July, 1926, from Baffin Bay (Laguna Madre) indicate. The absence of young redfish less than 10 to 15 centimeters in length (3.9 to 5.9 inches) from the waters of the Gulf of Mexico is most striking and would indicate that conditions in the Gulf are not suited to the early stages following hatching and that all newly hatched fish come into the bays.

After the first year most of the redfish leave for the deeper bays or Gulf during cold weather. The movement of fish out into the Gulf is gradual and not noticeable to any extent, but in the early spring the movement back into the bays and lagoons is pronounced. This spring movement into the bays, particularly of the younger year

classes (fish from 40 to 60 centimeters), provides hook-and-line fishing about the various passes, especially Corpus Christi.

After a certain maximum length is attained (about 70 centimeters or 27.5 inches) the redfish tend to travel in schools and remain for the most time along the sandy shores of the Gulf of Mexico. According to old fishermen, many of these schools of "bull" redfish frequented the bays and lagoons during the summer months, departing to the Gulf in early fall. At the present time, however, few such schools are noticeable within the bays (two schools taken by the writer in July and September, 1926, in Corpus Christi Bay). This fact has given rise to the opinion that the species is becoming depleted. It is the decided belief of the writer that this absence of larger redfish from the bays is not due to the actual scarcity of the fish (all redfish above 32 inches have been protected by law for some years) but to the marked changes that have resulted from the use of power boats and water traffic, as well as from the activities of sportsmen who congregate about the passes in large numbers. The schools of redfish are known to become easily frightened or "stampeded" at any slight disturbance, and any activities in the vicinity of the passes may be regarded as unfavorable to the entrance of the fish into the bays.

When spawning time approaches (September), the schools of redfish, composed largely of adults above 75 centimeters, travel along the shore lines of the Gulf beaches until they strike the mouths of the passes. This movement or spawning migration is most evident along Mustang and Padre Islands, Tex., during the early fall. Those few schools of ripening adults that have been living within the bays during the summer apparently seek the pass exits to the Gulf. A concentration of spawning schools of redfish at the mouths of the passes undoubtedly results in a condition favorable to natural propagation and distribution of young.

SIZE AND AGE AT MATURITY

One large, unselected collection of sexually matured redfish was captured in late September, 1926, several weeks before the first young of the 1926 year class were taken. The sample consisted of 80 fish, ranging in length from 74 to 96 centimeters (29 to 38 inches), and was part of a large school of fish that apparently was endeavoring to find an exit from the narrow cove into which it had wandered. Several of these fish when examined showed that spawning time was near at hand. A nearly ripe roe taken from a female 90 centimeters long (3 feet) weighed approximately 13 ounces and contained about 3,500,000 eggs. Two methods were used to calculate the total number of eggs, with the results presented below:

Von Bayer method:

D=diameter of known whitefish eggs, in inches	0.127
N=number of whitefish eggs to the quart, by actual count	33,036
d=average diameter of redfish eggs, in inches (0.5 millimeter)	.02
Total volume of redfish eggs, in quarts (400 cubic centimeters)	.4
By use of Von Bayer's formula $D^3:d^3::n:N$, where n is the unknown.	
n, or the number of redfish eggs to the quart, equals	8,457,216
Number of redfish eggs in 0.4 quart	3,382,886
Total number of eggs in 90-centimeter redfish (3 feet)	3,382,886

Actual weight method:

A total weight of 23 milligrams gave an egg count of	176
One milligram, by calculation, equals	7, 652
One gram of redfish eggs, by calculation, equals	7, 652
Total weight of redfish eggs, in grams	447
Total number of redfish eggs in 90-centimeter fish (3 feet)	3, 410, 000

Maturity appears to be reached at the end of the fourth or fifth year of life. No redfish under 75 centimeters (29.4 inches) were taken in a mature condition during the field operations, and ripe fish are virtually unknown to the fishermen, who must free all captured fish over the legal size limit of 81 centimeters (32 inches). On the basis of the one collection of nearly ripe fish taken in September, 1926, it would seem most likely that maturity is not reached before the end of the fifth year, certainly not before the end of the fourth.

Figure 12, showing the relation of weight to length in 222 redfish, indicates that a weight of 10 pounds or over is attained before the time of first spawning (70 centimeters, or 27.5 inches in length, at least, being reached by the fish).

FOOD HABITS

The food of the redfish along the Texas coast is made up principally of the crustaceans such as the shrimps and crabs. The commercial shrimps (Peneus) appeared to be the favorite food with some 236 redfish 6 to 72 centimeters long examined for stomach contents. The common blue crab (Callinectes), when small or in a molting condition, ranks second in abundance. (See Table 11.)

TABLE 11.—*Food preference of 236 redfish, presented in percentage of total number of fish in each length group that fed exclusively on the various organisms*

[Mixed food usually a combination of shrimp, fish, and crabs. Fish taken from February to May, 1927]

Length, centimeters	Number of fish	Percentage of fish that had eaten—				
		Shrimp	Fish	Crabs	Mollusks	Mixed
6–16	147	52	20	6	4	18
17–30	42	83	2	10	0	5
31–46	43	79	0	2	0	19
47–68	4	0	25	50	0	25

Fish are eaten to some extent, with the mullet, gobies, and Menidia being identified in the greatest abundance among the food fragments. The larger redfish are able to capture fish of considerable size, as shown by the presence of a 20-centimeter (7.9 inches) mullet (Mugil) in the stomach of a 68-centimeter (26.8 inches) redfish. Surf casting for the larger fish along the Gulf beaches yields the best results when small mullet are used as bait, while shrimp bring the largest catches of the smaller-sized fish.

Curious incidental food may be found in the stomachs of the fish at times. A large marsh rat, squids, annelid worms, and small bivalves have been recorded from redfish stomachs. The species undoubtedly has the ability to pursue its prey, although it can and does adopt a semibottom-feeding habit at times. It may be said to have a feeding habit intermediate between that of the drum, a strictly bottom feeder, and the spotted trout, a pelagic feeder.

COMMERCIAL CONSIDERATIONS

The redfish or red drum occurs in commercial quantities from New Jersey to Texas. Florida leads in the total production, with Texas ranking second. The Gulf States

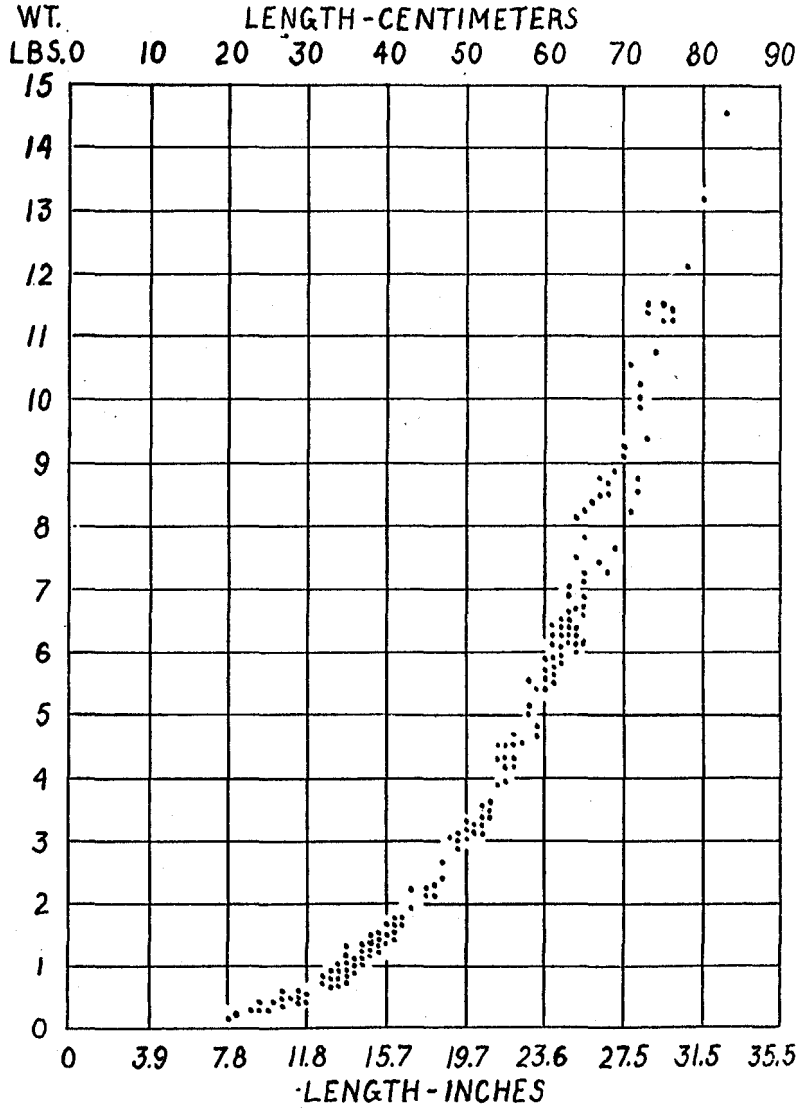

FIG. 12.—Relation of weight to length in 222 redfish

exceed the South Atlantic States in both the quantity and value of the commercial catch. The following table is taken from the reports of the United States Bureau of Fisheries.

TABLE 12.—*Catch of the redfish (Sciænops ocellatus)*

State	Weight, in pounds	Value	Value per pound	Year
Florida:				
West coast	1,398,291	$43,249	$0.030	1923
East coast	121,850	4,434	.036	1923
Texas	877,760	72,299	.082	1923
Louisiana	665,067	55,941	.084	1923
North Carolina	245,443	10,763	.043	1923
Mississippi	176,760	12,979	.073	1923
Virginia	125,390	2,243	.018	1925
South Carolina	31,000	1,730	.056	1923
Alabama	14,765	949	.064	1923
New Jersey	14,300	412	.029	1926
Delaware	3,310	60	.018	1926
Total	3,673,936	205,059		

The redfish provides both sport and commercial fishing along the coast of Texas. Surf casting along the beaches of the Gulf of Mexico is very popular, and, while such a method of fishing does not account for large quantities of market fish, the income secured by coastal cities and towns from visiting tourists and sportsmen is considerable. Many of the redfish taken along the Gulf beaches by anglers are the larger or "bull" fish (over 32 inches), the sale of which is forbidden by law.

Within the intercoastal bays, extensive commercial fishing operations are conducted to secure the redfish as well as other food fishes. By far the most efficient and practical method of fishing is by means of drag seines. In late years serious opposition has arisen to all forms of net fishing along the Texas coast, with the result that many bays, as well as Gulf waters, have been closed to net fishermen, although commercial hook-and-line fishermen may operate anywhere. Consequently, unrestricted line fishing is conducted within many of the bays, particularly around the passes, for redfish as well as several other species of food fish, although, naturally, more effort and expense is required to catch them in this manner. Simple pole-and-line fishing yields good catches of small redfish (1 to 3 pounds) at certain times of the year, especially in spring, while trot lines or long series of stationary hooks, baited usually with pieces of red rubber, are employed in some of the more shallow lagoons.

As stated by Higgins and Lord (1926, p. 180), the commercial catch of redfish in Texas has shown a virtually horizontal trend since 1890. No signs of depletion could be detected by these investigators on the basis of the rather meager statistical data available. Many fishermen, however, assert that the fishing effort expended to-day is much greater than occurred in former years. While this statement probably is true, for some years past the redfish has been given legal protection in several ways, which tends to reduce the catch to a marked degree.

Omitting from consideration at present the effect of closing many productive redfish fishing grounds, the State of Texas has in operation a minimum and maximum legal size limit for all redfish caught within State waters. No fish under 14 inches (36 centimeters) or over 32 inches (81.2 centimeters) may be offered for sale. From a market standpoint, these size limits appear well worth while, since dealers find it difficult to sell redfish under 14 and over 32 inches. Redfish of over 3 pounds are not especially esteemed for family use, but restaurants and hotels buy the larger

fish, which are served in the form of steaks. By preventing the sale of fish of over 32 inches, virtually all of the mature or spawning redfish are protected. This would seem most desirable from the standpoint of fishery conservation when it is realized that the bulk of the catch is composed of fish in their second and third year, and that the marketability of the species is reduced greatly after the third or fourth years.

The total catch of redfish in Texas undoubtedly could be increased if many of the closed waters were to be opened to net fishing. This applies particularly to a long stretch of Gulf beach along Padre Island, which is an exceedingly fine feeding ground for many of the larger redfish. No way to determine the capacity of any fishery is recognized, except by actual trial by the most efficient commercial methods, and the gradual reduction of the commercial coastal fisheries to a hook-and-line method of fishing will hardly allow such a capacity to be ascertained.

SUMMARY

1. The redfish spawning season occurs mainly in October, and in the Gulf of Mexico actual spawning takes place close to or at the mouths of the various passes.

2. The newly hatched redfish are carried by the tidal currents into the bays and lagoons, where they remain for an indefinite period.

3. The redfish attains a modal total length of about 13.4 inches (34 centimeters) by the end of the first year, 21.3 inches (54 centimeters) by the end of the second, 25.3 inches (64 centimeters) by the end of the third, probably about 29.5 inches (75 centimeters) by the end of the fourth, and 33 inches (84 centimeters) by the end of the fifth year. The species reaches suitable market size soon after the first year.

4. Maturity is reached not before the end of the fourth or fifth year, probably the fifth, with few fish under 30 inches (75 centimeters) in a sexually mature condition.

5. The food of redfish from 2.4 to 23.6 inches (6 to 60 centimeters) in length consists principally of shrimps (Peneus), crabs, and small fish.

NATURAL HISTORY OF THE BLACK DRUM, POGONIAS CROMIS (LINNÆUS)

Black Drum

Labrus cromis Linnæus, Syst. Nat., ed. XII, 1766, p. 479; Carolina.
Pogonias cromis Jordan and Evermann, 1896–1900, p. 1482, Pl. CCXXV, fig. 573; Welsh and Breder, 1923, p. 186; Hildebrand and Schroeder, 1928, p. 287.

DESCRIPTION OF ADULT

The adult black drum has an oblong, compressed body, with the back much elevated. The head is moderately short, with the snout blunt. The lower jaw possesses numerous large barbels along the inner edge of each side, with the series usually reaching back to below middle of eye. The color in life is generally silvery black, with often a brassy luster, and all fins are black or dusky. Variations in color are frequent among drum taken along the Texas coast, depending largely on the particular environment from which the fish is taken. Drum from the Gulf of Mexico are usually uniformly silvery, with the black lateral bars, characteristic of the young fish, becoming indistinct; while adult drum taken in the shallow bays are black or even bronze. (See fig. 19.)

DESCRIPTION OF YOUNG

The smallest larval drum taken in Texas measured 4.5 millimeters (0.2 inch). A small yolk sac is present, and the dorsal and ventral fins are not evident. Two prominent groups of chromatophores are present; both lying ventrally, one slightly

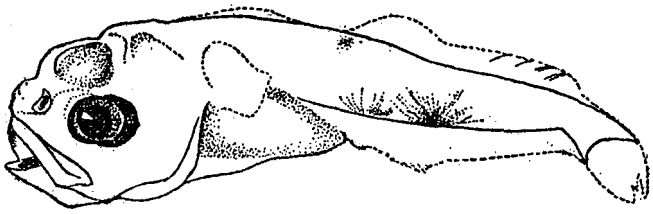

FIG. 13.—Larval black drum. Actual length, 4.5 millimeters

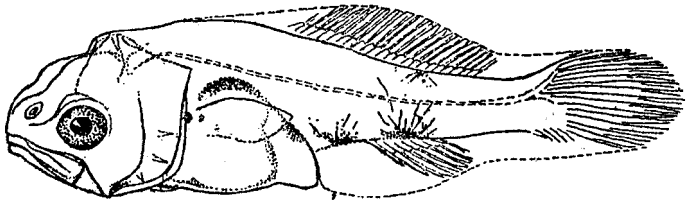

FIG. 14.—Young black drum. Actual length, 6 millimeters

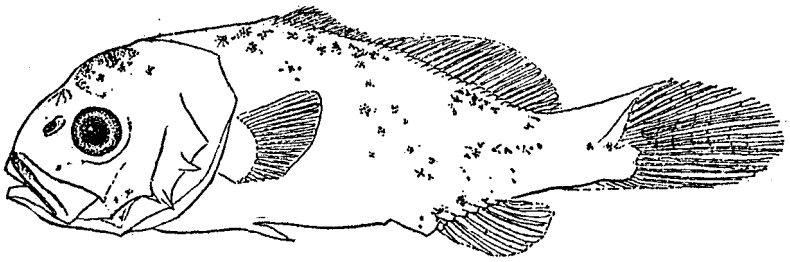

FIG. 15.—Young black drum. Actual length, 8 millimeters

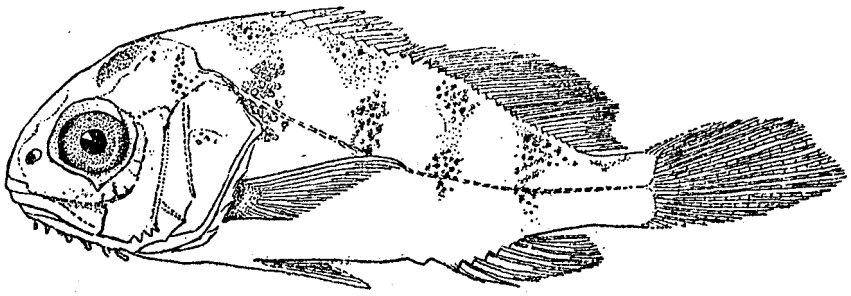

FIG. 16.—Young black drum. Actual length, 18 millimeters

posterior and above the vent, while the other lies approximately at the base of the undifferentiated anal fin. These groups of chromatophores are placed somewhat similarly to the ventral ones observed in the young larval redfish (*Sciænops ocellatus*), but the general absence of any pronounced dorsal markings in the larval drum separate the species distinctly. (See fig. 13.)

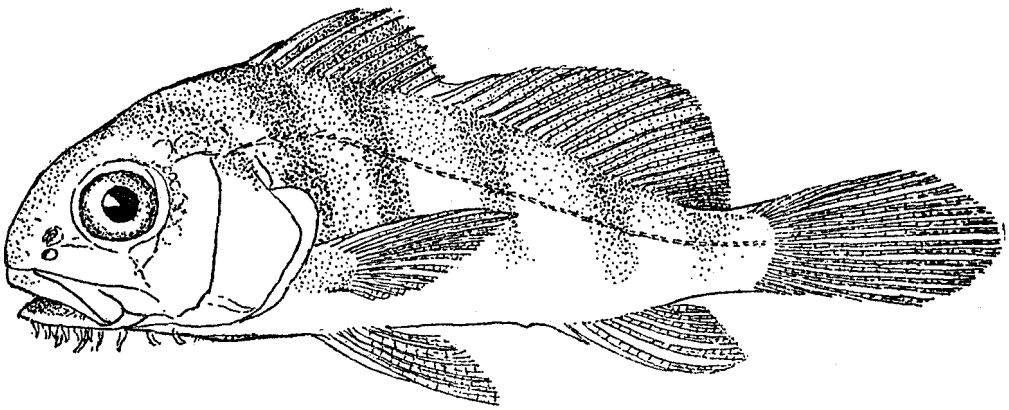

FIG. 17.—Young black drum. Actual length, 35 millimeters

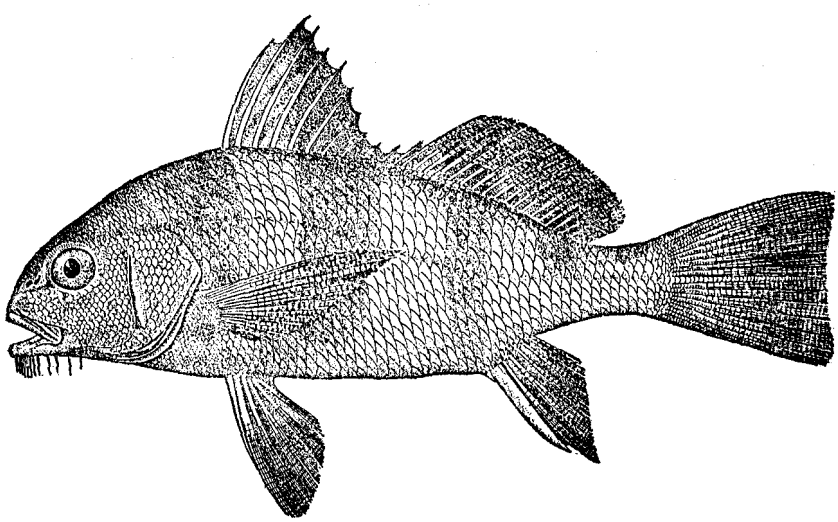

FIG. 18.—Young black drum. Actual length, 23.1 centimeters

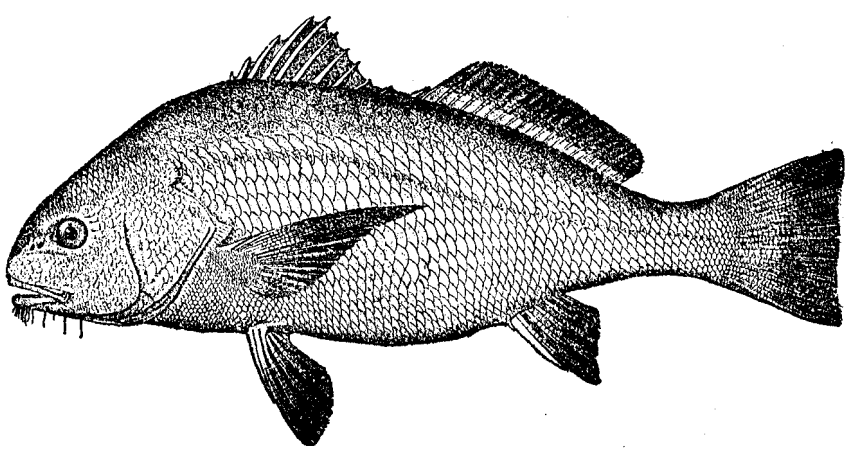

FIG. 19.—Adult black drum

At 6 millimeters the black drum has the vertical fins better developed, with 6 anal rays being discernible usually. This anal-ray count seems most constant and accordingly separates the species from other related ones. The dorsal and ventral fin folds still persist, although now separate from the tail, while the yolk sac is reduced further. The two ventral chromatophores are well marked and weak spines are present on the opercle or gill cover. (See fig. 14.)

A marked change occurs in the general pigment arrangement when the fish has reached a length of about 8 millimeters. Black chromatophores appear in profusion dorsally as well as along the sides and tend to arrange themselves into definite groups extending from the nape to the caudal peduncle. These groups are the forerunners of the six vertical black bars that soon appear, to remain until adult size is reached. On fish of about 8 millimeters, however, all six bars are rarely discernible in one specimen. All vertical fin rays are well formed and easily counted—dorsal, X–I, 21–23; anal, II 6. The ventral chromatophores present in the smaller stages tend to disappear entirely. (See fig. 15.)

When a size of 15 millimeters is attained, the young drum has assumed the general adult shape. The six black bars are pronounced and extend vertically from the back to slightly below the lateral line. All fins, with the exception of the dorsal, are colorless. The dorsal is dotted heavily with black punctulations, particularly along the anterior spines, while the soft rays are marked less heavily. The color of the body above the lateral line is light brown, marked with black vertical bars, while below the lateral line a bright silvery sheen prevails. The series of mandibulary barbels are now evident. (See fig. 16.)

In drum above 25 millimeters the color pattern remains essentially the same, with the exception that the pectorals and anal assume a black cast and the fish tends to become darker with age. (See figs. 17 and 18.)

SPAWNING AND EARLY DISTRIBUTION OF YOUNG

Along the coast of Texas the black drum spawns principally from February to May in the Gulf of Mexico near the mouths of the passes leading into the bays and lagoons. A late or secondary spawning period may also occur from late July to November. Both spawning seasons are preceded by well-defined migrations of the adult fish to the spawning grounds of the Gulf. The newly hatched drum are brought into the bays by the tidal current and soon distribute themselves into more or less definite localities.

The presence of large numbers of ripening adult drum within many of the more shallow bays and lagoons has led to the opinion among many that the species spawns within these bays and lagoons. The drum, well recognized as preferring the shallow and muddy areas of Nueces and Oso Bays and parts of Laguna Madre, is found in the greatest abundance within these particular bodies of water, and the casual observer might easily be led to believe that the entire life of the fish was spent within such localities. It was found, however, during the course of the recent study, that the spawning habits of the black drum were complicated, and that the general supposition of a bay spawning habitat was not tenable in the light of the results obtained by the writer during 1926 and 1927.

The first collection of young drum was taken on May 13, 1926, along the shores of Corpus Christi Bay near the channel entrance leading into Oso Bay. (See Table 13.) The fish, ranging in length from 9 to 37 millimeters (0.4 to 1.5 inches), were secured after a storm from several small, temporary pools along the beach, which had been filled by the abnormal high water resulting from the heavy seas the day previous. A strong current was flowing into Oso Bay from Corpus Christi Bay, and it seemed unlikely that such small drum could have breasted the current and come from Oso Bay to be washed up on the beach later along the shore line of Corpus Christi Bay. It was far more reasonable to expect that the young had come from Corpus Christi Bay and had been thrown into the beach pools accidently while endeavoring to gain the channel leading into Oso Bay.

TABLE 13.—*Collections of larval and young black drum (Pogonias cromis) taken in Texas, 1926 and 1927*

Date	Number of fish	Length range, in millimeters	Locality
May 13, 1926	94	9–37	Corpus Christi Bay by Oso Bay.
May 14, 1926	4	20–29	Nueces Bay.
May 25, 1926	16	25–47	Corpus Christi Bay by Oso Bay.
Feb. 28, 1927	27	4– 6	Harbor Island Lighthouse.
Mar. 11, 1927	140	6– 7	Corpus Christi Pass-Laguna Madre.
Mar. 16, 1927	68	5– 8	Harbor Island, east side.
Mar. 23, 1927	75	6– 8	Corpus Christi Pass-Gulf.
Mar. 24, 1927	3	4– 5	Aransas Pass, in channel.
Mar. 30, 1927	56	5– 8	Corpus Christi Pass-Gulf.
Apr. 6, 1927	8	4– 6	Harbor Island Light.
Apr. 9, 1927	82	8–11	Corpus Christi Bay by Oso Bay.
Apr. 11, 1927	15	5– 9	Harbor Island Light.
Apr. 26, 1927	14	9–15	Nueces Bay.
May 5, 1927	95	13–38	Do.
May 26, 1927	28	28–47	Do.

To substantiate this idea was the fact that on the same day large collections of small drum were secured within Oso Bay proper, and instead of taking smaller fish than were taken in the pools by Corpus Christi Bay, as might be expected had the young been hatched in Oso Bay, much larger and, hence, older fish were caught. Table 14 gives the length distributions of these two collections. All other localities, with the exception of Nueces Bay, failed to yield any young drum until some weeks later, when a considerable size had been attained by all fish. (See Table 14.) It was believed that spawning had terminated by the first of May with the sample of young obtained on the 13th of the month, consisting of a group of fish spawned toward the close of the spawning period.

TABLE 14.—*Collections of black drum illustrating distribution of fish under 25 centimeters (9.8 inches). Fish spawned in 1927 omitted. (See Table 13.) Collections of less than 10 black drum have been omitted also*

Length, centimeters	1926													1927		
	May 13, Corpus Christi Bay	May 13, Oso Bay	June 4, Oso Bay	June 11, Oso Bay	June 21, Oso Bay	June 24, Gulf	July 3, Corpus Christi Bay	July 26, Oso Bay	Aug. 3, Oso Bay	Aug. 16, Oso Bay	Aug. 26, Corpus Christi Bay	Aug. 30, Corpus Christi Bay	Dec. 9, Oso Bay	Jan. 19, Copano Bay	Feb. 1, Oso Bay	Mar. 9, Oso Bay
1	14															
2	74															
3	9															
4		6														
5		20			1											
6		32														
7		33	1	1	1		3									
8		6	2	2	2		11		5							
9			6	22	7		17	3	16	1						
10			17	28	10		20	10	24	6						
11			16	12	3	2	32	21	13	7			2			
12			18	2		13	23	9	1	9	3		10		3	2
13			19	1	1	12	17	6	1	10	32		5		9	2
14			3	2		5	15		2	5	44		3			3
15			1	1	3	1	6		1	5	18	1	13			5
16							2		1	1	1	2	12			2
17							1		2	2		4	7			1
18									3			5	7			
19									1			3	3			
20												4	3			
21									1			1	4	1		
22												1	2	4		
23												1		10		
24														7		
25														4		

Considerable surprise was occasioned on July 26, 1926, when a number of nearly ripe drum, ranging from 31 to 46 centimeters (12.2 to 18.1 inches) in length, were captured in and about the channel leading from Oso Bay into Corpus Christi Bay. Collections of a few ripening fish likewise were made within Oso Bay. All other fished areas, in spite of extensive collections of drum, failed to reveal any ripening fish. It appeared that all maturing fish were centered about Oso Bay, although many unripe adults were taken along with the nearly ripe fish.

Heavy commercial catches of drum were being made during July and August in the open fishing area in Laguna Madre, and it was learned by inspection of the catch that many fish were in a ripening state and apparently were coming into the fishing area from Baffin Bay and other southern points in Laguna Madre that were closed to commercial fishermen. As indicated by Figure 44, the peak of the drum catch, taken almost entirely from a central portion of Laguna Madre and landed at Corpus Christi in 1926, occurred during the months of July and August. While one of the causes for the much larger catch during these months was the general exodus of all fish from the waters of the lower Laguna Madre because of the high salinity that is reached during the late summer months, a spawning migration of many of the adult drum served to increase the catch by bringing the fish from the closed waters, where evidently they had matured, into the restricted open fishing area.

On October 14, 1926, after several months of futile effort in seeking newly hatched drum, together with the capture of small collections of ripening fish at infrequent intervals in and about Oso Bay, a large, nearly ripe female drum, 90 centimeters (35.5 inches) long, was found stranded in Corpus Christi Pass. This was the first indication that spawning drum were to be found near the Gulf of Mexico, and while it could not be determined in which direction the fish was traveling before it accidentally ran up on a shallow sand bar, it was evident that spawning might be looked for in the Gulf as well as within the bays.

In February, 1927, the spring spawning of the drum was indicated to be approaching. About the last week in January fishermen familiar with the movements of the fish in such bays as Nueces and Oso, as well as Laguna Madre, were in the habit of placing large-meshed gill nets near the mouths of the narrow channels leading into such bays to secure the larger migrating adults that generally were supposed to be coming into the bays from some unknown place for spawning. During the winter of 1927, these nets, discussed more fully in another section of this paper, were placed at the mouth of Nueces Bay in Corpus Christi Bay, along the south shore line of Corpus Christi Bay near the entrance to Oso Bay, and in the open fishing area in Laguna Madre. Examination of the larger stand of nets at the mouth of Nueces Bay in early March indicated conclusively that a marked spawning migration of adult drum was occurring. All fish were in a nearly ripe condition, and most of them ranged over 80 centimeters (31.5 inches) in length.

Meanwhile, ripening fish were being captured by commercial gill nets in Laguna Madre and by experimental gear operated by the writer in the closed fishing area of Oso Bay. During the preceding months fishing within Oso Bay had been very difficult and inconclusive on account of the heavy mud bottom and the lack of a landing place for the large seines. Often, nevertheless, large drum (above 60 centimeters, or 23.6 inches) were caught (more generally, only seen) in the shallow recesses of Oso Bay, and it was generally known that a considerable number of large fish were to be found within the bay.

Experimental gill nets were placed in Oso Bay near the channel exit into Corpus Christi Bay during the early part of March with the expectation of determining the direction of this spawning migration of drum. Good catches of large ripening fish soon were obtained, and by the position of the gilled fish in the nets it appeared that the schooling fish were endeavoring to gain their way over the shallow sand bars partly blocking the exit into Corpus Christi Bay. On one occasion large drum were seen deliberately making their way over the shallow bars from Oso into Corpus Christi Bay.

Upon reaching the deeper waters of Corpus Christi Bay, the migrating drum were difficult to catch or to observe. However, fishermen reported that while their boats were lying anchored in the various channels leading to the passes, particularly Aransas Pass, distinct drumming sounds could be heard during the night, presumably caused by the drumfishes on their way to the Gulf. The writer, while not doubting these reports, did not actually hear any such noises, although it is well known that the drum make a loud drumming vibration which is probably employed extensively during the breeding season for the purpose of sexual attraction.

On February 28, 1927, the first collection of larval black drum was secured in Harbor Island Light Bayou in nearly the same spot where the first larval redfish and croakers were taken some months previous. These young drum ranged from 4 to 6 millimeters in length and were not identified definitely as black drum (*Pogonias cromis*) until the second week in March, after the gill nets had indicated the movement of the spawning adults from the bays to the Gulf of Mexico. The fish were helpless and obviously at the mercy of the tidal current, which had swept them into the quiet bayou from the channel leading from Aransas Pass and the Gulf. (See Table 13.)

On March 11 Corpus Christi Pass was visited and large numbers of larval and post-larval drum were taken in the main channel of the pass itself, as well as along the shore lines of the various islands in Laguna Madre adjacent to the pass and reached by the incoming tides. In all cases was it evident that the larval drum were being brought in from the Gulf by the tidal currents. As shown in Table 13, continuous collections of larval and very young drum were made about both Corpus Christi and Aransas Passes during March and April.

It was observed that the young drum left the vicinity of the passes as soon as able, and it was believed, on the basis of the collection of small drum near Oso Bay on May 13, 1926, that the fish were making for definite localities, such as Oso and Nueces Bays. On April 9 a considerable number of young drum had reached the channel leading from Corpus Christi Bay into Oso Bay. These fish ranged in length from 8 to 11 millimeters (under 0.5 inch) and were the approximate size of the smallest of the young drum caught in the beach pools in the same locality on May 13, 1926. On the day these fish were taken, the current was running out from Oso Bay, with the result that the young were forced to remain at the mouth of the channel for some time.

Nueces Bay, similar in most respects to Oso Bay but on a nearly direct line with a recently completed ship channel that connects Aransas Pass with the city of Corpus Christi, was fished at various points during April and May. Many young drum from 9 to 15 millimeters long were taken in late April, while large numbers of young, growing rapidly in size, were secured throughout the month of May.

By the time field operations were discontinued, at the end of May, 1927, the young larval drum had ceased to come into the passes from the Gulf, and those that had gained entrance were concentrated largely within Nueces and Oso Bays and probably Laguna Madre. The young drum preferred the same type of environment as was chosen generally by the older fish.

Several complications in the way of a thorough understanding of the spawning habits of the black drum leave an interesting field for future research along this line. No explanation is offered for the lack of young drum that should have come from the ripening fish taken from July to October, 1926. Whether they escaped observation, owing to their small numbers, or whether there were no fish to be taken are questions unsolved at the present time. The writer expresses the opinion, however, on the basis of the relatively small size of the maturing fish taken in July to September, 1926 (Table 16), that spawning at this time was negligible. The main spawning season of the black drum in the vicinity of Corpus Christi Bay undoubtedly is from late February to May, and the spawning grounds probably are situated at the mouths of the passes in the Gulf of Mexico.

Little information on the spawning habits of the black drum in other sections of its range has been recorded. Welsh and Breder (1923, p. 197) stated that the eggs and larvæ of the drum were unrecorded and that little was known of the life history. Hildebrand and Schroeder (1928, p. 288) recorded a fully ripe male drum, 37 inches long, taken on May 22, 1922, at Cape Charles, Va., in 48 feet of water, but stated that no young drum under 8 centimeters (3 inches) have ever been secured.

GROWTH AND AGE

Study of the age and growth of the black drum brought out the fact that by the method of age determination employed with success in the case of the redfish, croaker, and spot (the Petersen method, whereby the individuals of a large collection are grouped according to their length, and each prominent mode or hump in the

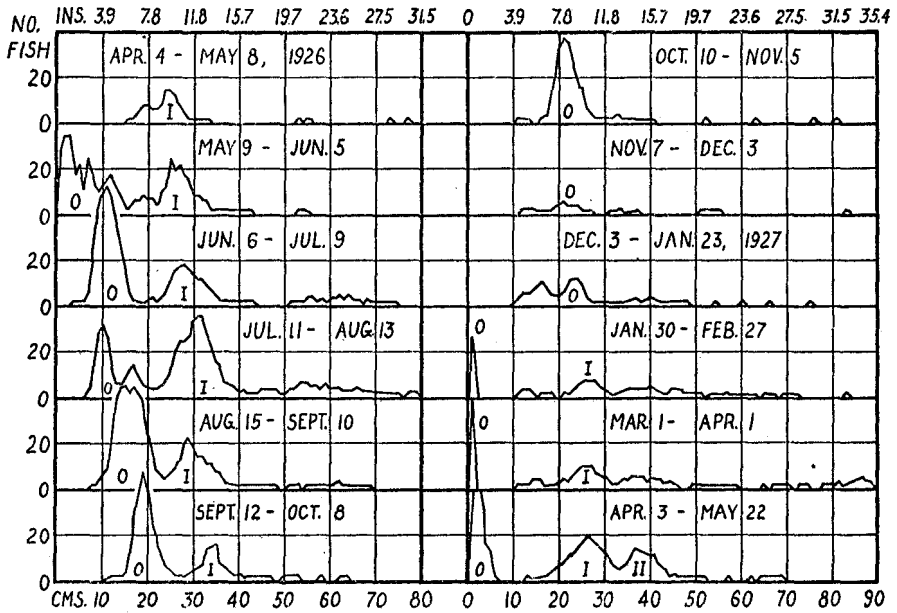

FIG. 20.—Length-frequency distribution of black drum in Texas, 1926-27. Actual frequencies have been smoothed by a moving average of threes. Roman numerals indicate year classes

plotted frequency distribution is assumed to represent an age class), only the first two year classes of drum could be discerned throughout the year with any degree of reliability. After the third year the various year classes overlap to such an extent as to render the Petersen method worthless.

A series of smoothed length-frequency distributions, taken from Table 15, is presented in approximate monthly summaries by Figure 20. Collections from April 4 to May 8, 1926 (following fig. 20), gave a group of drum (I-year class) assumed to be entering their second year with a modal length at about 25 centimeters (9.8 inches). This I-year class grew rapidly during the succeeding months, and by October (September 12 to October 8) had reached a modal length of about 35 centimeters (13.7 inches). While this class held its original identity well during the spring and summer of 1926, it nearly disappeared from the catches during the

winter of 1926–27. In April and May, 1927, the class reappeared in good numbers with a modal length at about 37 centimeters (14.5 inches).

TABLE 15.—*Length-frequency distribution of black drum taken in Texas waters from April, 1926, to May, 1927*

Total length, centimeters	1926								1927				
	Apr. 4–May 2	May 9–30	June 6–July 4	July 11–Aug. 8	Aug. 15–Sept. 5	Sept. 12–Oct. 3	Oct. 10–31	Nov. 7–28	Dec. 5–Jan. 23	Jan. 30–Feb. 27	Mar. 6–27	Apr. 3–24	May 1–22
1		14								27	342	113	1
2		74											94
3		19											26
4		10											20
5		23	1										4
6		32											
7		34	5										
8		8	15	8									
9		6	47	26	1								
10		17	62	45	6								
11		16	57	24	8				2				
12		18	49	10	12		1		10	3	2		
13		19	35	4	46	1		2	5	9	2		
14		3	29	8	60			2	3		3	1	
15		1	12	5	36	2		1	13		7	1	
16		3	2	13	45	8			12		2		
17	2	5	2	14	46	20	5		7	1	4	1	1
18	4	10	1	12	46	53	5	1	7			2	1
19	10	4		4	33	48	17	1	3		1	1	2
20	11	12	3	5	34	47	37	8	3		5	1	6
21	4	4	3	2	12	21	41	2	7		2	5	5
22	2	5	2	7	9	14	35	4	10	1	7	6	4
23	12	3	1	5	6	13	29	6	15	3	4	4	9
24	10	21	9	6	6	6	12	3	12	6	11	4	8
25	19	15	13	13	4	2	6	2	9	5	8	11	10
26	14	26	14	20	11	4	1	1	4	8	14	11	8
27	5	16	18	26	10	1	1			9	9	11	10
28	2	21	18	29	21				2	5	6	8	6
29	4	15	16	22	28	3			1	6	6	8	8
30	1	10	15	31	14	5	1			3	5	8	6
31		3	13	45	19	3	2			2	5	3	6
32	1	10	11	32	13	10	4	1	1	1		3	4
33		2	10	28	11	8	3	2	1		2	4	1
34		2	5	17	9	23	3	2		6	4	4	1
35			3	20	9	12	1		1	4	5	6	6
36		1	4	8	5	9	2	1	5	3	3	5	6
37		1	1	8	4	5	2		2	6	7	12	6
38		1	2	4	1	4	1		1	4	5	7	3
39		1	1	6	3	3	1			6	2	5	7
40				6		3			4	2	2	6	8
41		1		1	1	3			4	6	7	3	3
42			1	1	1	1				3	2	2	10
43				1		1				1	2	1	2
44				2	2	1			1	3	5	1	3
45				2		1				3	2	1	2
46				4	1	1			1	7		1	2
47				3	1				1	1			1
48				3								1	
49				1						1		1	
50			1							1	2	1	
51			1	2		1		1			1	1	
52			1	6	2	1	1						
53	1	1	1	5				1			1		
54		1	3	5				1	1	1	2		
55	1		3	7									
56			3	7	1					3	1		
57			3	2								1	1
58				6	2	1				2	1		
59			3	4	1								
60				4	1				1				

TABLE 15.—*Length-frequency distribution of black drum taken in Texas waters from April, 1926, to May, 1927*—Continued

Total length, centimeters	1926								1927				
	Apr. 4–May 2	May 9–30	June 6–July 4	July 11–Aug. 8	Aug. 15–Sept. 5	Sept. 12–Oct. 3	Oct. 10–31	Nov. 7–28	Dec. 5–Jan. 23	Jan. 30–Feb. 27	Mar. 6–27	Apr. 3–24	May 1–22
61			7	5	1					1			
62			2	3	3	1				1		1	1
63			2	3	1	1	1						
64			3	3									1
65			6	4	1						1		1
66				2					1	1			
67			3	6	1								
68				2	1						1	1	1
69			2	2							1	1	
70			1	3									
71				2						1			
72													
73	1		1	1							1		
74				1									
75									1				
76							1						
77	1												
78				2									
79											1		
80											2		
81							1				1		
82											2		
83								1		1	2		
84											2		
85											6		
86											5		
87											5		
88											2		
89											1		
90											5		
91													
92											4		
93											1		
94											1		
95													
96													
97													
98													
99											1		
100													
105											1		
Total	105	488	526	619	589	341	214	43	151	157	547	268	305

The second summary of drum collections, from May 9 to June 5, 1926, brought the O or youngest year class into consideration, with the fish ranging in length from 1 to 15 centimeters (0.4 to 5.9 inches). Several sharp modes exist within the length distribution of this O class, owing possibly to the various differences in time of hatching. The collections from June 6 to July 9, 1926, however, smoothed out this irregular distribution.

The O year class, positively known to be in its first year, grew rapidly during the summer of 1926, and by November (October 10 to November 5) had attained a modal length of 21 centimeters (8.2 inches), compared with the modal length at 11 centimeters (4.3 inches) shown by the class during June. Collections became much smaller during the winter, but spring catches (April 3 to May 22) showed that the class (I) had attained a modal length of about 26 centimeters (10.2 inches) when a

little more than 1 year old. This modal size in April, 1927, corresponds well with the modal length observed for drum of the same age captured in April, 1926.

In late February, 1927, a newly spawned year class appeared (O year class), which by the end of May, 1927, had attained a modal length of 2 centimeters with a range from 1 to 5 centimeters. It will be observed that during May, 1926, a length range from 1 to 15 centimeters was recorded, while a year later this range was reduced to 1 to 5 centimeters. From the fact that the larger fish included in the O class during May, 1926, possessed no winter scale checks, it must be inferred that spawning occurred earlier in 1926 than in 1927 (the scales of the drum were found to show annual winter growth checks, not including, of course, the first winter during which the fish are hatched). This supposition presumes, however, that the larger fish of the class (10 to 15 centimeters long) actually belonged to the O year class on account of its lack of a winter check, and that any group of fish hatched in the late summer or fall of 1925 would show a growth check during the winter of 1926. The fact that after the period from May 9 to June 5, 1926, all fish in the O year class fell into a more or less regular group would seem in itself to justify the inclusion of these larger fish in the youngest year class.

Some confusion was caused by the capture of a considerable number of drum from December 5, 1926, to January 28, 1927, showing a modal length at about 15 centimeters (5.9 inches), while the modal length of the O year class reached 21 centimeters (8.2 inches) during the preceding October. This small group of drum was reflected in the catches during the next few months, and nearly all fish were taken from Oso Bay. (See table 14.) While it is possible that this undermodal group of the O year class of drum was the result of the suggested spawning in the late summer and fall of 1926, the belief of the writer is that the group merely represented a late season's hatch in the spring of 1926, as indicated by the collection of many young fish around Oso Bay on May 13, 1926. Such differences within a single year class can easily result from the arrival of various schools of adult fish on the spawning grounds at different times. With the existing doubt as to the results obtained from the effort of some fish to spawn in the late summer of 1926, however, the writer suggests the possibility that some young may come from this spawning and be represented by these subnormal modes at about 16 centimeters instead of 23 to 24 centimeters, as appeared typical of the O year class in December, 1926, and January, 1927. Future work could easily clear up the present uncertainty as to the extent and influence of any late summer spawning, which, with the information at hand, appears to be negligible.

It seems reasonable to state, on the basis of an examination of the drum length-frequency distribution composed of about 4,350 fish taken with unselective gear, that a modal length of about 25 centimeters (9.8 inches) is reached by the end of the first year and about 37 centimeters (14.5 inches) is attained by the end of the second year.

The age of the black drum, up to a length of 60 centimeters (23.3 inches), usually may be determined by a count of the annually formed winter-growth checks on the scales. The extremely large size and the heavy calcification that the drum scale undergoes render the determination of age difficult and unreliable after the fish has reached the fourth or fifth year of life and generally has attained a length of 50 to 60 centimeters (19.7 to 23.3 inches). In general, the winter-growth checks of the drum

scales (annuli) have the nature of bilateral breaks or interruptions in the circuli pattern of the scale, most evident at the lateral terminals of the circuli. Many of the younger fish, however, in addition to the lateral terminal checks, show closer approximations of circuli formed during the retarded winter growth. In most respects the scales of the black drum closely resemble those of the redfish, both in size and structure, as well as in the nature of the winter-growth check.

Figure 21 illustrates the relation between age and length, secured by a study of the scales of several hundred drum. No fish over 60 centimeters (23.3 inches) in length has been included in this figure because of the present unreliability of age

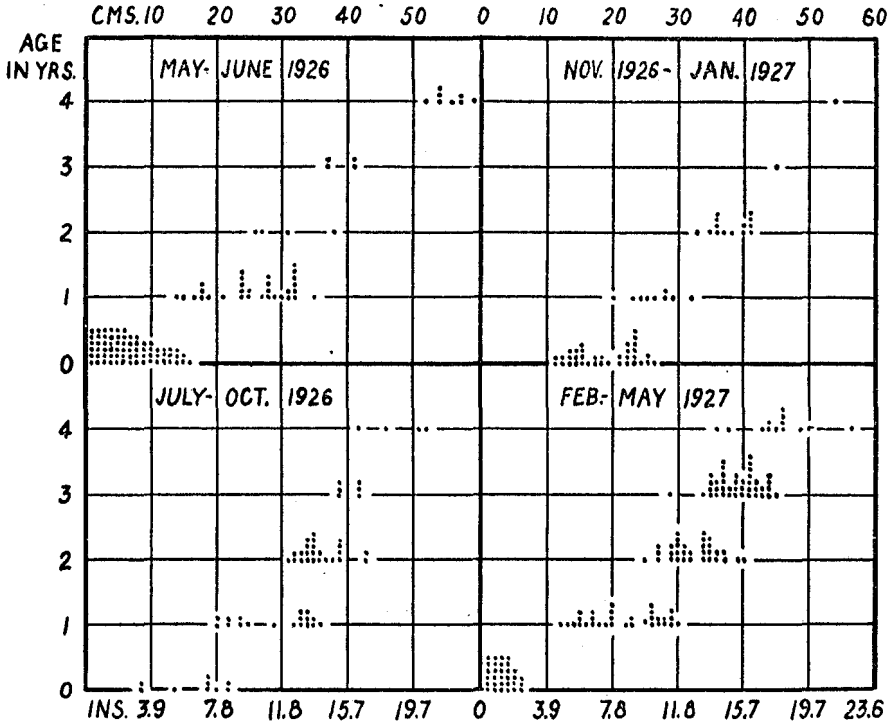

FIG. 21.—Age of black drum according to length, as indicated by winter growth checks on scales

determination as applied to the larger fish. The first four years of age are represented fairly well in the length distribution ranging from 1 to 60 centimeters, although insufficient numbers of fish prevent the discernment of any definite modal lengths at any particular age. The scale collections were small, unfortunately, but the results obtained seem to justify more intensive work in the future on the analysis of age of the drum by means of the scale method.

An incomplete examination of many scales from fish measuring more than 60 centimeters (23.3 inches) indicated that 5 years of age may be attained when the fish reach a length of about 60 centimeters, and that they are 7 to 9 years of age by the time they reach a length of 75 to 85 centimeters (30 to 34 inches).

SIZE AND AGE AT MATURITY

Sexually matured black drum with a total length range from 27 to 105 centimeters (10.5 to 41.6 inches) were taken. Only fish that possessed developing sexual products (granular roe in the females) were sexed, thus obviating personal errors in judging the state of development.

It will be observed, by inspection of Table 16, that the drum found in a ripening or spawning condition during July to October, 1926, were of smaller minimum and

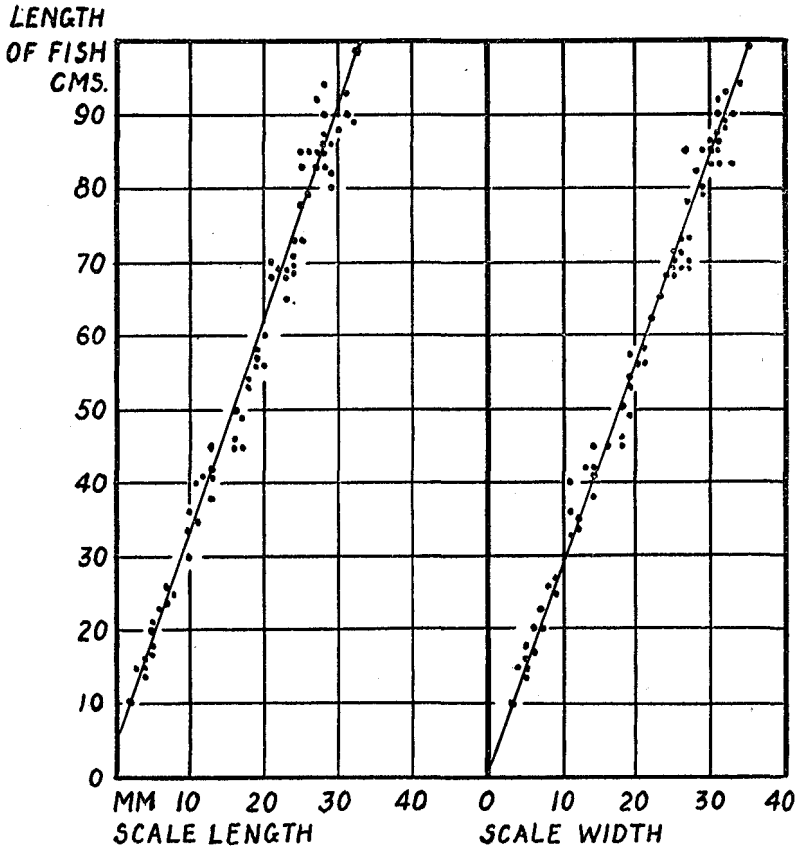

FIG. 22.—Correlation between scale length and width and total body length in the black drum. The average values of the scale lengths and widths corresponding to a succession of body lengths lie nearly upon a straight line, indicating that on the average the growth increment of the scales is a constant proportion of the growth increment of the fish

maximum length than those taken during the main spawning period in the winter and spring of 1927. This difference extends particularly to the older and larger fish, only one drum above 58 centimeters (22.8 inches) being taken during 1926, compared with many secured in 1927 by the writer and by commercial fishermen. This condition is unaccounted for at present. One possibility, however, is that many of the youngest maturing fish (I class) reach sexual maturity either several months prior to or after the older classes spawn.

While not all the drum captured from the adult age groups during 1927 were in a ripening condition (as judged by the writer), a much larger percentage was recorded than during July to October, 1926. From July 11 to October 10, 1926, approximately 490 adult fish were taken (all drum above 29 centimeters considered adult), but only 67 fish, or 13 per cent, were in a ripening condition as indicated by granular roe and running milt. From March 6 to May 1, 1927, 151 adults were secured (all fish above 34 centimeters considered adult), 121 of which, or 80 per cent, were in a ripening state. While these figures are subject to slight error because of the difficulty experienced in determining the state of maturity, the percentages indicate, in a rough way, the seasonal abundance of spawning fish.

TABLE 16.—*Size at maturity of the black drum*

[Only fish with ripening roe or milt were sexed. The 1926 period was from July to October; the 1927 period from February to May]

Length, centimeters	Summer-fall, 1926		Spring, 1927		Length, centimeters	Summer-fall, 1926		Spring, 1927	
	Males	Females	Males	Females		Males	Females	Males	Females
25–29	2	0	0	0	65–69	0	0	1	5
30–34	14	22	0	1	80–84	0	0	3	8
35–39	1	16	7	29	85–89	0	0	8	12
40–44	0	6	8	9	90–94	0	0	5	6
45–49	1	3	2	3	95–99	0	1	1	0
50–54	0	0	3	4					
55–59	0	1	1	2	Total	18	49	39	82
60–64	0	0	0	3					

On the basis of the age estimations secured from scale and length frequency studies it seems evident that the drum reaches sexual maturity by the end of the second year, with annual spawning continuing until death. The larger-sized black drum are very prolific. An approximate count was made of the eggs from a migrating female 110 centimeters long (44 inches) taken at the mouth of Nueces Bay by a commercial gill net on March 6, 1927. Nearly 6,000,000 were counted. (See below.) The average diameter of the eggs was 0.6 millimeter, most of them being equally developed.

Total weight, in grams, of eggs from 110-centimeter black drum	996
Total weight, in milligrams, of 60 unselected eggs	10
Total calculated number of eggs in 1 gram	6,000
Total calculated number of eggs in 996 grams	5,976,000

Figure 23 presents the relation of weight to length in 77 black drum. A fish about 30 centimeters long (11.8 inches) usually is slightly over 1 year of age and weighs about 1 pound. Weight increases rapidly after 70 centimeters in length (27.5 inches) has been reached. A drum measuring 90 centimeters (35.4 inches) weighs close to 22 pounds, while a fish measuring 105 centimeters (41 inches) weighs 37½ pounds.

SEASONAL DISTRIBUTION AND MOVEMENTS

The young drum, usually in a larval or post-larval condition when brought in through the passes from the Gulf spawning areas, make their way soon after entering to a few extremely shallow and muddy bodies of water typified, along the central section of the Texas coast, by Laguna Madre and Oso and Nueces Bays.

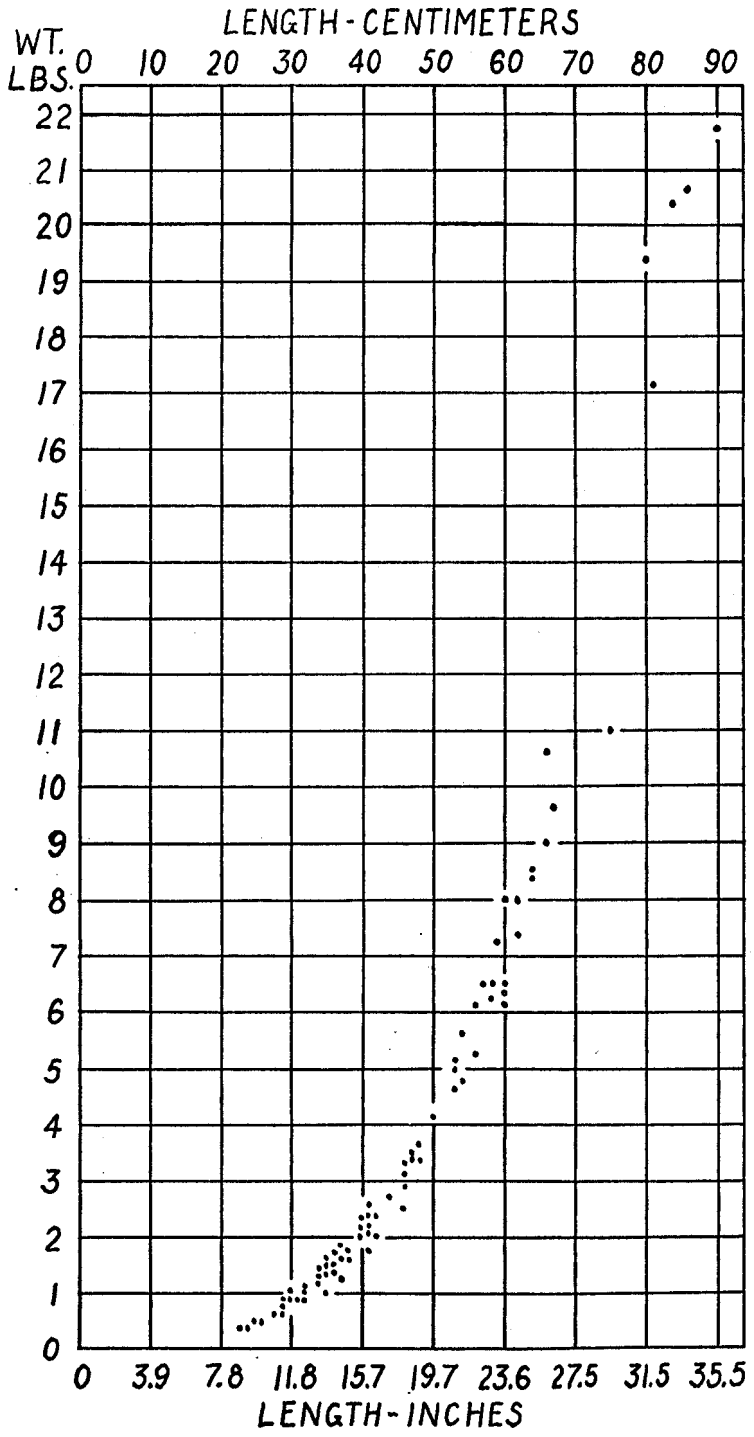

FIG. 23.—Relation of weight to length in 77 black drum

Present knowledge of the exact causes for the voluntary response of young fishes to a certain type of environment is too inadequate to permit a conjecture as to the possible factors that cause the determined effort of the young drum to reach definite isolated bays and lagoons wherein very few species of marine fish dwell. The fact remains, however, that these young drum are attracted to a particular type of aquatic environment soon after coming in from the Gulf of Mexico, to such a degree as to render the absence of the small fish in other types of coastal waters most noticeable.

The young drum generally remain within their favorite bays until they attain a length of at least 10 centimeters (4 inches), when many of them gradually move out into the deeper bays and, to a slight extent, into the Gulf of Mexico. The young drum (fish under 10 centimeters) are more prone than redfish to stay away from the open shores of the Gulf. Most of the drum population, however, appears to reside until maturity (spawning time) within the shallow waters chiefly of Laguna Madre and Oso and Nueces Bays, but relatively few fish roaming into the deeper waters.

The spawning migration of the adult drum from the shallow intercoastal waters to the Gulf of Mexico is most pronounced in the vicinity of Oso and Nueces Bays and Laguna Madre, where, from late January to May, special gill nets are employed to intercept and capture the schools of migrating fish. From personal observations it would seem that the greater part of this movement from the bays takes place at night. The distance to be traveled from such waters as Oso or Nueces Bay to the nearest pass to the Gulf of Mexico may lie, roughly, between 20 and 30 miles. Such a distance might easily be covered by the drum within a few days, which perhaps explains the nearly ripe condition of most drums before they leave the bays.

After spawning outside the passes the spent adults that survive appear to come closer inshore to seek their way back into the bays. Considerable numbers of these spent drum were taken in the late spring of 1927 along the Gulf beaches near the passes as well as immediately within some of the passes. No collections of spent adults were obtained at any time within the confines of either Oso or Nueces Bay, which fact in itself would indicate that spawning does not take place in these bays.

The drums are extremely persistent in remaining within the shallow intercoastal waters, both during the excessive heat and salinity of the water in summer and the sudden-killing cold waves in winter. With the shallow bays preferred by the drum nearly completely isolated from the deeper ones, escape in times of danger is not accomplished readily. Navigation within these shallow waters is difficult, and many of the migrating adults have their bellies badly lacerated from the continual friction in passing over oyster reefs, particularly during the excitement of breeding. It has been said that in past years farmers were accustomed to chase the large 10 to 40 pound drum over the shallow mud flats with pitchforks, such chase, of course, furnishing a considerable amount of thrill as well as fish.

During the summer the waters in the vicinity of Baffin Bay (Laguna Madre) often become extremely saline, with the result that many fish, particularly black drum, die. Cold waves in winter, which chill the shallow water rapidly, are said to work destruction with the species because of the inability of the fish to reach more favorable environments.

The writer feels that future scientific research into the life history of the black drum might take up, with profit, a more intensive study of the various seasonal movements or migrations of the species than was possible during this investigation.

FOOD HABITS

The feeding habits of the black drum bear out the belief that the fish is generally a strictly bottom feeder. Possessing heavily paved pharyngeal teeth, the species has long been known to frequent oyster beds or reefs, the supposition being that the young oysters are crushed and eaten in great quantities. Observations on the stomach contents of many Texas drum, particularly those of a large size, failed to show that oysters of any size make up any considerable percentage of the regular diet.

The main food of the drum after it has attained a length of about 20 centimeters (7.8 inches) is a small mollusk or "clam"—*Mulinia transversa corbuloides*—which abounds in the more muddy and shallow bays, such as Nueces and Oso, in the vicinity of Corpus Christi. Bottoms containing this mollusk invariably are covered with heavy mud, and along such bottoms the drum delights to feed. Certain localities in the more or less grassy-bottomed coves are well known as good "drum hauls" because the drum usually may be found feeding in these localities, which in all cases possess a clear but muddy bottom in which Mulinia may be found in varying abundance. The mollusks lie deeply buried in the mud but are sucked up by the drum, which retains them and proceeds to crush the shells by means of its strong pharyngeal teeth. As much as 2 pounds of broken shell from this small mollusk have been taken from a large fish. Whether or not the fish swallows dead shells can not be stated definitely, but in great numbers of fish examined, the intestines literally were filled with hundreds of fragments of the thin shell of Mulinia. The drum often nearly stand on their heads in feeding, with their tails out of water, so shallow is the water and so intent are the fish on sucking up the mud.

Various other mollusks, such as mussels (Mytilus) and oysters (Ostrea), are eaten in some abundance. Small crabs rank second in quantity to Mulinia, and shrimp also are consumed at times. The smaller-sized drum (under 20 centimeters, or 7.8 inches), with less powerful crushing teeth, tends to prey upon the softer food organisms, such as small fishes, annelid worms, and the smaller crustaceans. Surf fishing along the Gulf beaches, with dead mullet or shrimp for bait, yields catches of drum.

TABLE 17.—*Food preference of 117 black drum, presented in percentages of total number of fish in each length group that feed exclusively on the various organisms, the food named in the parentheses occurring most commonly*

[Forty per cent of the mixed food of the 21 to 50 centimeter group was composed of crustaceans and 60 per cent consisted of mollusks. March to May, 1927]

Length, centimeters	Percentage of first that had eaten—					
	Number of fish	Crustaceans (shrimp, crabs)	Mollusks (Mulinia, Mytilus)	Fish	Annelids (polychæts)	Mixed
8–20	25	8	20	36	32	4
21–50	61	28	33	0	2	37
80–99	31	16	74	0	10	0

Table 17 shows the changing food habits of the drum according to its size. The smaller drum feed largely on fish and annelids, represented by 36 and 32 per cent; the medium-sized drum cease feeding on the softer foods and consume larger amounts of mollusks (33 per cent) and crabs and shrimp (28 per cent), a 37 per cent mixed-food content consisting of mollusks and crabs; and the older drum confine their food largely to the mollusks (74 per cent) and crabs (16 per cent). In general, the food habits of the black drum may be correlated with the environment. In the more shallow, muddy lagoons and bays the greatest numbers of Mulinia are found, and it is in such waters that drum live in the greatest abundance. In an environment where extremely turbid water prevails throughout the year; where the water temperature ranges from 80 to 90° F. in summer and as low as 40° F. in winter; where during the summer salinity often is twice as great as that of ordinary sea water and during the rainy season a brackish condition exists; and where the average depth rarely is more than 4 feet, the black drum attains its greatest abundance along the coast of Texas.

COMMERCIAL CONSIDERATIONS

Texas produces about 70 per cent of the total annual black-drum catch of the United States. The species attains its greatest abundance in the Gulf States, although it occurs in commercial quantities as far north as New York. The trade always has had some aversion for the drum because the larger adults are likely to become infested with parasitic worms, which virtually destroy the marketability of the fish unless the flesh is cut into fillets or steaks. In most sections of Texas the drum is sold under the name of rockfish. The smaller fish (one-half to 3 pounds) are preferred by many people to either the redfish or the spotted sea trout.

The following record of commercial catch, taken from the publications of the United States Bureau of Fisheries, shows the extent of the fishery:

TABLE 18.—*Catch of black drum (Pogonias cromis) in the United States*

State	Weight, in pounds	Value	Value per pound	Year	State	Weight, in pounds	Value	Value per pound	Year
Texas	1,028,451	$36,807	$0.036	1923	South Carolina	13,150	$393	$0.030	1923
Virginia	228,180	3,529	.015	1925	Alabama	9,250	279	.030	1923
Florida	141,994	4,397	.031	1923	Delaware	4,240	73	.017	1926
Louisiana	59,988	2,000	.033	1923	North Carolina	1,794	194	.010	1923
Mississippi	38,989	1,263	.033	1923	New York	200	2	.010	1926
New Jersey	31,100	909	.029	1926					
Maryland	25,150	472	.019	1925	Total	1,582,484	50,318		

Approximately 432,000 pounds of drum were landed from January, 1926, to May, 1927, at Corpus Christi, Tex. (from records of the three leading fish dealers), as compared with 134,000 pounds of redfish and 138,000 pounds of spotted trout (fig. 44).

While the fishermen generally receive but from 3 to 5 cents a pound for drum that retails for 25 cents a pound, spotted trout bring nearly 10 to 12 cents a pound to the fishermen and 35 cents to the retailer. On the basis of the retail value, the drum exceeds in value the redfish and trout combined.

Owing to its relative abundance in Texas coastal waters and its low market value, the drum has not been protected by any special legislative measures. The fact that sport fishermen and commercial hook-and-line fishermen seldom catch this species has caused but little interest to be shown in a rational system of conservation of the fishery. The legal closure in recent years of many of the smaller bays, such as Oso and Nueces, in the vicinity of Corpus Christi has afforded the drum considerable protection because the species spends a greater part of its life in the more shallow, muddy bays and lagoons than elsewhere. At present, however, this attempt at conservation is partly nullified by certain fishing practices that appear to be unduly destructive in proportion to the actual value of the catch.

From late January to May a fishery is operated in Corpus Christi Bay and northern Laguna Madre for the nearly ripe drum that leave their favorite feeding grounds (such as Oso and Nueces Bay and southern Laguna Madre) for the spawning grounds in the Gulf of Mexico. This fishery is conducted largely by means of anchored gill nets with a large mesh (4 to 5 inches square) customarily set as near the entrances into Nueces and Oso Bays (in Corpus Christi Bay) and the deeper channels in northern Laguna Madre as is legally possible. The larger adult drum are secured in abundance, the flesh selling at wholesale at 10 cents a pound and the female roes (weighing about 2 pounds apiece) being supplied to the restaurant trade at 25 cents a pound. The fact that these gill nets secure the drum when they are preparing to spawn and are seeking their way out of restricted areas, together with the fact that most of the drum population congregate in a few small bays and lagoons and are forced to leave them through narrow exits in order to spawn, brings up a serious question as to the desirability in permitting this type of fishery to exist.

On the basis of the relatively slight food value of these large adult drum and the fact that such fish must be of considerable value in replenishing the drum stock, it would seem that their ultimate worth as spawners far surpasses their value as food. The writer, in seeking a way to increase the natural supply of black drum in Texas waters, recommends that suitable protection be afforded to the larger sizes of drum at all times of the year.

The establishment of a maximum legal size limit which operates favorably in the case of the redfish, would appear to be a logical way of protecting these larger drum against possible depletion. Usually all drum above 20 inches in total length (50 centimeters) are released from the drag seines because of the unwillingness of the fish dealers to handle the larger, less profitable sizes. The adoption of a maximum size limit at 20 inches (50 centimeters) would work little hardship to the fishing industry (in fact, it would be a boon to many dealers now forced to accept the nigh worthless large drum) and unquestionably would serve to increase the proportion of spawning adults. Of course, an end would be put to the wasteful gill-net fisheries at the mouths of Oso and Nueces Bays.

While no minimum legal size limit has been set for the drum, as has been done for the redfish and spotted sea trout, it would appear advisable to place some restriction upon the smallest size that might be marketed, since it is highly probable that attempts will be made to market fish of such small size as to be nearly worthless as food. A minimum size limit at 8 inches (20 centimeters) should not meet with any serious objection, at least from the fish dealers who have the task of selling the fish.

The closing of both Oso and Nueces Bays, as well as the southern part of Laguna Madre, to seine fishermen has destroyed the income of the fishing industry, as well as of the entire State of Texas, from some of the best drum-fishing waters along the coast of Texas. While an overflow of drum from these waters into open territory may result in some benefit, it has been shown that the fish prefer to dwell most of the time within such closed areas. Few species of food fish other than drum and croakers frequent Oso or Nueces Bay, and the former fishery in these bays was almost entirely for the black drum. Allowing a suitable area around the entrances to these two bays to permit the fish ingress or egress it would appear desirable to allow a return of seine fishing within the bays. With the larger adult drum protected by reason of a legal size limit, there seems little basis for expecting serious depletion of the drum from the opening of these waters.

Laguna Madre long has been a battle ground for commercial fishing interests and conservation forces, for no apparent reason save that this long, narrow lagoon constitutes a favorite feeding ground for several species of marine food fishes, particularly in summer. The ease with which fish generally may be captured with seines in the shallow waters of the lagoon has alarmed many sport fishermen, who fear the gradual extinction of their favorite game fish. With the sportsmen in the great majority and the general public knowing little of the problems confronting the fishing industry, pressure in legislative circles has resulted in the closure of much of Laguna Madre to any form of net fishing.

The writer, considering the intelligent conservation and utilization of the fish of commercial importance along the coast, sees no legitimate reason for continuing the closure of the southern part of Laguna Madre, particularly in and around the waters of Baffin and Alazan Bays. As mentioned previously, during exceedingly hot and dry summers, when its waters become excessively saline, Laguna Madre becomes the death place of thousands of food fish. To remedy this condition, it has been suggested by many that an artificial channel or pass be cut through Padre Island from the Gulf of Mexico to Laguna Madre in the vicinity of Baffin Bay, and thus allow (at least theoretically) fresh Gulf water to mingle with the excessively salt water within the lagoon. While the construction of such a pass might be possible from an engineering standpoint, there is no evidence that the expense would be warranted under present conditions. In fact, such a pass might bring about a marked biological change in environmental conditions, which would reduce naturally the present supply of some species within the lagoon, particularly the black drum. It would appear to be more practical, from an economic standpoint (perhaps from a biological one as well), to allow unrestricted seine fishing within all of Laguna Madre (except around Corpus Christi Pass) in an attempt to reduce the amount of loss suffered during a period of natural mortality, than to attempt a costly and perhaps futile experiment by making an artificial pass. Removal of restrictions in Laguna Madre would result in the utilization of many of the fish that now perish during the summer months, and it would also result in partly satisfying those who now advocate an artificial pass in the belief that fishery conditions might be benefited.

SUMMARY

1. The black drum spawns in the Gulf of Mexico near the entrances to the bays and lagoons. The young drum enter the inland bays through the various passes soon after hatching and make for definite localities within the inland waters.

2. The spawning period occurs mainly from February to May and is preceded by a marked migration of ripening adults from the bays and lagoons to the waters of the Gulf. A secondary spawning period may occur in late summer and early fall with some of the younger age classes.

3. The black drum reach a total length of about 25 centimeters (9.8 inches) by the end of the first year and about 37 centimeters (14.5 inches) by the end of the second year, with scale study indicating that five years of age may be attained by the time a length of 60 centimeters (23.3 inches) is reached.

4. Sexual maturity is reached at the end of the second year, when the fish generally has attained a total length of 35 centimeters (13.7 inches).

5. The food of the younger drum consists largely of annelids and small fish, while the older fish prefer mollusks and small crabs. A small mollusk, Mulinia, is eaten almost exclusively by the larger-sized drum.

6. The recommendation of a minimum legal size limit at 20 centimeters (8 inches) and a maximum legal size limit at 51 centimeters (20 inches) is made primarily in order to conserve the smaller, less marketable fish as well as the larger, more prolific drum that are caught in great numbers and are of relatively slight market value.

7. The recommendation is made also to allow seine fishermen to fish in the present closed waters of Nueces and Oso Bays, as well as Laguna Madre, after minimum and maximum legal size limits have been adopted.

NATURAL HISTORY OF THE SPOTTED TROUT, CYNOSCION NEBULOSUS CUVIER AND VALENCIENNES

Spotted Sea Trout or Squeteague

Otilithus nebulosus Cuvier and Valenciennes, Hist. Nat. Pois., V, 1830, p. 79.
Cynoscion carolinensis McDonald, 1882, p. 12.
Cynoscion nebulosus Jordan and Evermann, 1896–1900, p. 1409; Welsh and Breder, 1923, p. 164; Hildebrand and Schroeder, 1928, p. 296.

DESCRIPTION OF ADULT

The adult spotted trout has an elongate body, large, oblique mouth, and protruding lower jaw. The teeth are sharp; two enlarged ones occur at the tip of the upper jaw. The color is characteristic and serves generally to identify the species in its adult stage. The upper half of the body is dark gray with sky-blue reflections, while the lower half is pale silvery. The upper sides are marked with many round black spots, which extend to the dorsal and caudal fins. (See fig. 28.)

DESCRIPTION OF YOUNG

The young of the species differ markedly from the adults, both in color and shape of the caudal or tail fin. Young above 3 inches (8 centimeters) in length are recognized easily, however, by the round black spots on the upper parts of the body as well as on the dorsal and caudal fins.

The smallest specimen obtained in Texas waters measures 7.8 millimeters (about 0.25 inch). This fish has the general elongate shape of the species, and the long, acute snout is particularly marked. The vertical fins are well differentiated, the larval fin fold extending from the vent to the spinous anal fin as well as along the caudal peduncle, both dorsally and ventrally. A pronounced series of dark brown chromatophores is placed in the center of the body and extends approximately from the soft dorsal fin to the caudal peduncle. This series of markings is the beginning of the broad, dark, lateral band, characteristic of fish from 15 to 35 millimeters in length. Another smaller group of chromatophores lies along the ventral edge of the caudal peduncle, a distinctive group of darker pigmentations being present on the

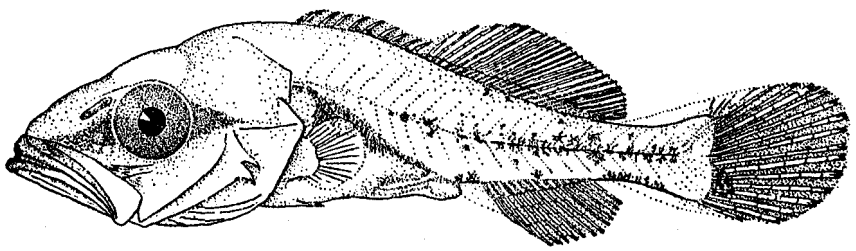

FIG. 24.—Young spotted trout. Actual length, 7.8 millimeters

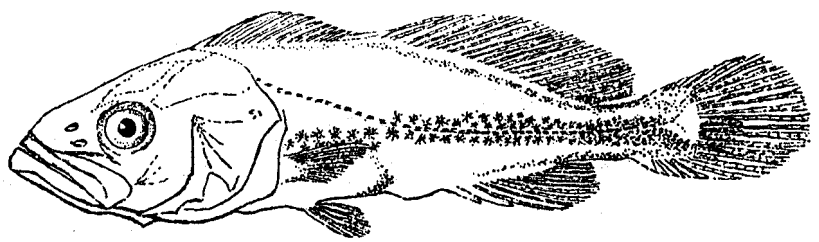

FIG. 25.—Young spotted trout. Actual length, 13 millimeters

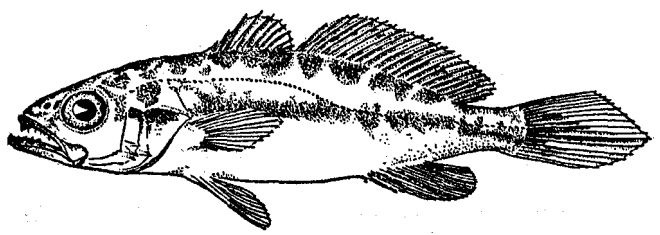

FIG. 26.—Young spotted trout. Actual length, 4.1 centimeters

lower anterior caudal fin. Fine punctulations are apparent behind and above the pectoral fins, as well as from the eye to the snout. (See figs. 24 and 25.)

Young spotted trout from 15 to 30 millimeters have the lateral black stripe most prominent and extending from the snout to the caudal fin in a continuous line. The ground color of the body is light, tinged with yellow and bluish reflections above and with a silvery sheen below. The caudal fin possesses a heavily marked, triangular, blackish area, the apex of which is near the tip of the fin. Fresh specimens have the iris of the eye colored a brilliant golden yellow, which disappears soon after death. The caudal is more sharply pointed in fish under 35 millimeters (1.3 inches). (See figs. 26 and 27.)

SPAWNING AND EARLY DISTRIBUTION OF YOUNG

The spotted trout spawns largely, if not entirely, within the bays and lagoons along the coast of Texas, in contrast to the redfish and black drum, which spawn (probably exclusively) within the Gulf of Mexico. The spawning season of the trout begins in early spring (not before March) and continues as late in the summer as October. The spotted trout do not appear to scatter their eggs within a relatively short period of time, as is the case with the redfish or drum, for individual fish are found in all stages of sexual development throughout the spring and summer and probably spawn for some weeks. The height of the spawning season occurs in April and May, however.

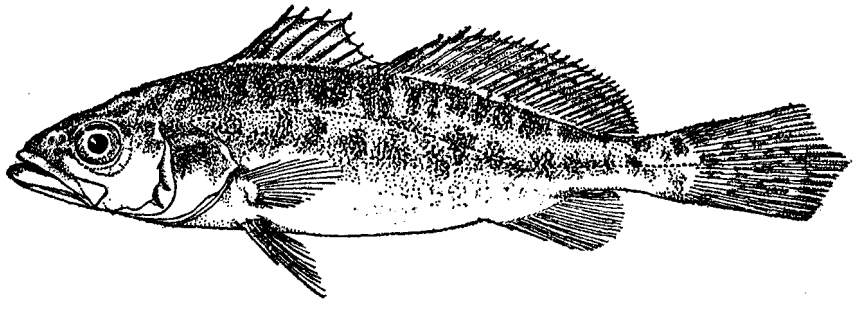

FIG. 27.—Young spotted trout. Actual length, 12 centimeters

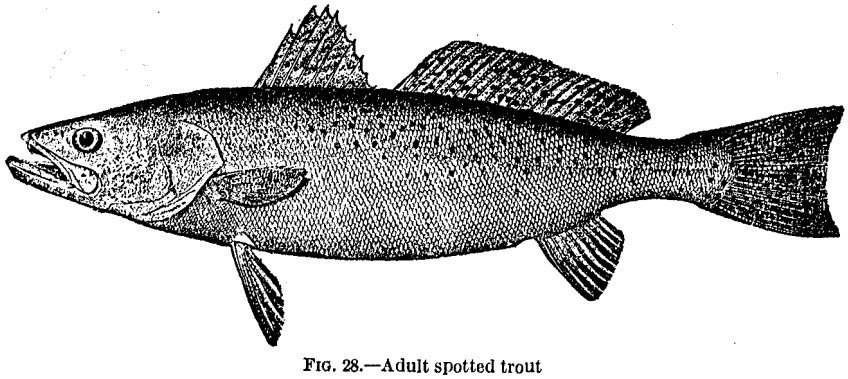

FIG. 28.—Adult spotted trout

The first collection of trout spawned in 1926 was taken on May 13, 1926, along the grassy shore line of Corpus Christi Bay near the channel entrance to Oso Bay. Several young, 10 to 22 millimeters long (under 1 inch), were secured in a few feet of water in the same approximate locality where large numbers of ripe and apparently spawning adult trout were being captured. Four days later another small fish, 18 millimeters long, was seined on the shore of Harbor Island about 1½ miles from Aransas Pass. (See Table 19.) Since Harbor Island was supplied with large numbers of marine organisms brought in from the Gulf of Mexico by the tidal currents, it was thought possible that this fish had been hatched in the Gulf and had entered the intercoastal waters through the pass.

TABLE 19.—*Collections of larval and young spotted sea trout (Cynoscion nebulosus) taken in 1926 and 1927*

Date	Number of fish	Length range, in millimeters	Locality
May 13, 1926	5	10–22	Corpus Christi Bay–Oso Bridge.
May 17, 1926	1	18	Harbor Island Light.
May 25, 1926	1	26	Corpus Christi Bay–Oso Bridge.
June 9, 1926	67	18–50	Corpus Christi Bay–Shamrock Cove.
June 18, 1926	9	30–50	Do.
June 23, 1926	55	18–48	Do.
June 29, 1926	5	37–45	Copano Bay.
July 3, 1926	3	21–22	Harbor Island Light.
Do	6	40–70	Corpus Christi Bay–Ingleside Cove.
July 22, 1926	61	15–27	Grass Island–Espiritu Santo Bay.
Aug. 5, 1926	44	24–61	Corpus Christi Bay–Shamrock Cove.
Sept. 23, 1926	28	28–69	Do.
Oct. 1, 1926	24	9–90	Corpus Christi Bay–Oso Bridge.
Oct. 18, 1926	64	15–68	Harbor Island.
Oct. 20, 1926	1	17	Harbor Island Light.
Oct. 22, 1926	4	22–39	Corpus Christi Bay–Ingleside Cove.
Oct. 28, 1926	3	16–29	Laguna Madre.
Oct. 29, 1926	1	22	Do.
Apr. 20, 1927	1	7	Do.
May 3, 1927	21	9–28	Harbor Island Light.
May 4, 1927	7	21–29	Aransas Bay–Mud Island.
May 11, 1927	2	26–42	Corpus Christi Bay–Shamrock Cove.
May 17, 1927	65	18–50	Copano Bay.
May 26, 1927	4	27–43	Nueces Bay.

Continued observations during 1926, however, soon led to the conclusion that, while considerable spawning of trout occurred along the shore lines of various islands lying inside the passes, no spawning actually occurred in the open Gulf of Mexico. Several definite facts supporting this conclusion were ascertained during the investigation.

As late as October 28, 1926, young spotted trout under 20 millimeters in length were taken within the bays and lagoons, and, together with the presence throughout the bays of ripe and spending adults until late fall, it seemed evident that spawning extended from March or April through September. The spawning season of 1927 contributed more conclusive evidence in support of the bay and lagoon spawning habit of the trout. The first fish, the smallest on record (7.8 millimeters long), was secured in northern Laguna Madre near Corpus Christi Bay on April 27, 1927, on the edge of a deep channel running from the lagoon into the bay by Demid Island–Flour Bluff. For some weeks previous to the capture of this small fish collections had shown the presence of large numbers of ripening trout within most of the bays, following a general movement into the intercoastal waters from the Gulf of Mexico during March and April.

During May, 1927, it was discovered that heavy spawning was occurring in various parts of Copano Bay. Along the grassy shore lines of this remote body of water hundreds of young trout, ranging from 20 to 30 millimeters long (0.8 to 1.1 inches), were procurable, as were also many ripe and spending adults. Small, restricted bayous or creeks that enter the bay proper yielded such abundant collections of very young fish as to preclude any possibility of the young coming into the bay from any considerable distance, certainly not from the Gulf of Mexico, some 50 to 60 miles away. The presence of the young trout with the spawning adults within such

remote bays throughout the spring and summer indicated conclusively that the species spawns within intercoastal waters.

Throughout the period of collection no spotted trout under 10 centimeters long (4 inches) were obtained from the Gulf of Mexico or from the immediate vicinity of any of the passes. This is in strong contrast with the large numbers of young redfish, drum, croakers, and spots spawned in the Gulf and that could be obtained either in the Gulf waters or about the passes. The fact that relatively few larval and post-larval spotted trout were secured by the investigator, compared with the abundant collections of other species, can be accounted for by the nature of the environment in which spawning occurs.

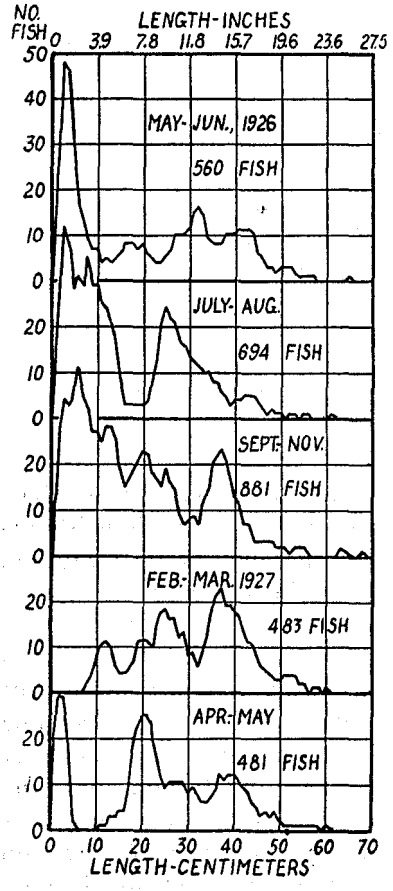

FIG. 29.—Length-frequency distribution of spotted trout in Texas, 1926–27. Actual frequencies have been smoothed by a moving average of threes

Since the eggs of the redfish and black drum were deposited, probably within a short period of time, in a limited area at the mouth of the passes, natural concentration of eggs and larval fish occurred, particularly when the young were carried into the channels of the passes. This concentration made possible large catches of the young fish around the passes. The spawning season of the spotted trout, on the other hand, was observed to be long, and the spawning ground covered wide areas in suitable bays and lagoons. Obviously, no concentration of young fish could result.

Spawning of the spotted trout probably occurs somewhat offshore in the various bays, in water not over 10 to 15 feet deep, although ripe and apparently spawning adults may be taken during the night close to shore. The eggs probably are buoyant and soon drift and hatch over the grassy-bottomed, shallow water, the young seeking protection in the thick aquatic vegetation. The concentration of young in patches of grass was noticeable. Smith (1907, p. 312) stated that the spawning grounds of the spotted trout in North Carolina are in the bays and sounds and that the egg hatches in 40 hours in water with a temperature of 77° F.

GROWTH AND AGE

On the basis of the frequency distribution of the total length measurements of approximately 3,000 spotted trout taken by experimental and commercial collecting gear from May, 1926, to June, 1927, it can be stated that, while size groups appear in the frequency summaries (Table 20 and fig. 29), no one definite year class, save the youngest, can be traced clearly or recognized throughout the entire period of collection. There is a decided tendency for the various age groups to overlap one another to such a great extent as to render any estimations of the growth and age, from length-frequency studies, unreliable. The writer had noted this fact previously with respect

to a series of length measurements made in 1925 upon several hundred spotted trout taken in Pamlico Sound, N. C. (Higgins and Pearson, 1927, p. 56.)

TABLE 20.—*Length-frequency distribution of spotted sea trout (Cynoscion nebulosus) taken in Texas May, 1926, to May, 1927*

Centimeters	1926							1927			
	May	June	July	August	September	October	November	February	March	April	May
1	4					1				1	6
2	10	16	51	1		47					33
3	2	66	29	6	3	22					48
4		50	4	32	15	14					5
5		21	9	21	27	17	1				1
6		22	4	16	12	20	2				
7		9	15	28	22	11	11				
8		7	15	10	12	6	9				
9		10	10	28	10	8	8	5	2		
10	1	4	13	10	7	4	16	5	1		
11	2	3	9	18	8	3	16	6	1		
12	2	1	10	14	4	2	15	11	5	2	
13	6	1	5	15	6	6	24	8	3	2	
14	3		3	17	4	8	14	2	2	3	2
15	6			8	2	4	6	2	2	1	1
16	10				3	1	14		4	2	2
17	6	3		1	4	3	7		4	1	6
18	4	1		7	8	6	5	1	5	6	10
19	8	1		2	14	6	4	2	9	9	20
20	8			1	12	5	4	1	14	11	10
21	4	2	1	5	10	9	5		7	8	18
22	4	1	2	2	8	7	5	3	7	13	16
23	2	3	2	11	9	2		1	12	10	4
24	2	1	7	15	12	6	1	1	18	3	6
25		4	10	15	5	6	3	1	18	5	8
26	2	5	7	17	11	8	4	2	15	2	4
27	1	9	5	12	5	5	2		11	4	6
28	3	9	5	16	3	4		1	18	7	8
29		7	1	13	3	2	2		5	3	1
30	2	8	2	11	4		4	7	8	6	6
31	4	12	2	12	3	2	3		5	2	7
32	2	16	3	8	7	2	1	1	6	2	4
33	5	8	3	8	2	1	1	1	5	5	4
34	4	6	4	5	14	3	2	4	10	1	2
35	1	4	5	4	11	1	6	4	13	2	3
36	3	6	2	5	17	3	3	7	14	11	1
37	3	6	4	3	17	3	5	11	13	6	5
38	2	5	2	2	17	2	3	12	13	9	3
39	5	8	2	2	10		5	7	3	5	6
40	4	7	1	1	9	3	3	10	12	12	1
41	5	2	2	4	3	2	2	9	13	6	6
42	4	10	3	2	6	5		2	6	6	2
43	3	10	3	1	2		1	4	8	6	2
44	1	6	4	3	2	3	1	6	6	4	4
45	5	4	2	1		1		3	3	2	
46	2	1		1	1		2	5	2	5	
47	2	2	2	1	1	1	2	4	1		1
48	3					2		3	1	2	3
49	1	1	3			2		1	1	2	2
50	1	1				2	1	1	2	2	1
51	2	3						3	1		
52	2		1			1	1	2	3	2	1
53	1	1		1				2	1		
54	1				1	3	1	3	1	1	
55	1			1							1
56		1		1		1		1		1	
57		1									3
58								1	1		
59											
60									1		1

TABLE 20.—*Length-frequency distribution of spotted sea trout (Cynoscion nebulosus) taken in Texas May, 1926, to May, 1927*—Continued

Centimeters	1926							1927			
	May	June	July	August	September	October	November	February	March	April	May
61				1				1			
62											
63						1	1				
64							1				
65	1										
66											
67											
68							1				
69											
70											
Total	160	385	267	419	366	287	228	167	316	193	284

From inspection of Table 20 it is evident that during the month of May in 1926 and 1927 the O or youngest year class appeared in the catches at an early age, the

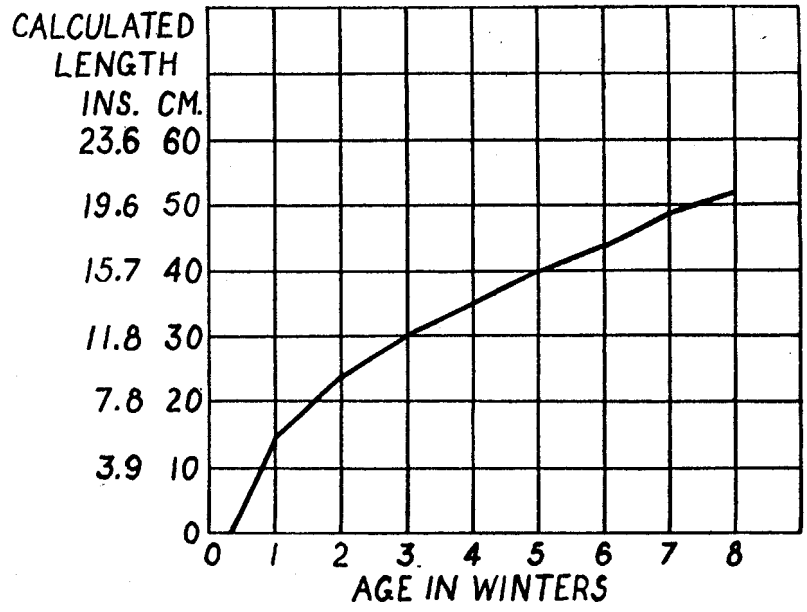

FIG. 30.—Averaged calculated lengths of spotted trout attained at formation of 1 to 8 winter checks. (See Table 23)

length distribution ranging from 1 to 5 centimeters (0.4 to 1.9 inches). The growth during the late spring and summer of 1926 was rapid, but extended spawning occurred from April to October, resulting in a wide length-frequency distribution. By the end of November, 1926, this O class, approaching its first winter, had attained a modal length of about 13 centimeters (5.1 inches), the length distribution being from 5 to 20 centimeters (1.9 to 7.8 inches). There appeared to be little increment in size from November to March, but in early spring growth was resumed, and by the

end of May, 1927, this year class (about 1 year old) reached a modal length of 19 to 20 centimeters (7.4 to 7.8 inches).

Study of the scales of the spotted trout was undertaken in the hope that seasonal-growth checks might be found and from them the annual growth and age of the species determined to a greater degree of accuracy than was possible from inspection of the length frequencies. From annual winter-growth checks (found to have been formed on most of the trout scales examined) it was possible to arrive at a reliable estimate of the age and growth of this species up to the seventh or eighth year of life.

The age of a fish, in years, according to the scale method of age determination, generally is found by counting the annuli or annual winter bands or checks, which supposedly are produced by a slower rate of growth during the cold months of the year. The length of the fish at the end of each year of life is computed from the series of measurements of a scale from a fish of known length. Given the total length of the scale, the length included in its annulus of year X, and the length of the fish from which the scale is taken, the length attained by the fish at the end of year X is determined by the use of the following formula, in which the third term is the unknown.

$$\frac{\text{Length of scale included in annulus of year X}}{\text{Total length of scale}} :: \frac{\text{Length of fish at end of year X}}{\text{Length of fish at time of capture}}$$

Repeating the above formula for the annulus of each evident year of life, the length attained by the fish at the end of each successive year is computed. From these lengths the annual increment in growth is obtained by simple subtraction.

It is not within the scope of the present paper to discuss in detail the various phases of the scale method of age determination. Most workers have found the scale method to be essentially correct, and it is upon this assumption that the writer presents the results obtained from a study of spotted-trout scales. The scales of the gray trout (*Cynoscion regalis*) provided material for a paper by Taylor (1916), and the reader is referred to Taylor's work for such information as may be of interest pertaining to the more theoretical aspects of scale study applied to the sea trouts (*Cynoscion regalis* and *nebulosus*).

The spotted sea trout is a typical warm-water shore fish, which appears very sensitive to the cold and which customarily departs into deeper and warmer water throughout its range on the coming of winter. Along the Texas coast, even as far south as the Rio Grande, this movement into deeper water is evident in the late fall and winter. A cessation of growth probably accompanies lowering of temperature and is reflected on the scale of the fish by a marked change in pattern and structure. The general character of these annual winter scale-growth checks consists in the formation of incomplete bilateral circuli that tend to become compressed, coalesced, or broken. A certain lack of distinctness is apparent in many of these winter checks (annuli), probably due to the intermittent cold weather that obtains along the Texas coast.

From approximately 2,000 unselected spotted trout taken with experimental fishing gear (excluding about 1,000 fish under 10 centimeters (3.9 inches) in length,

obviously in the O year class and not having reached one winter), 554 fish were examined for age by the scale method. From 4 to 6 individual, unselected scales from each of the 554 fish were mounted on a glass slide, the smooth side of the scales being moistened slightly with a mixture of mucilage and glycerine to cause adhesion to the glass. In all cases the scales were taken from the upper forward left side of the fish. The actual counting of the annuli and measurement of the scale with its annual checks was done by two distinct methods of magnification and measurement. Thus, a reliable check was made upon each method employed, as well as on the personal judgment of the writer. It should be stated, however, that knowledge of the life of the species of fish, particularly the time of spawning, assists greatly in understanding many of the annual checks that might appear confusing to one who knows and sees nothing of the fish save several scales, abstractly presented.

The first method used consisted in examining all scales through a binocular microscope at various magnifications and in selecting one typical scale for measurement by means of an ocular micrometer at a standard magnification of about 30×. Upon examination many scales were found to be useless for accurate age determination, some having broken edges, regenerated centers, or other abnormalities. A scale was judged "typical" by the ease with which it could be read and the support obtained from comparison with the other scales on the slide.

The results of the first method, while appearing reasonable, did not seem to be as accurate as would have been the case if a more refined measurement of the scale and its checks had been made. Two hundred of the original 554 fish had to be omitted from the calculations, either because of the imperfections of the scales or the inability of the writer to distinguish the annuli.

The second method, conducted independent of the results obtained from the first method, gave more accurate readings and measurements, in the writer's opinion, although a comparison of the two showed no serious differences. By means of a projection apparatus the image of the scale was projected on a white wall, and each scale annulus was counted and measured at a magnification of about 100×. The various scale and annuli lengths were recorded on adding-machine tape, and the distances were measured later with a millimeter rule. In many cases two scales from the same fish were read and measured for comparison. (See Table 22.) In both methods of scale measurement the distances usually were measured from the center of the focus, along the radius nearest the periphery of the scale.

Of the 554 trout, 452 were read for age and measured for annual growth by the projection method. Of the 452 individuals, 56 were discarded because of apparent discrepancies in the calculated measurements; and while the inclusion of these doubtful 56 fish did not affect the final results appreciably, it was believed desirable to eliminate obvious errors. In the final calculations 396 trout were analyzed by the second method, while 354 were analyzed by the first. The fact that about 28½ per cent of the original number of fish scales were omitted because the writer was unable to read them can hardly be considered serious, since it was thought better to omit questionable scales rather than obtain doubtful calculations.

The spotted-trout scales were collected from April, 1926, to June, 1927. Consequently, the various age classes of fish passed through one observed winter's growth check. The fish taken from April, 1926, to March 1, 1927, show one less winter

check on the scales than do fish secured from March to June, 1927 (the winter scale check usually is formed by March 1). Obviously, a fish 2 years old in 1926 would be 3 years old in 1927.

Table 21, containing the averaged calculated lengths of 396 trout at the time of the formation of the various winter checks, has two divisions—one presenting the averaged calculated lengths of fish of all ages taken from April, 1926, to March 1, 1927, and the other (bottom of table), the averaged calculated lengths of trout taken from March 1 to June 1, 1927. The latter group naturally show the additional winter check formed during the winter of 1926–27.

TABLE 21.—*Averaged calculated total lengths of 396 spotted trout at formation of winter checks on the scales*

Year of hatching	Age, in winters	Calculated lengths, in centimeters, at formation of winter check									Number of fish
		First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	
1925	1	13.5									71
1924	2	14.3	22.9								53
1923	3	14.8	24.2	30.6							54
1922	4	14.6	24.5	30.3	35.2						42
1921	5	15.0	24.5	31.1	36.1	40.5					28
1920	6	15.7	26.1	31.0	35.9	39.2	44.2				16
1919	7	14.6	24.0	29.7	34.4	39.4	44.7	49.1			19
1918	8	14.9	22.6	30.9	36.3	39.6	45.0	48.9	51.8		5
1926	1	13.8									22
1925	2	16.0	22.9								20
1924	3	14.5	24.1	29.6							16
1923	4	16.1	23.9	30.8	36.2						24
1922	5	14.9	22.5	30.5	34.9	41.0					9
1921	6	17.8	23.7	29.1	33.1	38.2	43.6				5
1920	7	16.3	25.0	29.6	33.0	38.6	42.8	48.6			9
1918	9	12.3	26.4	29.9	34.5	39.7	42.6	47.2	50.2	56.8	3
Weighted average		14.7	23.9	30.4	35.2	39.7	44.0	48.7	51.8		
Growth increment		14.7	9.2	7.5	4.8	4.5	4.3	4.7	3.1		

Inspection of this table reveals only slight differences in the various averaged calculated lengths at the same ages for fish ranging from 1 to 8 years of age. The decided absence of any "phenomenon of apparent change of growth rate" (such as observed by Lee (1912) and other workers, in which, with increasing age, the age classes of fish show a decreasing rate of growth in their calculated values for each year of life) is most noticeable. In fact, almost the reverse of Lee's phenomenon appears to be the case, for the youngest fish (those in their second year with one winter check) have the lowest calculated lengths (13.5 to 13.8 centimeters) for the first winter, omitting the calculated length of 12.3 centimeters for three 9-year-old fish.

Table 22, giving a comparison between the averaged calculated lengths of trout derived from measurements of two scales from the same fish, shows in a more distinct manner than does Table 21 the trend of the younger year classes to possess smaller calculated lengths than the older year classes. Averaging the two calculated lengths for fish of the same age, it will be seen that the 1-year-olds have an averaged calculated length of 12.9 centimeters at the formation of the first winter check; the 2-year-olds are 13.6 centimeters; the 3-year-olds are 14.9 centimeters; the 4-year-olds are 15.3 centimeters, and the 5-year-olds are 15.7 centimeters. A similar though much less pronounced progression occurs for the second and fourth years' calculated

lengths. Several natural factors may have caused this phenomenon, directly opposed to Lee's phenomenon of apparent change of growth rate.

TABLE 22.—*Comparison of the averaged calculated lengths of spotted trout, derived from measurements of two scales from the same fish*

[Scales measured by projection method and the total lengths expressed in centimeters. Fish collected from May, 1926, to May, 1927, and selected at random from fish represented in Table 21]

Scale reading	Age, in winters					Number of fish	Scale reading	Age, in winters					Number of fish
	1	2	3	4	5			1	2	3	4	5	
First	13.0					53	Second	14.9	24.3	30.7			28
Second	12.8					53	First	15.6	24.7	30.4	34.8		23
First	14.0	23.0				29	Second	15.1	24.4	29.9	34.5		23
Second	13.3	23.0				29	First	15.1	24.4	32.1	37.0	41.2	8
First	14.9	24.4	31.0			28	Second	16.4	23.9	30.8	36.4	40.3	8

Figure 31, presenting a comparison between matured male and female trout according to size, clearly indicates that a larger percentage of males than females

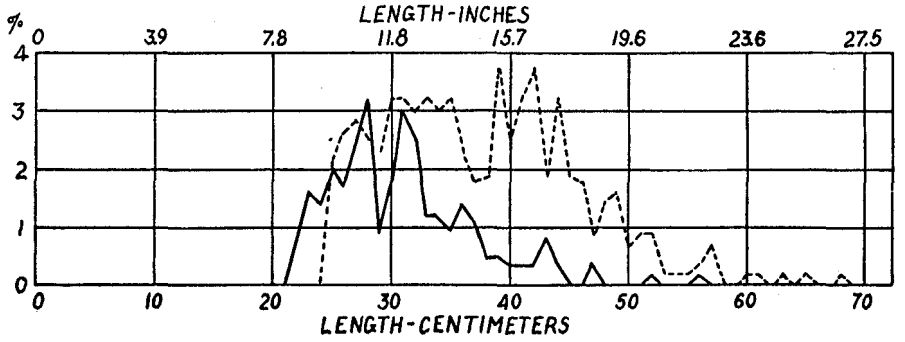

FIG. 31.—Size at maturity of the spotted trout. Males represented by solid line; females by dotted line. Total number of fish, 567

occurs in the smaller sizes than in the larger sizes. Hence, we may assume that in general the younger year classes contain a greater proportion of male fish than do the older year classes. Since the males do not appear to attain the same average mean length as the females (see p. 190), a greater rate of growth might be expected among the latter. Such a condition would result in smaller calculated lengths among the younger year classes with their higher percentage of males and a slightly slower rate of growth than among the older fish composed largely of females. While it is possible to assume that the growth of males and females is identical prior to spawning, and that the females merely reach a greater size (and age) than do the males, the writer hardly believes such an assumption probable, since it is known that in many species of fish the males are smaller than females of the same age.

Another explanation is to assume that the smaller calculated lengths among the younger age groups are the result of the occurrence of greater numbers of "runt" or constitutionally slow-growing fish during the early years of life, but which are eliminated from the fish stock gradually by the natural process of survival of only the largest and fastest-growing fishes. The writer observed often that many spotted trout in their first and second years possessed gill parasites (an isopod, *Livoneca*

ovalis, that generally caused the fish to be undersized, compared with modal lengths for the particular year class) and that older fish were singularly free from them. A greater number of such dwarfed or undersized trout may be expected during the early years, which lowers the averaged calculated lengths for the youngest fish.

While it is impossible at present to attribute any definite cause to this observed difference in calculated lengths according to the age of the fish, aside from the possible error in omitting the first winter's check of more of the older fish than of the younger, the differences among the various calculated lengths at the same age are hardly large enough to vitiate the general conclusions on the age and rate of growth of the species.

TABLE 23.—*Calculated and actual lengths of spotted trout compared*

[Calculated lengths, derived from scale-growth checks generally evident by March, given for fish collected from April, 1926, to February, 1927; actual lengths include only fish taken during March, 1927. The calculated lengths should approximate the actual lengths, but the latter should be slightly larger, since fish taken in March have a newly formed winter scale check plus some additional growth. The calculated lengths for March fish are also presented]

Age in winters	Averaged calculated length, in centimeters, all fish	Total fish	Averaged actual length, in centimeters, March	Number of March fish	Averaged calculated length, in centimeters, March	Age in winters	Averaged calculated length, in centimeters, all fish	Total fish	Averaged actual length, in centimeters, March	Number of March fish	Averaged calculated length, in centimeters, March
1	13.5	71	15.6	14	13.2	4	35.2	42	37.1	16	36.0
2	22.9	53	23.7	8	22.3	5	40.6	28	42.2	4	40.9
3	30.6	54	30.4	10	29.8	6	44.2	16	45.0	1	43.1

The average calculated length of the Texas spotted trout for the first six years approximates that of Florida fish, as indicated by the examination of the scales of 20 spotted trout by Welsh and Breder (1923, p. 165) from Punta Gorda, Fla. Comparison is made between the annual growth of the Texas and Florida fish in Table 24.

TABLE 24

	Calculated average length				Calculated average length		
	Florida fish	Texas fish			Florida fish	Texas fish	
	Cm.	*Cm.*	*In.*		*Cm.*	*Cm.*	*In.*
First winter	11-12	15	5.9	Fifth winter	40	40	15.7
Second winter	23	24	9.4	Sixth winter	43	44	17.3
Third winter	31	30	11.8	Seventh winter	----------	49	19.2
Fourth winter	36	35	13.7	Eighth winter	----------	52	20.4

SIZE AND AGE AT MATURITY

From approximately 1,500 adult trout taken during 1926 and 1927, 567 fish were sexed during the spawning season. The sexed fish were unselected and were either in a ripening, ripe, or spending condition when caught. While it is hardly possible to assume that the relation between sexual maturity and the length of the fish is constant in individuals of the same sex, nevertheless some reliable data concerning size and age at maturity were obtained from the sexing of these fish.

In the case of the spotted trout, as in many marine fishes, the matured male averages smaller than the female, the maximum size being attained by the latter. Of the sexed fish, only 4 males were taken with a length exceeding 45 centimeters

(17.7 inches), while 71 females longer than this were secured. The average mean length of the females exceeded that of the males by 6 centimeters (2.3 inches). The number of females obtained from the sexed 567 fish was 389, a ratio of two females to one male. Many matured fish were under the minimum legal size limit of 12 inches.

Results obtained from the study of the age of the spotted trout would indicate that maturity is attained and spawning occurs for the first time at the end of the second year of life, although it is probable that many fish do not mature and spawn until the end of their third year.

The approximate number of eggs in two nearly ripe trout 48 and 62 centimeters in length (18.9 and 24.4 inches) was 427,819 for the smaller fish and 1,118,000 for the larger one.

Length of fish, in inches (62 centimeters)	24. 4
Total weight of eggs, in grams	238
Total weight of 141 unselected eggs, in milligrams	30
Number of eggs in 1 gram	4, 700
Number of eggs in total of 238 grams	1, 118, 000
Length of fish, in inches (48 centimeters)	18. 9
Total weight of eggs, in grams	87. 3
Total weight of 141 unselected eggs, in milligrams	29
Number of eggs in 1 gram	4, 900
Number of eggs in total of 87.3 grams	427, 819

Figure 32 presents the relation of weight to length in 154 trout. The fish generally reach maturity before a weight of 1 pound is attained. A weight of about 3 pounds is reached by the end of 7 or 8 years.

SEASONAL DISTRIBUTION AND MOVEMENTS

The spotted trout may be taken throughout the year in nearly all of the bays and lagoons along the Texas coast, as well as along the Gulf beaches in proximity to the passes. The species prefers the less turbid, grassy-bottomed areas, and large fish are secured rarely in such muddy waters as Oso and Nueces Bays. Quiet, shallow lagoons and coves, possessing a heavy grass bottom, are the favorite localities for the young trout; while the adult fish generally remain in deeper water, although frequently they come close inshore to feed and possibly to spawn. The young, being spawned within the bays, seldom seek the waters of the Gulf of Mexico until maturity is reached, at about 25 centimeters (9.8 inches), although many adults linger around the entrances to the passes at all times of the year. On the arrival of cold weather most of the trout move off into the deeper waters of the bays or the Gulf. Deep holes or channels that are fished during freezing weather are found to be filled with fish. An example of the movement of trout into deep water during cold waves was afforded during the winter of 1926–27, when a newly completed ship channel near Corpus Christi, at the mouth of the extremely shallow Nueces Bay, became crowded with fish during each cold period. Anglers who fished around the edges of this channel secured heavy catches of trout during the cold weather, but when warm days arrived the fish would scatter over the shallow waters and the fishermen's catches would decrease. Many trout are said to die when caught unawares in shallow lagoons during sudden cold weather, so sensitive are they to the cold.

Many of the larger trout leave for the warm waters of the Gulf of Mexico in winter and in early spring enter the bays in order to spawn and feed. Commercial line fishermen take advantage of this pronounced movement into the bays by fishing in the more shallow passes, such as Corpus Christi, during the early spring months. By May the movement virtually ceases, and the adults distribute themselves through most of the bays. Many trout, both young and old, wander into brackish water, as abundant collections of fish from such localities as Aransas and Copano Creeks show.

In Chesapeake Bay, the northern range of the species, Hildebrand and Schroeder (1928, p. 297) observed two definite periods of abundance—from March to May and from September to November. This fact probably is due to the same general seasonal movements as were observed along the Texas coast—the fish coming into the shallower waters during the spring for spawning and feeding and leaving in the fall for deeper, warmer waters. In the vicinity of Corpus Christi the warm waters of the Gulf are near at hand, and consequently all seasonal movements are less pronounced than in the more northern regions.

Definite schooling prior to and during spawning must occur to some extent, although no very satisfactory evidence could be obtained by the writer. It would appear from collections that small groups of fish make up the spawning units at various localities. This view would seem reasonable for the extended spawning season is hardly in accord with continued schooling of adult fish.

The larger trout travel in small schools, as do the redfish, drum, and croakers, but the movements of these schools are difficult to follow, possibly because of their aimlessness. Young, immature fish usually are well scattered but generally are found in certain localities at all times.

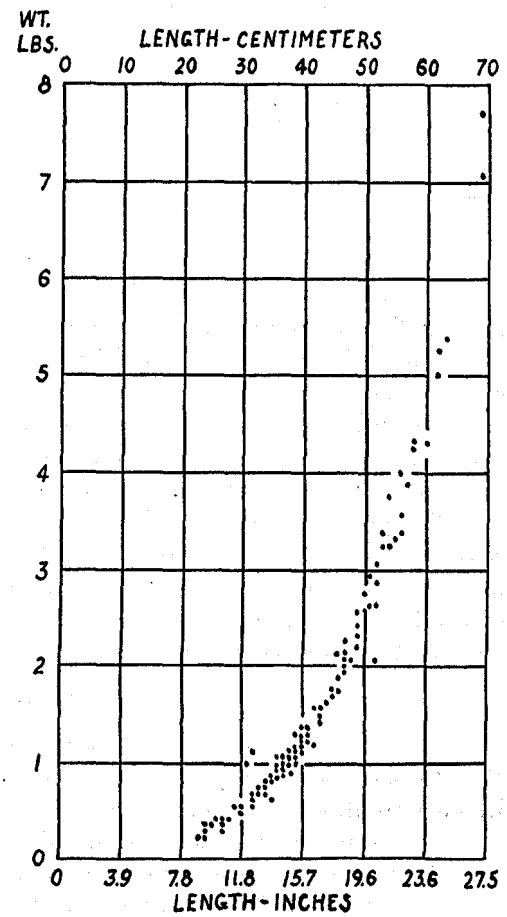

FIG. 32.—Relation of weight to length in 154 spotted trout

FOOD HABITS

The food of the spotted trout, as indicated by an examination of the stomach contents of 220 fish ranging in length from 6 to 60 centimeters (2.3 to 23.6 inches), is composed largely of various species of marine shrimp and fish. Table 25 presents, in percentages of the total number of fish in various length groupings, the preference for definite organisms and also the percentage of the total number of fish of all sizes

that feed exclusively on these definite forms. Of the 220 trout, 61 per cent had been feeding on shrimp exclusively, usually Peneus, 24 per cent had eaten fish, 1 per cent crabs, and 14 per cent mixed organisms. The mixed food usually was composed of shrimp and fish. The food of the trout, according to the size of the fish (6 to 60 centimeters), appears to be fairly uniform in character.

TABLE 25.—*Food preference of 220 spotted trout*

[Mixed food usually consisted of shrimps and fish. All fish taken February to May, 1927]

Length in centimeters	Number of fish	Percentage of fish that had eaten—			
		Shrimp	Fish	Crabs	Mixed
6–15	86	59	26	0	15
16–30	30	80	7	0	13
31–60	104	57	27	3	13
Total		61	24	1	14

The various species of fish captured and consumed by the spotted trout include principally the young of the croaker, spot, and mullet, besides the young and adult Menidia and Anchovia. Small grass-dwelling fishes, such as the gobies, also are eaten extensively,

The avidity of the trout for its favorite food, the shrimp, is attested by the success fishermen have when they use this crustacean as bait. Often commercial hook-and-line fishing is suspended for lack of shrimp with which to bait the hooks.

The preference of the fish for the clear waters of the more quiet, grassy-bottomed coves and lagoons might justly be attributed to the habit of the trout of selecting its food with some care, taking in little mud and débris, as is customary with such species as the black drum, croaker, and spot, which prefer as feeding grounds areas covered with little or no vegetation.

COMMERCIAL CONSIDERATIONS

The spotted trout (squeteague) has commercial importance from Delaware Bay to the Rio Grande. It is essentially a warm-water, coastal fish, the center of its natural abundance being in Florida and the Gulf States. The maximum recorded size for the species is 16 pounds for a fish from Chesapeake Bay. Individuals weighing over 10 pounds are rare, however, particularly along the Texas coast. The fish is always in market demand and brings a good price to the fishermen at all times of the year. Table 26 gives the catch of spotted trout in certain years as shown by the records of the United States Bureau of Fisheries.

TABLE 26.—*Approximate commercial catch of spotted sea trout (Cynoscion nebulosus) in the United States in certain years*

State	Weight, in pounds	Value	Value per pound	Year	State	Weight, in pounds	Value	Value per pound	Year
Florida:					Virginia	418,797	$41,879	$0.100	1920
West coast	1,590,523	$157,169	$0.099	1923	Mississippi	410,294	37,327	.091	1923
East coast	1,198,400	122,854	.100	1923	Alabama	48,910	4,903	.100	1923
Texas	1,523,965	154,238	.100	1923	Maryland	20,000	2,000	.100	1920
North Carolina	913,910	116,316	.128	1923					
Louisiana	783,214	73,031	.093	1923	Total	6,908,013	709,717		

The spotted trout is the most valuable marine food fish of Texas. Its popularity, both as a game and a market species, has lead to many controversies as to the best method for protecting the fish against overfishing.

The commercial catch is made principally with hook and line in and about the passes and channels (which are closed to net fishing) and with drag seines in the more remote open bays and lagoons. A small amount of gill-net and trammel-net fishing is done during the winter, principally along the northern Texas coast, while a few fish are taken at times with light surf seines along the beaches in the Gulf of Mexico. The drag seines, because of their superior efficiency, account for the greater part of the commercial catch.

Besides by the closing of extensive areas to net fishing, the spotted trout are protected by a minimum legal size limit of 12 inches (30.5 centimeters). This limit, in general, allows the species to reach maturity unmolested, as well as to attain an adequate market length.

While the imposition of a minimum legal size limit appears to be justified, both from an economic and a biologic standpoint, there is some question as to the actual value to be derived from closing extensive marine areas to net fishermen while permitting commercial hook-and-line men to operate anywhere at all times of the year. The closure of most of the inland bays (excepting Oso and Nueces) was prompted by a desire to allow the spotted trout to spawn unmolested. Line fishermen assert that when drag seines are allowed to operate in the bays they destroy young trout as well as other food fishes. No concrete evidence in support of this supposition exists, however, since few impartial observers have witnessed extensive seining operations. The usual method of fishing with drag seines within the Texas bays and lagoons allows the entire net to be in the water until all fish are removed. The gradual hauling of the seine permits most of the illegal fish to escape through the meshes, while any illegal-sized fish that may have gilled are removed and thrown back into the water. Extensive fishing operations conducted by the writer in favorable spotted-trout localities failed to reveal the destruction of any appreciable quantity of young fish (the net used was a standard Texas drag seine, such as is employed in the commercial fisheries). While some young fish (not food species in particular) may be dragged along in the detached bottom vegetation, there is little reason for supposing that these fish die when they come into contact with small quantities of this vegetation. By law, as well as from the needs of the fishery, seines full of fish can not be dragged upon dry land. Since such a practice does not exist, to the writer's knowledge, no great destruction of young, unmarketable trout can be possible.

The small, natural passes should be closed to all fishing operations, whether sport or commercial, for extended movements of trout as well as other food fish necessitate the use of these passes. Commercial and sport hook-and-line fishermen congregate in large numbers about the shallower passes, such as Corpus Christi, to take toll of the ripening or migrating trout on their way to or from the bays and lagoons. Such a condition is not favorable to the fish and consequently is detrimental to the fisheries as a whole.

Higgins and Lord (1926, p. 180) pointed out that no evidence could be found that would indicate that the stock of spotted trout along the Texas coast is undergoing

depletion. As stated before, it is not known how to determine the extent to which a fishery may be prosecuted except by actual trial by unrestricted fishing effort. With the present tendency to discourage the use of the most efficient types of fishing gear in Texas, it can not be expected that the annual catch of trout will be increased to any great degree.

SUMMARY

1. The spawning grounds of the spotted trout in Texas lie within the inland bays and lagoons, often close to the passes and the Gulf of Mexico. The spawning season extends from early April to September, and the height of the season is reached in April and May.

2. The young trout are found in large numbers along the grassy-bottomed shore lines in more or less definite localities prefered by the adults as spawning areas.

3. The species attains an average length of approximately 6, 10, 12, 14, 16, 18, 19, and 20 inches by the end of the first to the eighth winter, as indicated by scale study. The extended spawning season, however, causes a wide overlapping of age classes.

4. Sexual maturity is reached by the end of the second or third year, at a time when the fish generally attain a legal market length of 12 inches.

5. The food of the spotted trout consists largely of shrimp and small fishes.

6. The natural passes, such as Corpus Christi, should be closed to all forms of fishing, since they constitute necessary passageways for the trout, as well as other food fish, from the bays into the Gulf of Mexico, and vice versa.

NATURAL HISTORY OF THE CROAKER, MICROPOGON UNDULATUS (LINNÆUS)

CROAKER, HARDHEAD

Perca undulatus Linnæus, Syst. Nat., ed. XII, 1766, p. 483; South Carolina.
Micropogon undulatus; Jordan and Evermann, 1896–1900, p. 1461, Pl. CCXXIV, fig. 570; Welsh and Breder, 1923, p. 180; Hildebrand and Schroeder, 1928, p. 283.

DESCRIPTION OF ADULT

The adult croaker has a rather robust body with a somewhat elevated and compressed back. The mouth is horizontal and inferior, and the chin has several pores and a row of short, slender barbels on each side. All jaw teeth are small. The color is generally grayish silvery above and silvery white below; the upper part of body is highly irridescent in life. The back and sides have many brassy or brownish spots arranged in irregular, wavy, olique bars on the sides. Both sexes are capable of making a croaking sound, which may be heard when the fish is under the water or after it has been removed from the water. (See fig. 36.)

DESCRIPTION OF YOUNG

The larval croaker of about 6 millimeters length is transparent, and the larval fin fold, or membrane, extends from the vent to the anal fin and along the caudal peduncle, both dorsally and ventrally. The vertical fins are fairly well differentiated, the anal rays being distinct and usually having a count of II–8. The dorsal soft rays are not so well developed, and the spines are not yet visible. The pectorals and

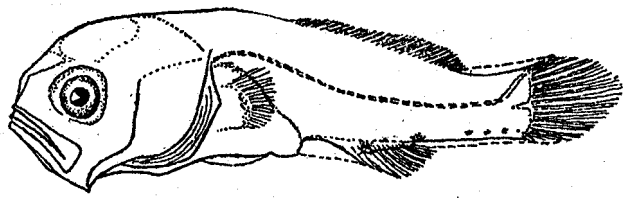

FIG. 33.—Larval croaker. Actual length, 6.5 millimeters

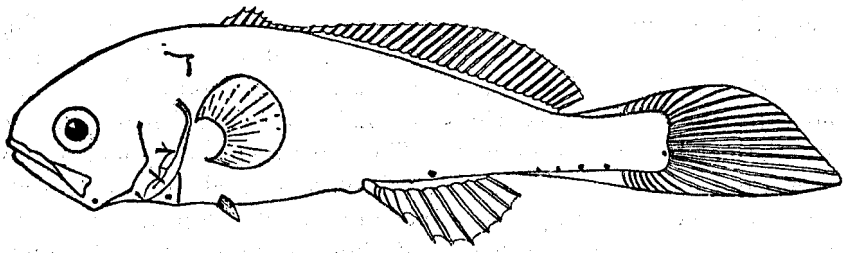

FIG. 34.—Larval croaker. Actual length, 1.225 centimeters

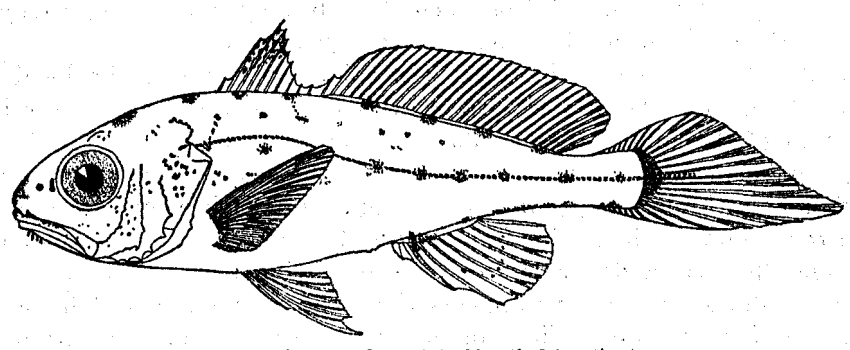

FIG. 35.—Young croaker. Actual length, 3.4 centimeters

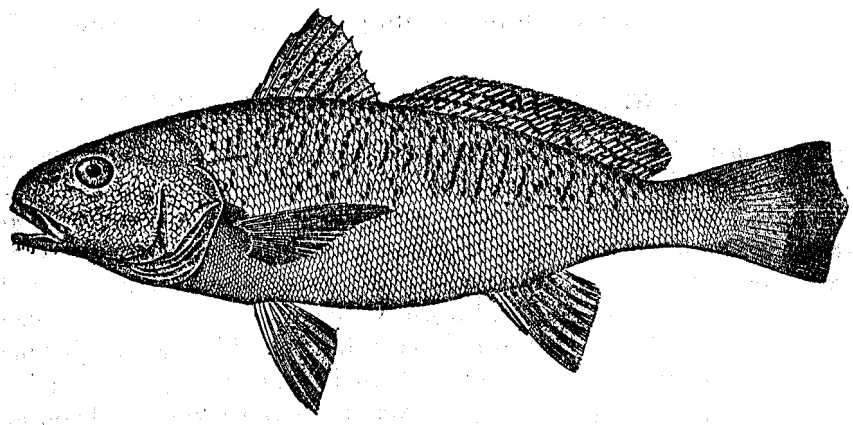

FIG. 36.—Adult croaker

ventrals are inconspicuous. The pigmentation is quite distinctive and helps to identify the larval and post-larval croakers from larval and post-larval redfish and black drum. Two very small chromatophores are at the base of the anal fin—one generally between the first and second soft rays, the other directly posterior to the last ray. The presence of these two markings seems to be constant in all specimens examined, up to a length, at least, at which little doubt exists as to the correct fin-ray count. Three to five small chromatophores lie posterior to the anal fin along the ventral edge of the caudal peduncle. No dorsal chromatophores are evident. (See fig. 33.)

At a length of 11 millimeters a croaker has all rays in the vertical fin distinct, with the usual count of II–8 for the anal and X, I–29 for the dorsal. The fin fold has disappeared, and the caudal fin is now considerably produced, a condition that at once separates the species from the spot (*Leiostomus xanthurus*). Pectorals and ventrals are distinct but not prominent. The ventral chromatophores may or may not be present, but usually are, with the addition of several smaller ones at the base of the caudal fin. Teeth and opercle spines are well developed. (See fig. 34.)

When Texas croakers reach a length of about 30 millimeters (1.1 inches), they closely resemble a 30-millimeter specimen described by Welsh and Breder (1923, p. 182), and their description is given in part. (See fig. 35.)

A croaker 30 millimeters long has the spiny armature of the head strongly developed, the mandibular barbels are in evidence, and the shape of the body approaches that of the adult. The caudal has a flowing extension of the lower rays, the longest ray being about equal to the length of the head. The color (in preserved examples) is pale throughout, punctuated 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 the opercular flap to caudal, a less distinct row lying between these. (In Texas specimens the dorsal row always appears the most pronounced.) The snout, premaxillary, tip of spinous dorsal, base of anal, and base of caudal rays are punctulate with brownish. The adult color pattern is assumed gradually after a length of 3 centimeters is reached, but the fish retains its greatly lengthened caudal fin until a much larger size.

SPAWNING AND EARLY DISTRIBUTION OF YOUNG

Along the coast of Texas the croaker (*Micropogon undulatus*) spawns in the late fall in the open Gulf of Mexico near the mouths of the various passes that lead into the shallow bays and lagoons. Together with the spot (*Leiostomus xanthurus*) this species greatly outnumbers in natural abundance the other members of the Sciænidæ; and, as a result of this abundance, particularly of young, observations on the spawning and distribution of larval and post-larval fish were clear cut and informing.

Soon after the first larval redfish had been discovered in the vicinity of Aransas Pass, Tex., in October, 1926, a deluge of larval croakers filled the pass on each incoming tide. The concentration of the young fish was most remarkable. Thousands were obtained in a short haul with a silk tow net in the deeper waters of the pass itself and thousands more were obtained along the Gulf beach adjoining the pass by means of a small minnow seine hauled along the surf line in a few feet of water. (See Table 27.)

TABLE 27.—*Collections of larval and young croakers (Micropogon undulatus) in Texas 1926 and 1927*

Date	Number of fish	Length range, in millimeters	Locality	Date	Number of fish	Length range, in millimeters	Locality
Mar. 4, 1926	27	30-70	Copano Bay.	Dec. 3, 1926	90	4- 9	Aransas Pass-Gulf.
Apr. 3, 1926	3	40-55	Aransas Pass-Gulf.	Dec. 13, 1926	170	8-30	Harbor Island.
May 6, 1926	12	30-70	Harbor Island.	Jan. 4, 1927	29	11-19	Do.
Oct. 18, 1926	12	7- 8	Do.	Jan. 10, 1927	500	13-24	Aransas Pass-Gulf.
Oct. 29, 1926	200	6-12	Corpus Christi Pass.		14	21-40	Copano Bay.
Nov. 3, 1926	115	10-14	Aransas Pass-Gulf.	Jan. 25, 1927	98	12-27	Aransas Pass-Gulf.
Nov. 5, 1926	3,000	5-11	Aransas Pass.	Jan. 27, 1927	3	14-37	Corpus Christi Pass.
Nov. 16, 1926	1,500	9-17	Corpus Christi Pass.	Mar. 16, 1927	3	13-26	Do.
	2	14-18	Oso Bay.				

During September and October a noticeable migration of ripe adult croakers from the bays to the Gulf was indicated by the frequent collections around the passes and the lessening numbers of fish in the more remote lagoons and bays. It was not expected, however, that a profusion of young would result from this spawning, since the size of the adult Texas croaker rarely runs over 30 centimeters (11.8 inches)—much smaller than the Atlantic coast fish.

Both Aransas and Corpus Christi Passes were fished in order to find young croakers and young redfish, and the confusion that resulted from the mixture of these two species (which resemble each other closely in larval form) was disconcerting to the investigator, who for a time did not know which fish was being taken in such great numbers. Thousands of larval and post larval croakers were obtained, however, compared with the tens of redfish, as comparison of Tables 4 and 27 shows clearly, although much more time was spent trying to find the young redfish.

The young croakers came into the bays from the Gulf on the incoming tidal currents, to be distributed over the many miles of intercoastal waters. A determined attempt on the part of the post larval and young fish to gain the shelter of the bays was observed on many occasions. Few fish could breast the strong current of the ebb tide, but the young croakers, massed in schools, were seen attempting to enter the passes by hugging the sides of the channels and to take advantage of the slower current in the shallower water as well as the counter wash from the Gulf surf, which tended to offset the outgoing current from the bays and lagoons. Careful fishing around Corpus Christi and Aransas Passes showed beyond any doubt that the young were striving to get through the passes into the quiet bay and lagoon waters. This important fact in the life of the fish was observed in the case of the spot, also, and there is no reason to doubt that the other Gulf-spawned Sciænidæ, particularly the redfish and drum, also make a deliberate attempt to reach the bays from the spawning grounds outside of the passes. That such an attempt was not noticed in the case of the redfish and drum probably was due to the fact that these fish occurred in less abundance.

A marked and interesting concentration of post larval croakers was found to take place during the height of the spawning season in November, 1926, in the angle of the rock jetty at Aransas Pass lying on the north side of the pass. Thousands of young congregated along the Gulf beach in the immediate corner of the jetty, while in the opposite angle, formed by the south jetty, few, if any, young

ever were obtained. This concentration was most noticeable during flood or incoming tide, while the ebb tide had the effect of taking the young fish offshore.

While no definite reason for this curious fact was ascertained, it is believed by the writer (in the light of later observations made on the young spots, as well as observations at the time) that this concentration of young on the north side of the pass only was induced by the heavy northerly winds, which caused a more violent surf along the north beach shore than on the protected south side of the pass. This surf probably caused the young to be thrown farther inshore and out of range of the pass inlet, which lies about 1 mile offshore in the case of Aransas Pass. The incoming tide probably would be felt for some distance around the mouth of the pass and would tend to take in all fish within range of its influence. With the surf, plus the movement of water inshore, being particularly strong along the north side of the pass, many young could not get into the current coming in through the pass perhaps and consequently were caused to drift inshore by the angle of the jetty, where they had to remain until the next outgoing tide, which would carry them offshore and nearer the entrance to the pass.

The capture of larval and post larval croakers from October to February (Table 27) indicates that the spawning season extends over a considerable period of time. The great abundance of fish in November, 1926, however, would place the height of the spawning in this month. Welsh and Breder (1923, p. 180) stated that the spawning season of the species is a long one, extending from August to December and possibly later in southern waters. Hildebrand and Schroeder (1928, p. 284) believe that the early part of November is the principal spawning period in Chesapeake Bay, which estimate agrees with the observations made along the Texas coast by the writer.

GROWTH AND AGE

The growth of the croaker during the first two years of life was determined on the basis of the length-frequency distribution of 3,378 fish collected during the course of the investigation. Following a smoothed length distribution of monthly collections, by means of Figure 37, the first period in April, 1926, gave two distinct groups of fish with modal lengths at 9 and 17 centimeters (3.5 and 6.7 inches). The collections made during May brought these modes up to 11 and 18 centimeters (4.3 and 7.1 inches), with considerable overlapping between these two groups of fish (probably of the first and second year classes.) During July, small numbers of fish of the older year classes appeared in the catches, with faint modes at around 21 and 25 centimeters (8.2 and 9.8 inches). These two larger modes probably represented the third and the fourth year classes. Serious overlapping of size groups during August and September throws little light on the growth of any particular year class. During October, a newly spawned year class of fish entered the catch, with a mode around 1 centimeter; while the third year class was represented strongly by a mode at 22 centimeters (8.6 inches). In the winter months of November, December, and January only fish of the new or O year class were taken, owing largely to the fact that all fish above the second year class had gone to the Gulf of Mexico the previous fall

for spawning purposes. During March, 1927, the second year class, spawned in the late fall of 1925, again appeared, possessing a modal length at about 14 centimeters (5.5 inches), and this class became very abundant during the following spring months.

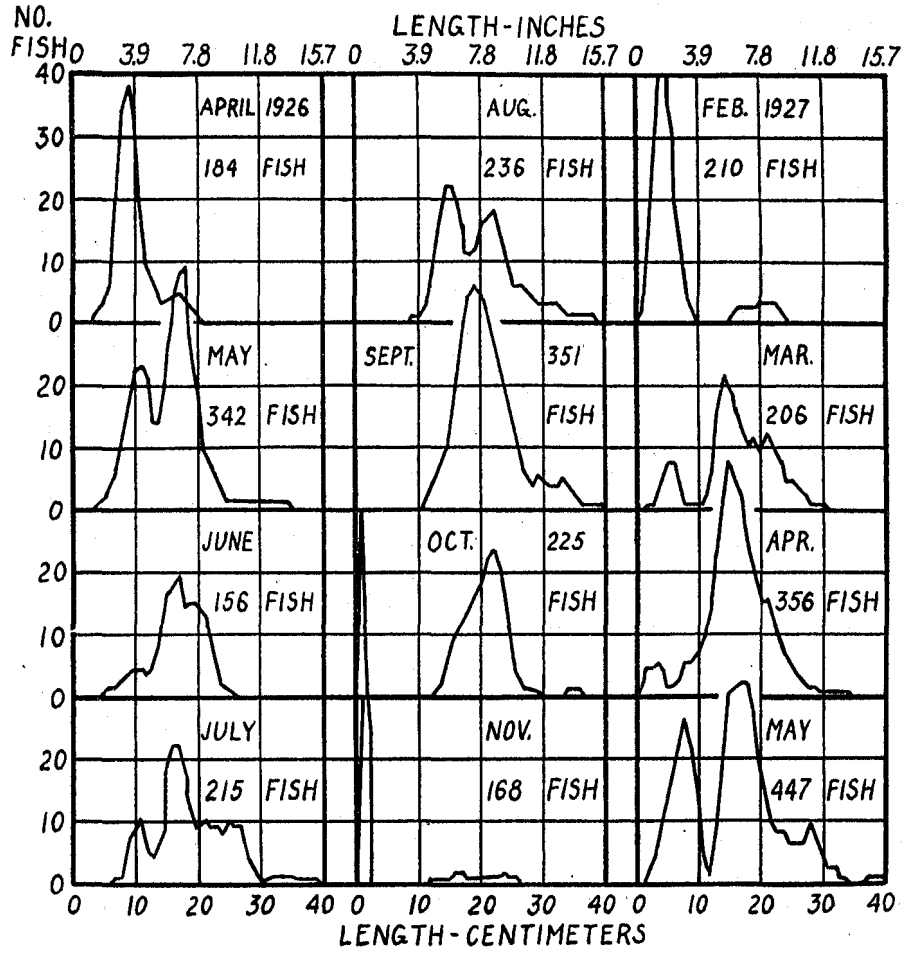

FIG. 37.—Length-frequency distribution of croakers in Texas, 1926-27. Actual frequencies have been smoothed by a moving average of threes

The third year class, with a mode at 22 centimeters in October, 1926, grew little during the winter but apparently attained a length of about 24 centimeters (9.4 inches) by the end of May, 1927. (See table 28.)

TABLE 28.—*Length-frequency distribution of croakers (Micropogon undulatus) taken in Texas, April, 1926, to May, 1927*

Centimeters	1926									1927				
	April	May	June	July	August	September	October	November	December	January	February	March	April	May
1							50	100	50	5	1			
2								50	50	50	7		2	
3									50	50	49	1	12	1
4										6	52	3	4	11
5	5	4								2	35	12	1	16
6	3	3									15	8	1	12
7	16	3	2								10	3	4	28
8	39	13	2	1							8	1	4	25
9	50	20	2	2							1		9	27
10	25	17	5	17	1							1	5	12
11	12	29	4	8	2								8	3
12	9	23	2	4	6	4						3	16	
13	3	15	3	2	15	10		2				16	18	3
14	3	5	9	5	25	3	1	2				27	37	31
15	3	23	15	14	26	10	5			2	3	22	38	33
16	5	36	26	26	16	22	14	3		5	3	12	38	28
17	5	45	10	25	12	32	11	2		10	2	13	30	35
18	5	32	20	16	9	41	12	1		2	3	15	27	36
19	1	29	11	6	13	34	20	1			4	6	14	29
20		12	14	11	15	33	15				3	14	20	24
21		10	16	10	19	37	23	1			5	10	15	14
22		9	9	10	16	23	29	1			5	14	14	8
23		6	4	7	19	19	19	2			1	6	9	7
24			2	10	4	20	14	1			2	4	7	11
25		3		8	6	14	7	2			1	6	7	8
26		1		13	7	8	2					6	4	3
27		1		7	4	3						1	2	9
28				7	4	4	1					1	2	10
29					4	6	1						2	10
30		2			2	7						1	1	3
31				1	2	3							1	5
32				1	4	3							1	
33		1			3	5							2	3
34				2		6							1	
35				1	1	1	1							
36						1								
37					1	1								
38				1										1
39						1								1
Total	184	342	156	215	236	351	225	168	150	132	210	206	356	447

In the last month (May, 1927), during which 447 croakers were measured, the first 4 year classes were present, with all classes save the third marked by distinct modes. At 8, 18, 24, and 28 centimeters (3.1, 7.1, 9.4, and 11 inches), these modes correspond well with the size and age estimates of Welsh and Breder for Atlantic coast croakers, in which they approximate the length attained for the first four winters at 4, 15, 22, and 27 centimeters. A few months of spring growth probably would have brought the Atlantic fish to about the size shown by croakers collected in May, 1926, along the coast of Texas. Length frequencies of 243 croakers taken in Pamlico Sound, N. C., during June, 1925, showed clear modes at 18 and 24 centimeters (Higgins and Pearson, 1927, p. 45), which are identical with the modal lengths of Texas croakers taken in May, 1927.

SIZE AND AGE AT MATURITY

The first collection of croakers with well developed roe and evidently preparing to spawn was taken on September 28, 1926, in Laguna Madre near Corpus Christi Pass, while the last sample of ripe or nearly ripe fish was secured about a month later in the same general locality.

Table 29, giving the length distribution of 230 matured croakers, shows a range in length from 14 to 37 centimeters (5.5 to 14.5 inches) and a modal length for the entire group of 22 centimeters (8.6 inches). This mode corresponds with the actual length-frequency mode for fish caught in October, 1926, and judged to be at the end

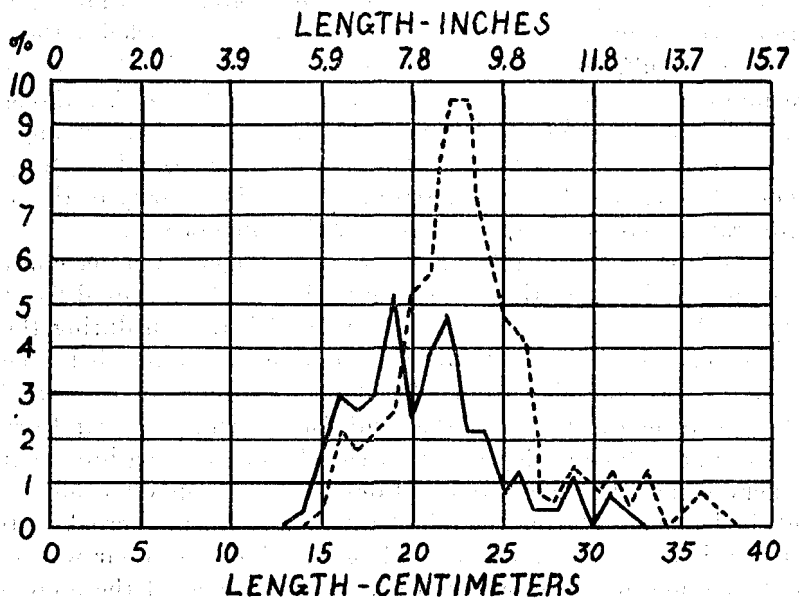

FIG. 38.—Size at maturity of the croaker. Males represented in percentage of total number of fish, by solid line; females, by dotted line. Fish taken at Corpus Christi Pass, Tex., October–November, 1926

of their second year. It appears, therefore, that sexual maturity must be reached and spawning takes place for the first time at the end of the second year of life.

TABLE 29.—*Size at maturity of the croaker (Micropogon undulatus) in Texas, September 28 to October 29, 1926*

Length in centimeters	Males	Females	Total	Length in centimeters	Males	Females	Total
14	1		1	27	1	2	3
15	4	1	5	28	1	1	2
16	7	5	12	29	3	3	6
17	6	4	10	30		2	2
18	7	5	12	31	2	3	5
19	12	6	18	32	1	1	2
20	5	12	17	33		3	3
21	9	13	22	34			
22	11	22	33	35		1	1
23	5	22	27	36		2	2
24	5	15	20	37		1	1
25	2	11	13				
26	3	10	13	Total	85	145	230

Welsh and Breder (1923, p. 183) stated that maturity is reached at the age of 3 or 4 years in the case of the Atlantic-coast fish, but did not explain whether spawning took place at the beginning or at the end of the third or fourth year. Hildebrand and Schroeder (1928, p. 284) estimated the roe of a female croaker, 39 centimeters long (15.3 inches), taken in October, 1921, in Chesapeake Bay, to contain approximately 180,000 eggs of uniform development.

SEASONAL DISTRIBUTION AND MOVEMENTS

After entering the bays and lagoons the young croakers, voluntarily and otherwise, are distributed throughout most of the inland waters. So abundant are they and so hardy are the young that hardly a locality seined or trawled, either within the bays or in the open Gulf, failed to yield large catches. Unlike the redfish and black drum, large numbers of the young croakers remain in the Gulf, although shallow, muddy, brackish-water lagoons and bays hold thousands of the young fish. The young croaker when a year old on the approach of their second winter go into the deeper waters of the bays and Gulf in large numbers, where many of them are caught in the shrimp trawls that operate extensively at this time of year.

By the end of the second year a marked reduction has taken place in the natural abundance of the species. At this time a migration of the matured fish takes place from the bays and lagoons to the Gulf, where the fish remain during the spawning season and the following winter, to return again in small numbers the following spring. Table 29 was compiled from miscellaneous catches of ripe croakers taken from schools of fish on their way to the Gulf for spawning. Near Corpus Christi Pass is situated a large hole or depression in the channel leading into Laguna Madre proper (Packery Channel), which at low tides is almost cut off from the waters of the pass and the lagoon. During the fall of 1925 many ripening croakers temporarily congregated in this hole on coming out of Laguna Madre on their way to the Gulf. Fishing the depression at low tide would give large catches of these croakers, while fishing after the following high tide would reveal that most of them had departed through the pass into the Gulf.

The causes for the probable great mortality after the first and second years of life are unknown, but it is known that the fish seldom reach a desirable market size in Texas waters. It may be that most of the croakers die after spawning, which would explain the sudden decrease in abundance after the second winter. The following quotations from Hubbs (1926, p. 59) may indicate some points to be considered in explaining the smaller size of Texas croakers as compared with fish that dwell farther north.

> The general growth inhibitions often are associated with the ripening of gonads, the attainment of maturity being marked by a cessation of growth in warm-blooded animals, and usually by a sharp decline in the growth rate in the case of fishes and other animals exhibiting indeterminate growth. Accelerating conditions hasten the inception of maturity and the associated decline in growth rate * * * the abrupt and extensive retardation of growth under accelerating conditions of development explains the general observation that fishes of cold or saline waters usually attain a larger size than do individuals or races of the same species inhabiting warm or brackish water, or both.

FOOD HABITS

Of 60 Texas croakers 21 to 35 centimeters (8.2 to 13.7 inches) long, 55 per cent had eaten shrimp; 13 per cent, annelids; 12 per cent, fish; 5 per cent, crabs; 5 per cent, mollusks; and 10 per cent had a mixed diet. Of 19 fish 14 to 20 centimeters (5.5 to 7.8 inches) long, 21 per cent had eaten shrimp; 63 per cent, annelids; 5 per cent, fish; and 11 per cent had a mixed diet. The smaller fish had eaten mainly annelids, particularly polychæt worms, but no crabs or mollusks. Small bottom-dwelling fish, such as gobies and even small croakers, also were found to be the food of some of the fish. Hildebrand and Schroeder (1928, p. 284) stated that the food of croakers in Chesapeake Bay, as shown by 392 stomachs, consists of crustaceans, annelids, mollusks, ascidians, and fish.

COMMERCIAL CONSIDERATIONS

While the croaker is one of the most abundant and valued food fishes of the Middle and South Atlantic States (the average annual catch is about 25,000,000 pounds), the species is hardly represented in the commercial catch in Texas waters. Along the more northern part of the coast a few thousand pounds of small fish are marketed annually, but they are very inferior in size, usually averaging about 22 centimeters in length (8.6 inches) and 3.7 ounces in weight. The lack of any considerable number of croakers above 25 centimeters (9.8 inches) in Texas waters would seem to indicate that the species can never become a leading source of fish supply, in spite of intensive fishing effort. However, the smaller fish, which are marketed to some extent at present, provide a cheap grade of food for those who can not afford the higher prices demanded for the more popular redfish, spotted trout, and Spanish mackerel, and should be utilized whenever possible.

SUMMARY

1. The croaker spawns along the Texas coast from October to February; the height of the season is in November.

2. Spawning takes place in the Gulf of Mexico, and the young fish enter the intercoastal waters or remain along the Gulf beaches in the vicinity of the passes.

3. A total length of about 15 centimeters (6 inches) is reached by the end of the first year, while about 22 centimeters (8.6 inches) is attained by the end of the second year.

4. Maturity is attained at the end of the second year, and few fish appear to live after the first spawning.

5. The croaker is marketed only in small quantities, owing to its inferior size and lack of popularity.

NATURAL HISTORY OF THE SPOT, LEIOSTOMUS XANTHURUS (LACÉPÈDE)

SPOT; FLAT CROAKER; LAFAYETTE

Leiostomus xanthurus Lacépède, Hist. Nat. Poiss., IV, 1803, p. 439; Jordan and Evermann, 1896–1900, p. 1458, Pl. CCXXIII, fig 569; Welsh and Breder, 1923, p. 177; Hildebrand and Schroeder, 1928, p. 271.

DESCRIPTION OF ADULT

The adult spot may be distinguished from other closely related species by its comparatively short compressed body, elevated back, short head, blunt snout, and small horizontal mouth. The color above is bluish gray with golden refections; silvery beneath; the sides have from 12 to 15 oblique yellowish (dusky in preserved specimens) bars in fish above 50 millimeters (2 inches). A large yellowish black spot is found on the shoulder, and the fins generally are pale. (See fig. 42.)

DESCRIPTION OF YOUNG

Young fish, 7 to 15 millimeters long, generally are more slender than the adults and usually are lacking in pronounced pigmentation, which distinguishes them from related species. A specimen measuring 7 millimeters had the larval fin fold extending from the vent to the anal fin, as well as both dorsally and ventrally along the caudal peduncle. The presence of 12 anal rays and the lack of pigmentation on the body separate the fish from other sciænoids. A truncate caudal fin also is a character that serves to distinguish the species in its young stages. (See figs. 39 and 40.) Young spots 20 to 50 millimeters (0.8 to 2 inches) long are quite pale, with the sides of the head silvery and the sides of the body and back with a row of dark blotches composed of dusky punctulations. (See fig. 41.)

SPAWNING AND EARLY DISTRIBUTION OF YOUNG

Along the Texas coast the spot spawns in the Gulf of Mexico in close proximity to the mouths of the passes that lead into the intercoastal waters. The spawning season is extended from late December until the last of March, but the height of the period is reached during January and February. The larval and post larval fish enter the bays and lagoon in great numbers and become distributed over a large extent of territory in a manner comparable to that of the croaker.

The first collection of larval and post larval fish that resulted from the spawning season of 1926–27 was secured on December 23, 1926, in the Gulf of Mexico outside of Aransas Pass by means of a small seine that was swept along the shore north of the rock jetties. A few weeks previous this locality yielded large numbers of larval and post larval croakers, and it was soon learned that the young spots could be taken in the same localities where the croakers were a short time before. The newly hatched spots were extremely abundant around both Aransas and Corpus Christi Passes throughout January and February, and the young spread rapidly throughout all the bays and lagoons. (See Table 30.)

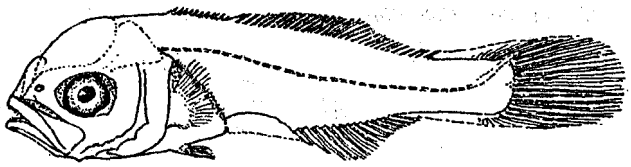

FIG. 39.—Young spot. Actual length, 10.5 millimeters

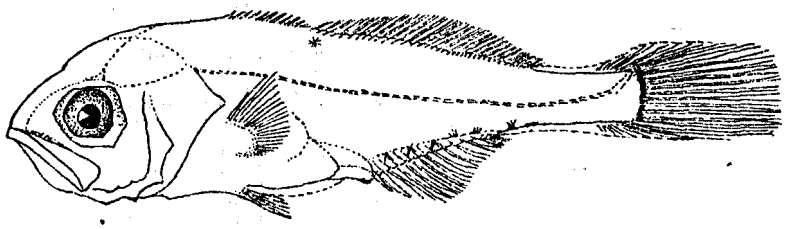

FIG. 40.—Young spot. Actual length, 13.5 millimeters

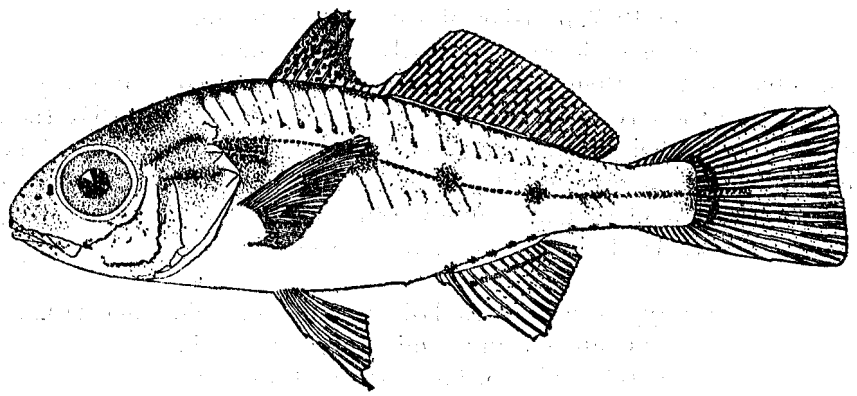

FIG. 41.—Young spot. Actual length, 2.9 centimeters

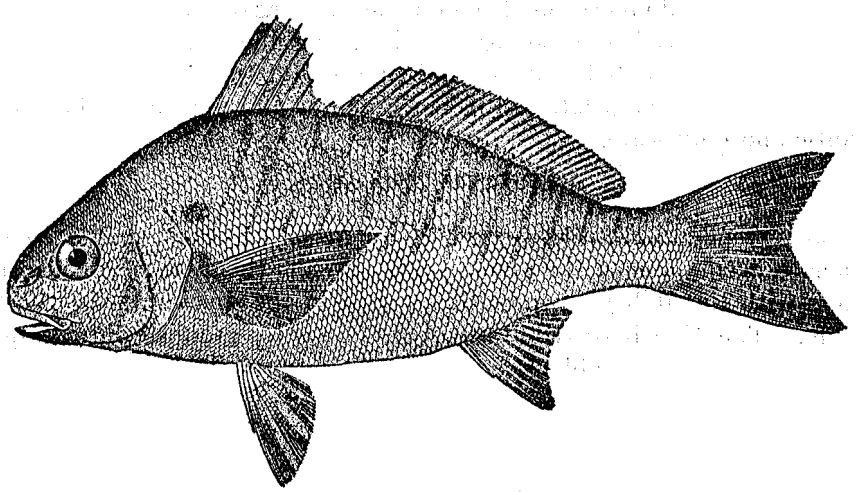

FIG. 42.—Adult spot. Actual length, 16.4 centimeters

TABLE 30.—*Collections of young spots taken in Texas*

Date	Number of fish	Length range, in millimeters	Locality
Feb. 4, 1926	15	11–17	Shamrock Cove.
Mar. 31, 1926	10	13–17	Laguna Madre.
	2	13	Aransas Pass.
Dec. 23, 1926	200	12–15	Aransas Pass-Gulf.
Jan. 4, 1927	14	7–14	Harbor Island.
Jan. 17, 1927	2	18–19	Corpus Christi Bay.
Jan. 20, 1927	160	10–33	Harbor Island.
Jan. 21, 1927	4	11–18	Copano Bay.
Jan. 27, 1927	500	12–22	Corpus Christi Pass.
Feb. 3, 1927	40	9–14	Aransas Pass-Gulf.
Feb. 21, 1927	16	14–29	Oso Bay.
Feb. 28, 1927	500	9–18	Harbor Island.
Mar. 23, 1927	15	11–17	Corpus Christi Pass.
Mar. 24, 1927	3	12–15	Aransas Pass-Gulf.
Mar. 30, 1927	12	12–22	Corpus Christi Pass.

As late as March 30, 1927, post-larval fish were secured on their way into the bays, although the numbers had decreased greatly. The surge of young into the bays made it possible to trace them easily. Observations showed that the young spots not only came into the bays with the incoming tidal currents, but, like the croakers, they sought to gain their way through the passes against the tide. The schools of post-larval fish invariably sought the side of the pass where the velocity of the current was weakest, and a small minnow seine hauled at advantageous points at times secured thousands of the young that were attempting to gain the shelter of the bays.

In Chesapeake Bay, according to Hildebrand and Schroeder (1928, p. 274), "spawning takes place in late autumn and probably in winter and apparently at sea, for in the fall a general exodus of large fish with maturing roe takes place from the bay, the height of this migration occurring during late September and throughout October." This fall migration of ripening adults was observed in Texas, although it was not so pronounced as it appears to be along the Atlantic coast, where the center of abundance is located. Welsh and Breder (1923, p. 177) stated that spawning time for the species is in late fall or early winter and appears to be the same in both Atlantic and Gulf waters.

GROWTH AND AGE

With an extended spawning period, it might be expected that a considerable range in length occurs among the young spots. While this is true in general, it does not interfere with the ability to trace the growth of the species during the first two years of life. The length distribution of 3,471 spots, grouped into approximate 4-week periods, is given in Table 31.

TABLE 31.—*Length-frequency distribution of the spot (Leiostomus xanthurus) taken in Texas from March, 1926, to May, 1927*

Length, centimeters	Mar. 28–Apr. 25	May 2–23	May 30–June 27	July 4–Aug. 8	Aug. 15–Sept. 5	Sept. 12–Oct. 3	Oct. 10–31	Nov. 7–Jan. 9	Jan. 16–Feb. 13	Feb. 20–Mar. 13	Mar. 20–Apr. 10	Apr. 17–May 22
1	4							250	172	48	5	
2	6							30	263	23	15	
3									66	7	22	
4	10	1							77	50	14	
5	36	8							18	12	19	5
6	84	25									27	21
7	53	49	11								35	50
8	28	46	15	1							10	26
9	5	39	6	5							1	20
10		20	5	9								3
11		7	5	10	2	2	2					3
12	1	1	8	9	24	17	27				6	1
13		1	30	10	31	40	39	1	7	1	22	
14	4		26	3	46	40	28		8	3	16	2
15	3	2	9	6	38	12	15	1	8	5	22	13
16	5	1	17	5	18	11	9	3	9	8	25	4
17	17	5	16	24	25	11	6	2	7	6	19	14
18	17	6	6	21	32	25	19	1	5	10	21	22
19	21	5	13	20	49	39	21	1	11	9	22	21
20	25	9	9	18	42	31	13		7	9	4	10
21	9	9	12	6	33	14	7	4	1	5		9
22	3	4	7	8	17	17	5		2	3		3
23	3	1	3	1	8	13	6	2				1
24	1			1		7						1
25	1				4	1	1	1				1
26						1	1					
27					1							
Total	336	239	198	157	370	281	199	296	661	199	305	230

Following Figure 43 (a smoothed frequency graph secured from the data in Table 30), the first period of collection through the weeks of March 28 to April 25, 1926, showed the presence of the first two year classes having modal length at 6 and 19 centimeters (2.3 and 7.4 inches). The youngest or O class grew rapidly during the following summer, reaching a modal length of 13 centimeters (5.1 inches) by October 10 to 31, 1926. Growth of this class during the winter of 1926–27 was not great, but by the end of May, 1927, a modal length of 18 centimeters (7.1 inches) was attained.

The I class, represented by a modal length of 19 centimeters (7.4 inches) in April, 1926, showed very little growth during 1926. At the end of its second year (November to December, 1926) this I class apparently migrated from the bays to the Gulf of Mexico for spawning purposes and did not return to the bays in the spring in any considerable numbers.

The month of December, 1926 (see table 34), brought a new year class of spots into existence. The modal length attained by this youngest or O class by April 17 to May 22, 1927, was about 7 to 8 centimeters (2.7 to 3.1 inches), with a length distribution ranging from 4 to 12 centimeters (1.5 to 4.7 inches). The modal length reached during the period from March 20 to April 10, 1927 (6 centimeters), by this O class was identical with the modal length observed for the O class from March 28 to April 25, 1926.

During the early part of 1926 two distinct modes usually served to distinguish the first two year classes, but after May, 1926, a considerable overlapping between the first and the second year classes resulted, probably owing to the greater rate of

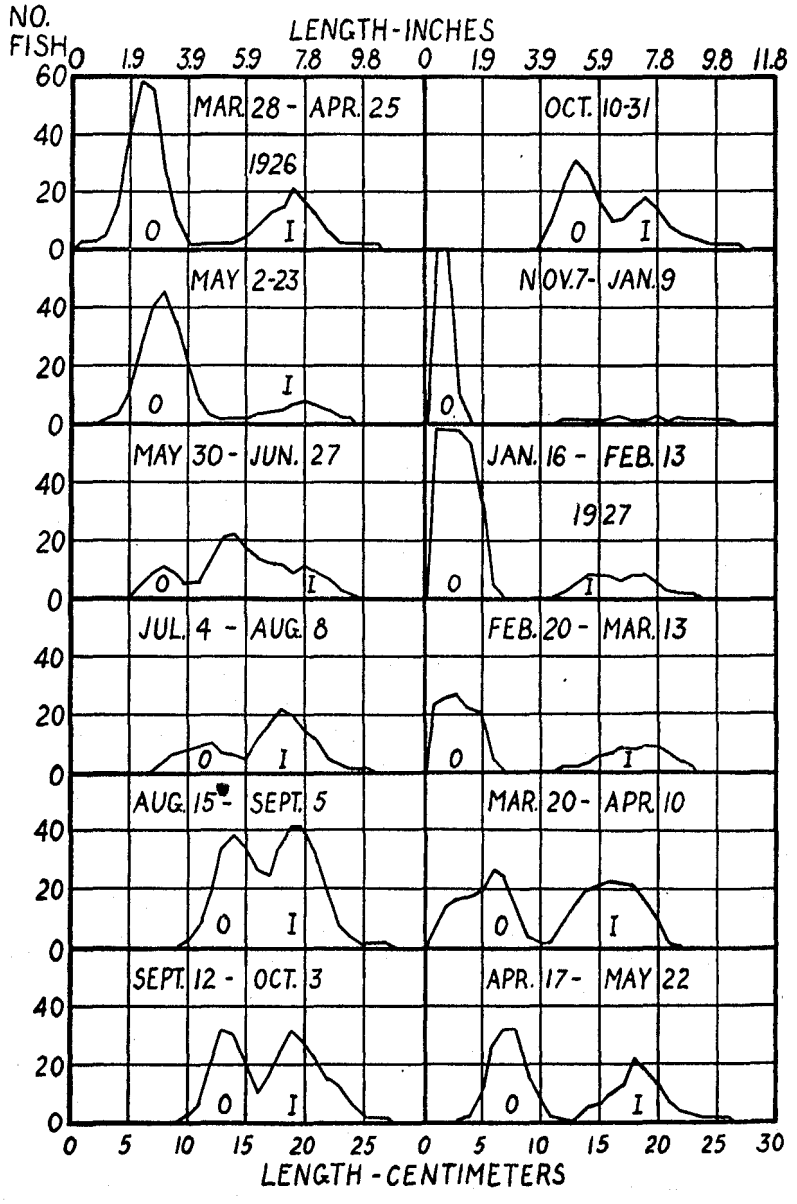

FIG. 43.—Length-frequency distribution of spots in Texas, 1926-27. Actual frequencies have been smoothed by a moving average of threes. Roman numerals indicate year classes

growth of the youngest or O class and the reduced rate of growth of the second or I class. An unusual feature in the length frequencies is the presence in the catch from May 30 to June 27, 1926, of an unusually large number of spots at 13 to 14 centi-

meters (5.1 to 5.5 inches) when the true modes for the two classes would appear, from other collections, to be at 8 and 19 centimeters (3.1 and 7.4 inches). It is assumed that the fish making up this 13 to 14 centimeter mode were composed of rapidly growing fish of the O class or unusually small fish of the I class, or both.

Hildebrand and Schroeder (1928, p. 274) estimated that the spot in Chesapeake Bay attained a length of about 13 centimeters (5.1 inches) at 1 year of age. This is but slightly less than the size reached by the Texas spots, which is about 13 to 14 centimeters (5.1 to 5.5 inches) by the end of the first year and 19 to 21 centimeters (7.4 to 8.2 inches) by the end of the second year. The maximum length attained by the spot is recorded for Chesapeake Bay fish by Hildebrand and Schroeder (1928, p. 276) at about 34 centimeters (13.4 inches). Welsh and Breder (1923, p. 179) stated that fish from 26 to 28 centimeters long, and probably in their third year, were taken abundantly at Atlantic City, N. J., in the summer of 1920. Collections of Texas spots revealed but 3 fish out of 3,471 that were over 25 centimeters (9.8 inches) in length. It must be concluded, therefore, that few fish reach an age of over 2 years in Texas coastal waters.

SIZE AND AGE AT MATURITY

With few Texas spots reaching an age of over 2 years, it seems probable that most of the annual spawning must be done at the end of the second year. Small numbers of ripening adult spots were taken in early December, 1926, near the Passes, and the length distributions of these fish indicated that they belonged to the I class at the approach of the end of the second year. The lengths of the fish ranged from 17 to 21 centimeters (6.7 to 8.2 inches). The migration of the spawning fish out of the bays prevented the taking of large collections of adults.

SEASONAL DISTRIBUTION AND MOVEMENTS

During its first year the spot is extremely abundant in all of the intercoastal waters, as well as in the Gulf of Mexico in the vicinity of the Passes. After entering the bays the larval and young fish tend to remain in the shallower lagoons and coves until the coming of cold weather (the winter following hatching), when many fish move into the deeper waters of the bays and Gulf. Trawls operated in the deeper waters of the bays secure many spots in winter and spring. The young spots, like the young croakers, do not all come into the bays, for many are secured around the Passes throughout most of the year.

A great decrease in natural abundance occurs between the first and second years and particularly at the end of the second year. Along the Atlantic coast the spot has long been known to make a spawning migration in the fall of the year, evidently going out into the deeper waters of the ocean to spawn and for winter protection. This spawning migration takes place along the Texas coast, likewise, and with the general exodus of the 2-year-olds from the bays they disappear forever, for the most part into the Gulf of Mexico.

Hildebrand and Schroeder (1928, p. 274) noticed that spots are very thin and poor in Chesapeake Bay in the spring of the year, indicating that much energy has been spent in the process of reproduction. It may be safe to state that the majority of the spawning 2-year-old Texas spots fail to survive after the first spawning.

FOOD HABITS

No examination was made on the food of the Texas spots. Hildebrand and Schroeder (1928, p. 272) recorded the stomach contents of 157 spots from Chesapeake Bay as consisting mainly of small minute crustaceans and annelids, together with smaller amounts of small mollusks, fish, and vegetable débris. Welsh and Breder (1923, p. 179) mentioned that Florida spots had principally small crustaceans, such as amphipods and ostracods, in their stomachs.

COMMERCIAL CONSIDERATIONS

The spot is not marketed along the coast of Texas to any great extent for the chief reason that few fish of suitable market size are taken in the nets of the fishermen. Occasionally a few fish about 25 centimeters long (9.8 inches) are marketed with mixed catches of fish, but from Corpus Christi to the Rio Grande the species is

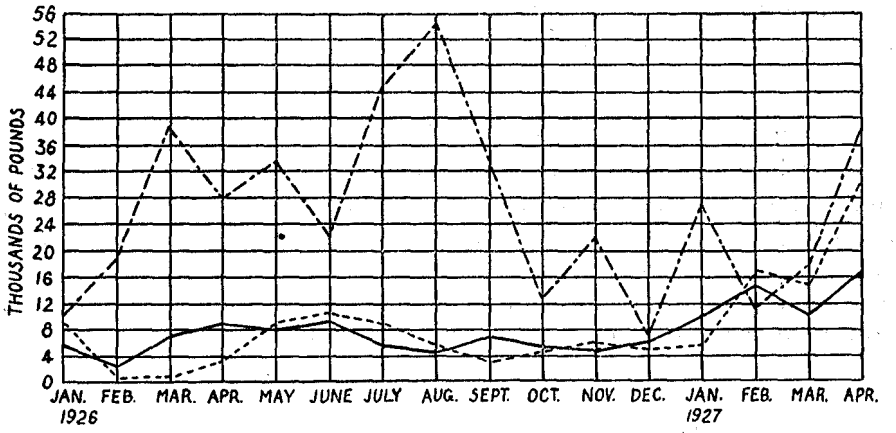

FIG. 44.—Monthly receipts of market redfish (solid line), spotted trout (dotted line), and black drum (dot and dash line) landed at Corpus Christi, Tex., from January, 1926, to April, 1927. Includes only the receipts of the three leading fish dealers

virtually unknown in the market. With the spot, as with the croaker, it would seem that the species does not attain sufficient size to be considered of much value, although it is somewhat of value as a food for other fishes, such as the spotted trout.

SUMMARY

1. The spot spawns in the Gulf of Mexico at the mouths of the passes, and the young come into the bays in great numbers.

2. A length of about 14 centimeters (5.5 inches) is attained by the end of the first year and about 21 centimeters (8.2 inches) by the end of the second year.

3. Spawning occurs at the end of their second year, and after the first spawning most of the 2-year-old fish apparently perish.

4. The species does not attain sufficient size along the coast of Texas for it to be considered a market fish.

SUMMARY OF RECOMMENDATIONS

While certain definite recommendations as to conservation and development of the Texas coastal fisheries have been offered for each species of fish considered in this paper, it seems desirable to present a summarized discussion of them.

At the present time the State of Texas relies upon two major methods of fishery conservation—(1) the imposition of a minimum and maximum legal size limit on certain species of fish and (2) the closing of extensive areas of marine waters to net fishing. The former method, which prohibits the sale or possession of the less valuable redfish under 14 and over 32 inches in length, and the spotted trout under 12 inches, undoubtedly has proved of value both to the fish and to the industry, for it allows the redfish and trout to reach a profitable market size and (in the case of the redfish) protects nearly all of the adult or matured fish.

The black drum never has had the advantage of either a minimum or a maximum size market limit, principally because it has been so abundant in the past and because of its low market value. The day is rapidly approaching, however, when the black-drum stock will be subjected to more intensive fishing than in the past. While several bays that support fish populations consisting largely of drum have been closed to net fishing (Oso and Nueces Bays and Laguna Madre), this protection is offset largely, at the present time, by a fishery operated by a few individuals to capture the large, migrating drum on their way to the spawning grounds. This fishery has been described on page 176. The larger black drum, like the larger redfish, have very little market value but constitute an important element in the annual replenishment of the species. Moreover, many of these larger fish are wasted by the fishery. At the present time sport fishermen and commercial hook-and-line fishermen cast quantities of them upon the beaches to die, and in late winter the local gill-net fishery in Corpus Christi Bay utilizes only the female roes and a small amount of the coarse flesh of the larger fish, which frequently is infested with parasitic worms.

It seems logical, from an economic and biological standpoint, to place a maximum legal size limit on the black drum. This limit should be about 20 inches total length, since few drum larger than this are handled by the more conservative fish dealers, who recognize their general unpopularity and undesirability. As in the case of the redfish, this limit should insure, primarily, a permanent supply of spawning fish. There should be no serious objection to this proposed limit, for it is well known that drum above 20 inches in length are extremely prolific as compared with the younger mature sizes, and that such fish are of slight value to the industry. The further imposition of a minimum legal size limit at 8 inches total length is suggested in order to save the young fish until a time when an adequate market value can be realized.

Along with the imposition of these legal size limits for black drum, it is recommended that Oso and Nueces Bays and Laguna Madre be opened so that the fishing industry may utilize more of the black drum before they attain an undesirably large size. Oso and Nueces Bays yielded fairly large quantities of drum in the past, and the writer believes that if the recommended legal size limits are adopted, commercial seining in these bays can be resumed. The presence in these waters of large areas in which fishing operations can not be conducted (owing to mud bottom, oyster reefs, and débris) will give all the fish a certain amount of protection. While it will cause the fishermen a little trouble to liberate all drum under 8 inches and over

20 inches, it is believed that they would be willing to go to this trouble to secure market catches of the more valuable sizes. Gill nets, or forms of gear that generally cause the quick death of the fish, should be forbidden in both Oso and Nueces Bays and similar waters. Likewise, the opening of Laguna Madre south to and including Baffin and Alazan Bays is recommended. The excessive salinity that occurs at times within the closed section of this lagoon destroys great quantities of fish with no benefit whatsoever to the State of Texas, and better utilization of those fish within the lagoon (mainly black drum) undoubtedly could result from more intensive fishing than is permitted at the present time.

The closing of many inland bays to net fishing has afforded considerable protection to the spotted trout throughout the year. The greater part of the closed territory is considered spawning ground for the trout, although it is known that the closing of such territory throughout the year prevents the taking not only of non-spawning trout but of all other species of fish that come into the closed areas. The assertion has been made (usually by commercial line fishermen, who are allowed to operate in all closed waters) that the bays were closed to net fishing primarily on account of the destructiveness of the drag seines. This view, as stated on page 193, seems to have little foundation, for from extensive tests with commercial seines and from examination of commercial catches the writer found no evidence of serious waste of fish from the use of the drag seines.

The closing of marine waters to the most efficient types of gear brings up the question of whether such a method is the most valuable for properly conserving the spotted trout or whether some better means can be devised, whereby the closed bays may be opened for part of the year. At present large numbers of ripening and ripe trout are captured in open territory by seines and about the passes and in closed waters by hook-and-line fishermen. A closed season during the summer was in effect at one time in Texas, but such a method has the serious disadvantage in a mixed fishery of not only stopping the capture of trout but of all other species of fish as well. The virtual abolition of the entire bay and lagoon fishery during the period of the closed season renders this method decidedly impractical. It is probable that the continued closure of the present closed areas (with the exception of Oso and Nueces Bays, Laguna Madre, and Padre Island Beach) is a better means of conserving the trout, with least harm to the industry as a whole, than any other.

In addition to the continued closure of certain bays, it is urged that the immediate vicinity of all the natural passes, particularly Corpus Christi, be closed to all methods of fishing. It has been pointed out in previous chapters that it is necessary for the redfish, black drum, and spotted trout to use the passes during spawning or seasonal migrations. The passes are the key to the inland waters, and disturbances caused by fishermen and tourists about the smaller, shallower natural passes produce conditions unfavorable to the movement of these fish into or out of the bays and lagoons.

The complete closure of Padre Island beach is believed to be unwarranted, and the opening of this 180-mile stretch of nearly virgin fishing territory to all forms of gear is strongly recommended. Large quantities of food fish of species seldom found elsewhere along the Texas coast occur along this shore line. Robalo or Gulf "pike," pompano, Spanish mackerel, redfish, and spotted trout are found here in considerable numbers. Pound for pound, the most valuable Texas fish, the pompano, occurs in commercial quantities only along the Gulf beaches. Large schools of these fish often

are seen by fishermen along Padre Island, and abundant collections of young made by the writer in 1926 and 1927 near the passes indicate the presence of many adults in the Gulf surf. With the opening of Padre Island, modern surf-fishing gear should be employed by the fishing industry to secure the largest catches of fish. While it is recognized that hordes of sharks and other predaceous fish render fishing here more difficult than in the inland bays, such gear as that used along the coast of Florida certainly would make profitable catches at certain times of the year.

In the above discussion the writer has attempted to present a few recommendations as to practices that he believes will benefit the Texas coastal fishes and fisheries. The proper regulation and development of any fishery, however simple, is a difficult matter, particularly when the many biological and economic factors affecting the fishery change constantly. Some sort of an indicator is necessary to show the trend of abundance of any particular fish stock. Such an indicator is provided in adequate fishery statistics. Should the redfish stock be overfished, this condition would be reflected in the decline of catch per unit of gear, with the result that effort could be made to rehabilitate the stock.

The writer urges the passage of a law requiring the collection of statistical data in Texas, so that the future trends in abundance of the various species of food fishes may be discerned more easily than is possible at the present time. There is no way at present to determine the actual annual catch of any particular species of fish along the Texas coast in any locality, except from statistics collected by the United States Bureau of Fisheries every five years.

For some time several States have successfully operated systems of collecting fishery statistics, which in their general features might be used advantageously by the State of Texas. The most suitable of these consists essentially in securing original records of the daily catch of each species of fish made by each individual fishing boat or unit of gear. Such a record could be collected easily by providing each dealer with manifolding receipt books, in which the landings or original sales of fish should be recorded. A duplicate copy of the receipt should be the property of the State, to be collected and filed for compilation and analysis.

The various facts in the life histories of the redfish, black drum, and spotted trout, as presented in this paper, suggest many new lines for biological investigation of the fisheries. The need for scientific research to determine the exact biological relationship between the Gulf of Mexico and the inland waters, the distribution of fish eggs and young prior to their entrance into the bays and lagoons, and the possibilities in developing a practical method of artificial propagation of the leading marine food fishes offers an abundant field for study. In conclusion, a condensed summary of the above recommendations is given.

1. The establishment of minimum and maximum legal size limits for black drum (the minimum length at 8 inches, the maximum at 20 inches).

2. The opening of Oso and Nueces Bays and Laguna Madre to seine fishing in order to utilize black drum of the more valuable sizes and to prevent the economic waste (in the case of Laguna Madre) of many food fish that now perish as a result of occasional cold weather and excessive salinity.

3. The opening to all forms of fishing gear of Padre Island Beach along the shores of the Gulf of Mexico in order to utilize the large quantity of food fish occurring in this territory.

4. The closing of the immediate vicinity of the smaller natural passes (particularly Corpus Christi Pass) to all methods of fishing, since most of the shore fishes utilize these passes during spawning or seasonal migrations.

5. The adoption of an adequate system of collecting fishery statistics to provide means for learning the trend of abundance of the various species of marine food fishes and to indicate the possible need for modifying existing regulations.

6. The continuing of biological research along the Texas coast to determine the practicability of artificial propagation of the leading food fishes and devising better methods for conserving and utilizing the marine resources of the State.

BIBLIOGRAPHY

HIGGINS, ELMER, and RUSSELL LORD.

1926. Preliminary report on the marine fisheries of Texas. Appendix IV, Report, U. S. Commissioner of Fisheries for 1926 (1927), pp. 167–199, 4 figs. Bureau of Fisheries Document No. 1009. Washington.

HIGGINS, ELMER, and JOHN C. PEARSON.

1927. Examination of the summer fisheries of Pamlico and Core Sounds, N. C., with special reference to the destruction of undersized fish and the protection of the gray trout, *Cynoscion regalis* (Bloch and Schneider). Appendix II, Report, U. S. Commissioner of Fisheries for 1927 (1928), pp. 29–65, 15 figs. Bureau of Fisheries Document No. 1019. Washington.

HILDEBRAND, SAMUEL F., and WILLIAM C. SCHROEDER.

1928. Fishes of Chesapeake Bay. Bulletin, U. S. Bureau of Fisheries, Vol. XLIII, 1927, Part I (1928), 388 pp., 211 figs. Bureau of Fisheries Document No. 1024. Washington.

HUBBS, CARL L.

1926. The structural consequences of modifications of the developmental rate in fishes, considered in reference to certain problems of evolution. American Naturalist, Vol. LX (1926), pp. 57–81. New York.

JORDAN, DAVID STARR, and BARTON WARREN EVERMAN.

1898. The fishes of North and Middle America. Bulletin, U. S. National Museum, No. 47, Part II (1898), pp. 1392–1490. Washington.

LEE, ROSA.

1912. An investigation into the methods of growth determination in fishes. Publications de Circonstance no. 63, 34 pp., 11 figs. Copenhague.

MARMER, H. A.

1927. The truant tides of Tahiti. Natural History, Vol. XXVII, no. 5, September-October, 1927, pp. 431–438, 7 figs. New York.

SMITH, HUGH M.

1907. The fishes of North Carolina. North Carolina Geological and Economic Survey, Vol. II (1907), pp. 306–326, col. pls. 15–19, text figs. 137–146. Raleigh, N. C.

TAYLOR, HARDEN F.

1916. The structure and growth of the scales of the squeteague and the pigfish as indicative of life history. Bulletin, U. S. Bureau of Fisheries, Vol. XXXIV, 1914 (1916), pp. 285–330, Pls. L–LIX, 8 text figs. Bureau of Fisheries Document No. 823. Washington.

VON BAYER, H.

1910. A method of measuring fish eggs. Bulletin, U. S. Bureau of Fisheries, Vol. XXVIII, 1908, Part II (1910), pp. 1009–1014, 2 figs. Washington.

WELSH, WILLIAM W., and C. M. BREDER, JR.

1923. Contributions to the life histories of Sciænidæ of the eastern United States coast. Bulletin, U. S. Bureau of Fisheries, Vol. XXXIX, 1923–1924 (1924), pp. 141–201, 60 figs. Bureau of Fisheries Document No. 945. Washington.