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**UNIVERSITY OF MIAMI**

**Sea Grant Program**

**(Estuarine and Coastal Studies)**

**Abundance of Young Sciaenid Fishes in Everglades  
National Park, Florida, in Relation to Season and  
other Variables**

**Thomas E. Jannke**

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Sea Grant Technical Bulletin #11

Abundance of Young Sciaenid Fishes in Everglades National Park,  
Florida, in Relation to Season and other Variables

Thomas E. Jannke

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## PREFACE

The Sea Grant Colleges Program was created in 1966 to stimulate research, instruction, and extension of knowledge of marine resources of the United States. In 1969 the Sea Grant Program was established at the University of Miami.

The outstanding success of the Land Grant Colleges Program, which in 100 years has brought the United States to its current superior position in agricultural production, was the basis for the Sea Grant concept. This concept has three objectives: to promote excellence in education and training, research, and information services in the University's disciplines that relate to the sea. The successful accomplishment of these objectives will result in material contributions to marine oriented industries and will, in addition, protect and preserve the environment for the enjoyment of all people.

With these objectives, this series of Sea Grant Technical Bulletins is intended to convey useful research information to the marine communities interested in resource development quickly, without the delay involved in formal publication.

While the responsibility for administration of the Sea Grant Program rests with the Department of Commerce, the responsibility for financing the program is shared equally by federal, industrial and University of Miami contributions. This study, Abundance of Young Sciaenid Fishes in Everglades National Park, Florida, in Relation to Season and other Variables, is published as a part of the Sea Grant Program. Graduate research support was provided through a National Defense Education Act Fellowship and Bureau of Commercial Fisheries contracts.

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## INTRODUCTION

Until recently the fish fauna of Everglades National Park has received little attention (see Clark, 1970, unpublished). The larval fish fauna has been almost completely neglected, even for those species which have been studied intensively. Stewart (1961, unpublished) tried to collect the young of the spotted seatrout, Cynoscion nebulosus, without success and Yokel (1966, unpublished) sought larval red drum, Sciaenops ocellata, capturing only 9 specimens. Roessler (1967, unpublished) caught 99 postlarval spotted seatrout. The present study has been conducted to identify a part of the larval fish fauna in the Park and to study changes of abundance in response to changes in season and variations in environmental conditions.

The larvae of relatively few fish have been identified (Berry, in press) so the present study has been limited to the larvae of one important family, the Sciaenidae. This group of fishes support the third largest fishery in the Gulf of Mexico (Gunter, 1967), and two species, Cynoscion nebulosus and Sciaenops ocellata, are among the most sought-after sport fish in Everglades National Park (Rouse and Higman, 1967). Most adult sciaenids spawn outside the estuaries, but usually not far from them (Pearson, 1929; Hildebrand and Cable, 1934; Miles, 1950, unpublished, 1951,

unpublished). The young migrate into the estuaries and remain there for various periods of time. The estuaries are necessary for the survival of the young of most sciaenids (Pearson, 1929; Myers, 1960).

Although studies on some fishes have shown that mortality is highest during early life stages (Marr, 1956; Farris, 1960; Pearcy, 1962b), the ecology of larval fishes is, in general, poorly known. The ecological data available for larval sciaenids has been generated primarily in connection with taxonomic studies. Pearson (1929) and Hildebrand and Cable (1930, 1934) found that young sciaenids live in estuaries. Hildebrand and Cable also found that sciaenid larvae are more common near the bottom than at the surface; Pearson (1941) observed the same distribution. Miles (1950, unpublished) reported that young spotted sea-trout, Cynoscion nebulosus, live in beds of the sea grass, Ruppia maritima. Arnold, Wheeler, and Baxter (1960) collected larval sciaenids in a Texas lagoon, but they did not report their data by individual species so that temperature and salinity information they collected cannot be applied to any particular species.

The objectives of the present study were (1) to identify the larval sciaenids which enter the estuaries of Everglades National Park, (2) to record their seasonal abundance, (3) to investigate the relation between catch and physical variables, of the three most abundant species,

and (4) to investigate the diel variation in catch of the spotted seatrout, Cynoscion nebulosus.

## TERMINOLOGY

The terminology used in this paper follows Berry  
(in press):

Larva--from hatching to completion of formation of the adult complement of rays in all fins (as determined by their staining red in alizarin).

Juvenile--from the end of the larval to the commencement of the adult stage.

Adult--beginning with the attainment of sexual maturity.

## PROCEDURES

The fish used in this study were collected by Roessler and associates during a postlarval pink shrimp sampling program. Collection methods are reported in detail by Roessler and Rehner (in press) and are summarized below.

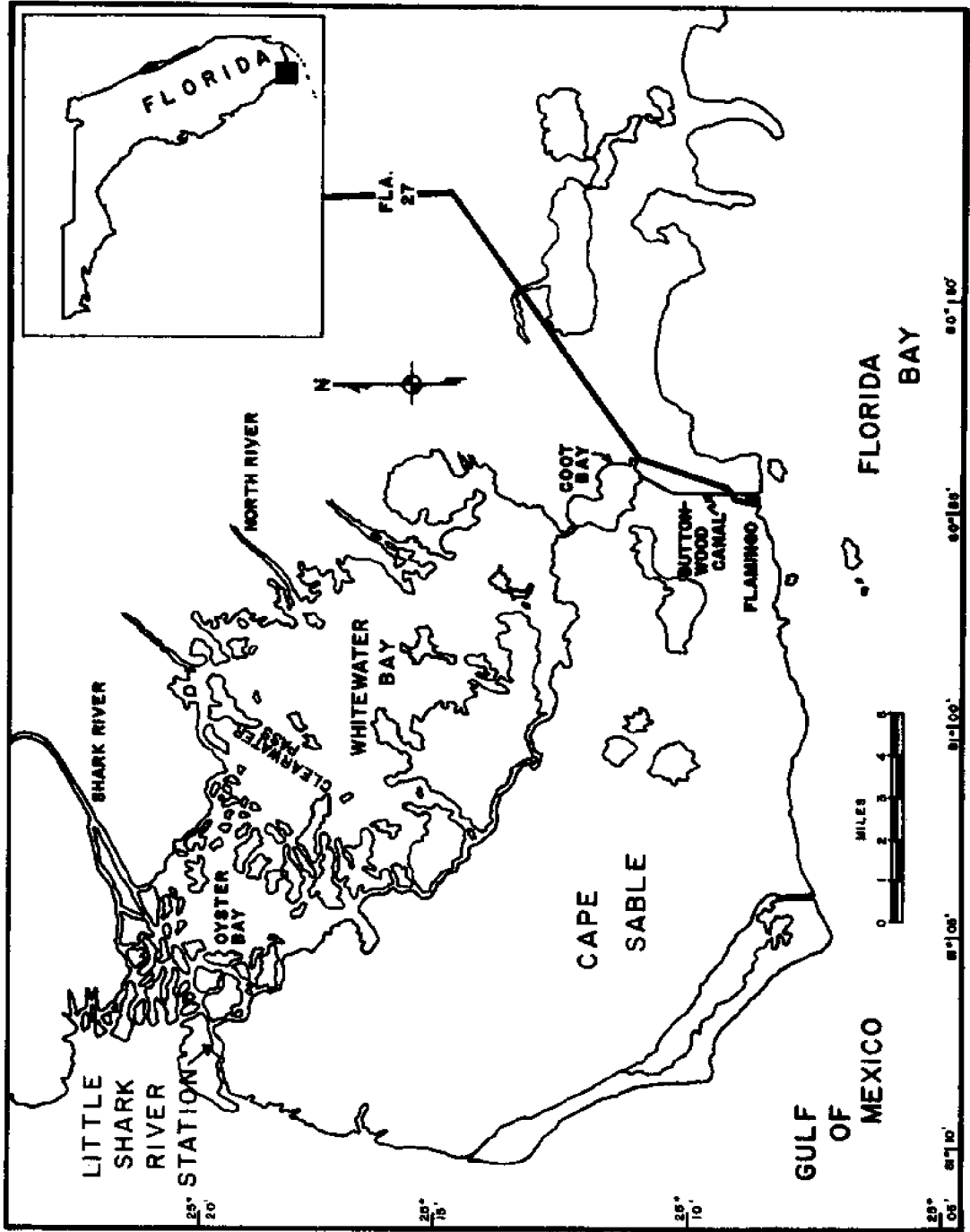
### Area of Collection

Samples were taken at two sites in the Everglades National Park, one in Buttonwood Canal and the other near the mouth of the Little Shark River (Figure 1). Each station is located in a tidal pass through which young fish move enroute to their nursery grounds within the estuary. For this study, however, only the samples from Little Shark River were used because there the catches were larger and the fish were younger.

The Little Shark River is a channel about 6.5 km long which connects Oyster Bay and the Gulf of Mexico. Tidal currents are mixed semi-daily (Marmer, 1954) and are greatly affected by wind (Tabb and Dubrow, 1962).

At the sampling station the Little Shark River is about 100 m wide and 3-5 m deep. The bottom is scoured by tidal currents; it has some sponge and algal growth. The banks are steep, and are composed mostly of peat deposits.

Figure 1.--Map of Whitewater Bay, Florida, showing  
location of Little Shark River sampling station





## Sampling Gear

The primary sampling gear was one meter plankton nets with 471 mesh mylon netting. Each net was equipped with a flow meter attached to the middle of the frame by elastic cords. The cod end of the net was attached to a plastic ring tapped to receive a half gallon specimen jar. Two nets were fished, one near the surface and one about 0.5 m off the bottom. The bottom net was weighted with lead tied about 0.5 m from the frame (Roessler and Rehrer, in press).

## Sampling Procedure

Samples were collected on flood tides which occurred between the end of nautical twilight in the evening and the beginning of nautical twilight in the morning (U.S. Naval Observatory, 1966, 1967), except during July 1967 when stations were sampled hourly for 24 hours on each moon phase.

At each station an anchor and buoy were fixed in the middle of the canal. At slack low water, temperature and salinity samples were taken from a boat tied to the buoy. Temperature was read to the nearest 0.1° Celsius. Salinity samples were taken at the surface in plastic bottles and returned to the laboratories where they were read with an optical refractometer. The readings were recorded to the nearest 0.1 parts per thousand (ppt) but they should not be considered more accurate than 0.5 ppt. A tide staff permanently fixed in position was read to give the depth of the canal.

Surface and bottom water velocity readings were made with mechanical flow meters before and after each plankton tow. The surface meter was held so that it was approximately 0.5 m below the surface. The bottom meter was weighted so that when the lead touched bottom the meter was approximately 0.5 m from the substrate. Both meters were equipped with vanes which held the meter into the current.

In sampling for shrimp the vessel was freed from the buoy and when both engines registered 1000 rpm the nets were lowered. The bottom net was released first to prevent crossing of the warps. When both nets were in the water a timer was started and the nets were towed for 10 minutes. In the middle of the tow a salinity sample was taken and the water temperature recorded. After returning to the buoy and anchoring, the nets were washed and the plankton was preserved in 10% formalin.

At the beginning of the experiments samples were taken at 45-60 minute intervals throughout the flood tide. Later, when it had been determined that [shrimp] catches were roughly proportional to the velocity, sampling was reduced to that period of the tide before the maximum tidal velocity (Roessler and Rehrer, in press).

For the samples used in this study, all tows were taken by the latter technique except that:

In July-August 1967 a series of 24-hour stations were occupied. The sampling procedure was identical with the above methods except that samples were taken hourly for a full 24 hours regardless of tidal conditions (Roessler and Rehrer, in press).

During spring and summer, tows were made on all major moon phases ( $\pm 3$  days), whereas during winter, tows were made only on new and full moon phases ( $\pm 3$  days). This was done because shrimp are most abundant during the summer, and because "catches were generally highest on new moons and lowest on full moons so that by using the combined new and full moon catches an average monthly immigration index was obtained" (Roessler and Rehrer, in press).

#### Processing Procedures

The samples were taken to the laboratory. The staff

of the shrimp project separated postlarval pink shrimp and the fishes from the samples. I separated the sciaenids from the other fishes and put them in 40% isopropyl alcohol for storage.

#### Identification of Larval Sciaenids

Larval fishes are difficult to identify. Berry (in press) has discussed problems encountered in studying larval fishes and has evaluated the techniques most commonly used. The methods used to identify larvae in this study follow Berry's outline. He stressed the importance of knowing the faunal composition of an area before trying to identify the larvae, so a list and descriptions of sciaenids occurring in Florida, the Gulf of Mexico, and the Caribbean Sea were collected (see Meek and Hildebrand, 1925; Briggs, 1958; Lowe, 1966). Sciaenids are well-known taxonomically (Robins and Tabb, 1965) so there is little chance of undescribed species being caught. There are two undescribed species of Pareques living in Florida (Dr. R. V. Miller, personal communication), but since this genus is restricted to reefs (Myers, 1960) it probably does not occur in the brackish areas of the Park.

Irwin (personal communication) is reviewing the genus Menticirrhus on a world-wide basis and has found that the minkfish, M. focaliger, is not a valid species. Clinal changes in meristic characters of the northern kingfish,

M. saxatilis, caused Ginsburg (1952) to describe populations in the Gulf of Mexico as a new species.

For Atlantic and Gulf coast sciaenids most of the larvae have been described and the descriptions are accurate. Descriptions and drawings found in Kuntz (1914), Welsh and Breder (1924), Pearson (1929, 1941) and Hildebrand and Cable (1930, 1934) were useful for identifying young sciaenids during this study. Other useful references, pertaining more to juveniles and adults, were Jordan and Eigenmann (1889), Jordan and Evermann (1898), Ginsburg (1930), Moffett (1957), Guest and Gunter (1958), Robins and Tabb (1965), and x-ray records from the files of the Bureau of Commercial Fisheries.

Specimens of nearby all sciaenids which occur in Florida's waters were cleared and stained by the trypsin-alizarin red technique (Taylor, 1967) in case internal characters were necessary to identify fishes.

Preserved specimens were obtained from the Tropical Atlantic Biological Laboratory, of the Bureau of Commercial Fisheries, but the smallest fish available in those collections was about 6 mm. To facilitate identification of all the fish, a reference collection, consisting of a size-sequence of larvae and small juveniles, was compiled for each species in the samples (see Figures 17 through 24 for diagrams of selected specimens). This collection was made by identifying a fish which had its full complement

of rays and then identifying progressively smaller specimens by comparison with larger ones. Pigment pattern and general body shape were the most useful characters when meristic ones could not be considered dependable.

The genus Menticirrhus presented the only serious taxonomic problem: meristic counts do not clearly separate the three species found in Florida. X-ray studies (for technique see Bonham and Bayliff, 1953; Sutherland, 1958) and clearing and staining revealed no internal differences for these three species. Normally, young northern kingfish, Menticirrhus saxatilis, can be distinguished from the other two species because they usually have one more anal fin ray and because their pigmentation is distinctive (Hildebrand and Cable, 1934). Pigmentation can be quite variable within a species and during ontogeny, however, which caused some difficulty. I am certain that those individuals identified as M. saxatilis have been correctly identified.

Southern kingfish M. americanus and Gulf kingfish, M. littoralis, can be separated easily only after chest scales have formed and the pectoral fin ray formation is complete. The few individuals, large enough so that these characters were useful, were M. americanus. For smaller individuals pigment pattern and body shape were the only useful characters. For fishes as small as 6 mm SL, diagrams, descriptions, or preserved specimens were available. There are differences in fin and belly pigmentation (see Hildebrand

and Cable, 1934) between these two species at 9 mm SL. My 9 mm fish had the color pattern of M. americanus and it was maintained in fish as small as 4 mm. The caudal fin of one specimen resembled that of M. littoralis (Figure 21).

Identifications of fishes smaller than 4 mm SL must be considered tentative. Hildebrand and Cable (1934) have described M. americanus as small as 1.7 mm and Welsh and Breder (1924) have described M. saxatilis from hatching to 2.8 mm. By using a size-series, I concluded that no fishes below 4 mm SL were M. saxatilis. The larvae looked like M. americanus described by Hildebrand and Cable, but since those authors did not have complete size-series of both M. americanus and M. littoralis, their work cannot be considered definitive.

Young M. americanus enter estuaries readily whereas young M. littoralis rarely do, the latter being restricted almost completely to the shallows on the seaward side of the beach (Hildebrand and Cable, 1934; Gunter, 1945; Joseph and Yerger, 1956; Springer and Woodburn, 1960; Bearden, 1963; McFarland, 1963). The fish in these samples were caught entering an estuary, which suggests that they are M. americanus.

#### Measurement Procedures

Larval fish are easily damaged and bent out of shape during collecting and preserving. Fish with only slightly

arched backs, or with lateral bends, were measured and counted, but more seriously damaged fish were just counted. Laterally bent fish were flattened before measuring by holding them tightly against the bottom of the viewing vessel with a pair of flexible forceps. Fish which were too badly damaged to be identified were neither measured nor counted.

Measurements were made with an ocular micrometer and the lengths were recorded to the nearest half-millimeter.

#### Types of Measurements

Larval fish lack hypural bones at hatching, but develop them as they grow. For the sciaenids studied, the bones may have formed when a fish was as small as 2.5 mm or as large as 4.5 mm; they formed most commonly when the fish was between 3.0 and 3.5 mm SL. Consequently, two types of measurement, notochord length and standard length, were employed. They are defined following Berry (in press):

Standard length--from the snout tip, through the horizontal body axis, to the end of median bones at the caudal base (the hypural bones) (SL).

Notochord length--from the snout tip to the tip of the notochord prior to its dorsal flexion and afterwards to a perpendicular of the horizontal body axis through the tip of the upturned notochord (NL).

These two measurements are superior to total length or fork length because of frequent damage to fins of larval fishes and because of allometric growth of the caudal fin.

The SL measurement is not precise until horizontal alignment of the median hypural bones is completed, but it can be approximated once the hypural elements begin to form (Figure 2). If the hypural bones were not properly aligned, the standard length was measured to the division between upper and lower sets of bones (Figure 2). This division was sometimes difficult to find; if a notch existed between the dorsal and ventral sets of hypural bones, this was used, but if no notch was present and the hypural bones were sufficiently developed to distinguish individual ones, the measurement was taken to the point where the small, most dorsal bone of the ventral series and the large, most ventral bone of the dorsal series met (Figure 3). In no case was the division located simply by counting elements of one series, because opaque tissue could easily obscure one or more of them.

Since the two measurements are not the same (notochord length is larger) and since the mean length of the fish in each sample was to be calculated, it was necessary to adjust notochord length to standard length. The method chosen was a regression analysis, because the resulting equations could be used to adjust the NL measurements mathematically. This technique is artificial, but it is more realistic than assuming that the two measurements are equivalent or measuring all fish below a predetermined size to NL and all fish above that size to SL.



Figure 2.--Diagrammatic larva (Thunnus albacares) indicating reference features for measurements of specimen lengths.

(A) Early larval stage with notochord straight and caudal bones not formed. (B) Mid-larval stage with caudal elements forming and notochord flexing. (C) Late larval stage with caudal elements formed and notochord completely flexed (Figure 1 from Berry and Richards, in press).

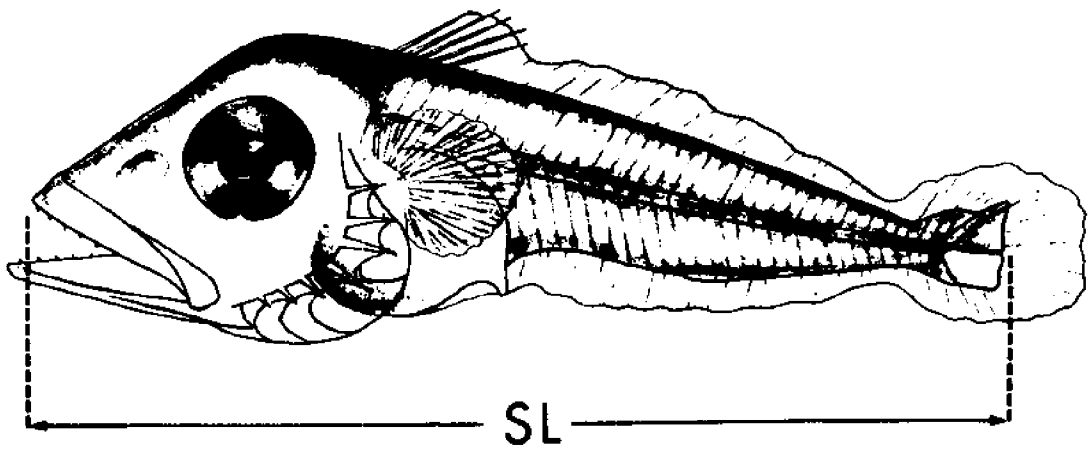
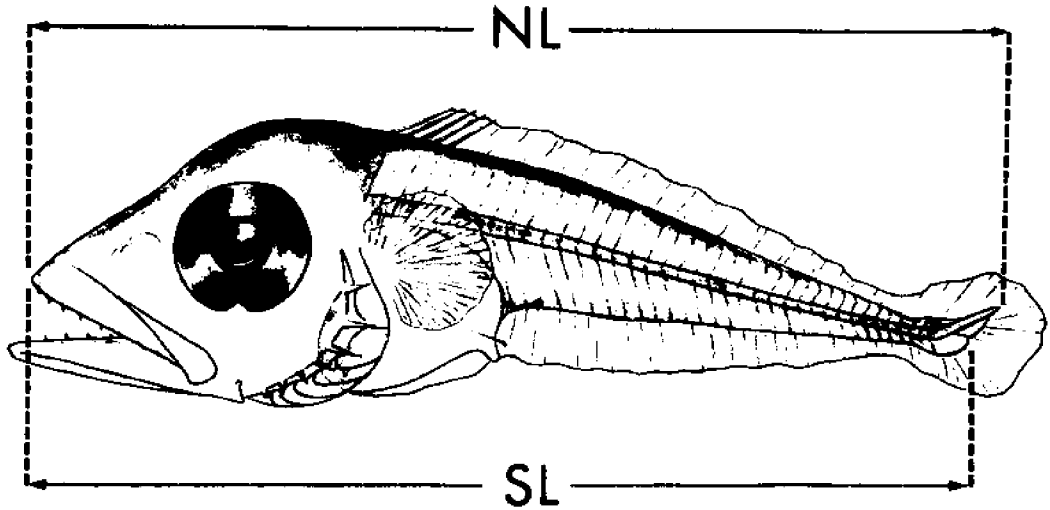
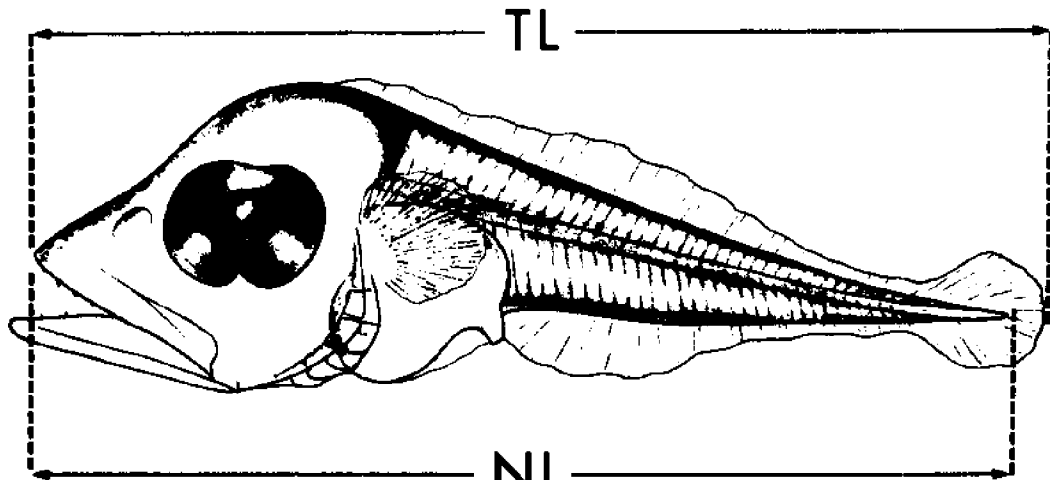
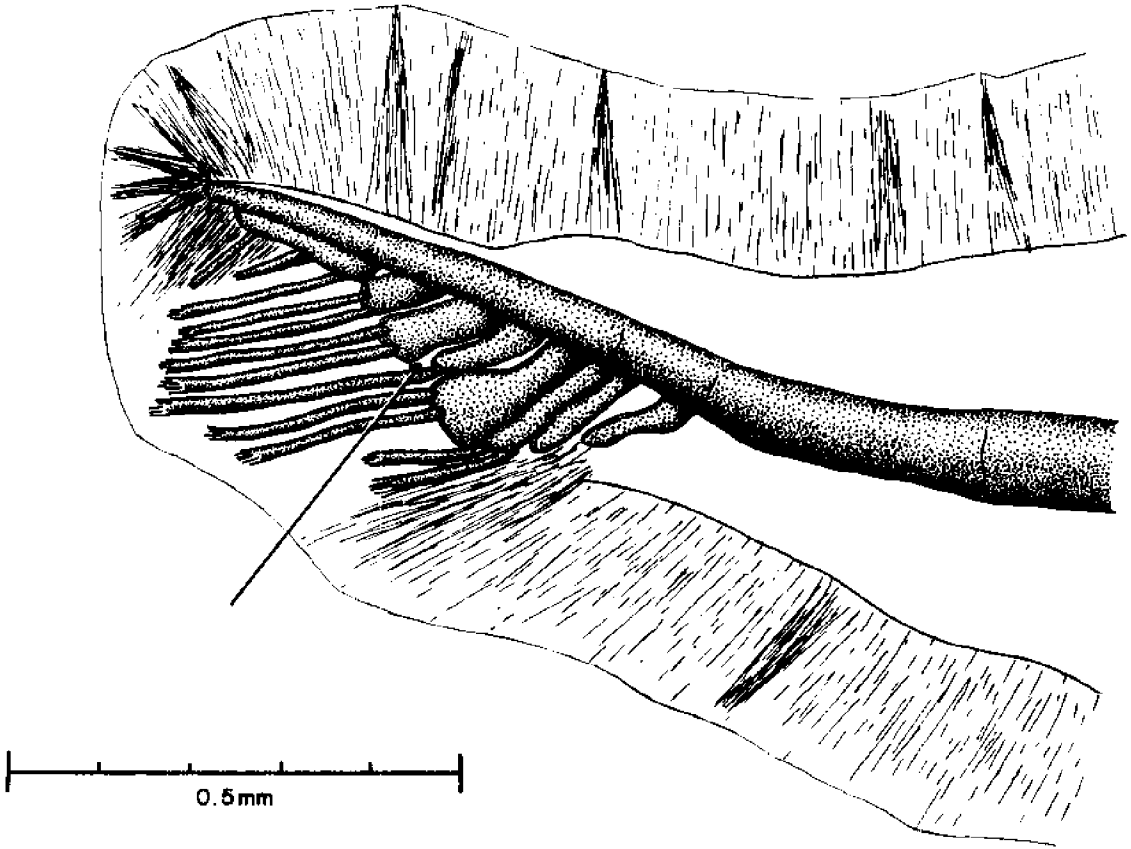


Figure 3.--Location of the division between dorsal and ventral sets of hypural bones (arrow).

Drawn from a 3.0 mm specimen of Bairdiella chrysura.



Fifty fish ranging in size from 2.55 mm to 8.65 mm SL were chosen from each of three samples: silver perch, Bairdiella chrysura, collected during June 1966 and February 1967, and spotted seatrout, Cynoscion nebulosus, collected during June, 1966. Both NL and SL measurements were made on each fish, and regression equations were calculated for the three subsamples (Table 1).

TABLE 1

EQUATIONS FOR THE REGRESSIONS OF NL ON SL  
 (CN6 = Cynoscion nebulosus caught on  
 June 5, 1966; BC2 = Bairdiella  
 chrysura caught on February 27,  
 1967; and BC6 = B. chrysura  
 caught on June 21, 1966)

Symbol	Regression Equation
CN6	NL = 0.5727 + 0.9196 SL
BC2	NL = 0.7294 + 0.8888 SL
BC6	NL = 0.4054 + 0.9316 SL

The analysis of covariance showed (1) that one regression line is not suitable for all the data, (2) that not all slopes are equal, and (3) that the adjusted means are not all equal.

Test for suitability of one line  $F = 53.92^*$

Test for equality of slopes  $F = 4.73^*$

Test for equality of adjusted means  $F = 98.02^*$

A comparison of the slopes and intercepts of the two regression equations for Bairdiella chrysura showed that there were significant seasonal differences in the NL:SL ratio.

$t$  (Slope)  $= 2.93^{**}$

$t$  (Intercept)  $= 10.25^{**}$

Therefore, fish which had been measured to notochord length were not used in the analysis dealing with mean size. Because knowledge about Cynoscion nebulosus was limited, a correction factor was not applied to the newly-hatched young of this species either.

### Analytical Procedures

Because there was a shortage of bottles during the study, the samples collected during one night often had to be combined into a single jar. As a result the catch data for each night had to be combined in a similar manner and the salinities and temperatures had to be averaged for each night, thus limiting the study to comparisons among sampling trips. The only exception to this was the data used

---

\*Significant at 95 per cent level of significance.

\*\*Significant at the 99 per cent level of significance.

to study diel movements of larvae into the estuary, when the integrity of individual samples was maintained.

The data from nighttime, flood-tide samples were summarized for each species in three ways: (1) a size-frequency summary; (2) a summation of catch for each trip (or night); and (3) a mean size calculation. For the size-frequency calculation, if two samples were taken less than 12 days apart, they were combined and henceforth considered as collected on the first sampling date. All subsequent pairs of samples collected less than 12 days apart, were treated similarly (Table 4). Fish measured using the notochord length were kept separate from those measured by standard length. No damaged fish were used in this summary. The total catch is the number of fish caught during a single night, including damaged ones. Mean size was calculated after deleting all fish measured to notochord length and damaged fishes. For each trip a mean size and  $\pm 2$  S.D. were calculated and each fish was tested to see if its length was within two standard deviation units of the mean. Fish outside this range were discarded and a new mean and standard deviation were calculated. This process was repeated until all specimens used in the calculation were within  $\pm 2$  S.D. of the mean. This was done because it prevents one or a few unusually large or small specimens from dominating a calculation.

Some parameters were not measured for every sample. When this occurred, the fish caught were eliminated from the total catch summary and from the mean size calculation. Also, when either a surface or bottom tow was missing from a paired-sample, the other half of the pair was removed too. Occasionally, however, the other sample had been combined with its analogues from other tows in order to conserve bottles. There was no way to remove this half of the pair from the data without eliminating an entire night's samples. Since this did not occur when catches were at or near their peaks, the data were used and no compensation was made for the missing sample.

During the 24-hour study the velocity of the current was measured, and a designation of flood, ebb or slack tide was given, depending upon the direction of current flow. Sometimes currents noted as slack were accompanied by a current velocity (Tables 11-14). When graphing the current velocity for the 24-hour study (Figure 15), all such "slack" currents were placed on the graph so that they yielded the smoothest curve.

#### Catch and Effort Selection

Roessler and Rehrer (in press) have discussed their selection of catch/ $m^3$  for a measure of effort. Because of the small numbers of fish caught, catch/ $1000 m^3$  was chosen as an effort measure for this study.



## RESULTS AND DISCUSSION

### Spawning Time of Adults and Seasonal Abundance of Larvae

During this study three types of data were collected which indicate spawning time: the length-frequency distribution, the percentage of larvae measured to notochord length, and the number of larvae caught. A length-frequency distribution with many size-classes indicates that young as well as older fish are being caught. A series of this type of length-frequency distributions indicates that spawning is replacing those fish which move through the pass, or which grow so large that they are able to avoid the net. The presence of larvae with minimal development of their hypural bones indicates very recent spawning. Since spawning may vary in intensity during the reproductive period, the number of larvae caught indicates relative amounts of spawning.

In the fall, small silver perch, Bairdiella chrysura, sand seatrout, Cynoscion arenarius, spotted seatrout C. nebulosus, and southern kingfish, Menticirrhus americanus disappeared from the catches (Figures 5, 7, 10, and 12). This absence of small fish and that at the beginning of the spawning seasons (Figures 5, 10, 12, and 14) suggest that the spawning adults move offshore and onshore in response

to seasonal temperature changes. The absence of large fish during the fall suggests that those individuals which were caught were slow growers or stunted ones. This is probably not the case, however, because with the possible exception of the southern kingfish, Menticirrhus americanus (Figure 12), none of the fish caught at this time showed an increase in length. Yokel (in press) found that even the slowest growing pink shrimp showed some increase in size, which suggests that the fish are new recruits rather than stunted ones.

#### Bairdiella chrysura

In 1966 catches were low from January until April (Figure 4), although only three samples were taken from January 5 to February 20. During early January the percentage of recently-hatched larvae was high, but it declined during late January and February (Figure 5), indicating that the concurrent decline in catch is due to low spawning activity. During 1967 catches rose slowly in January and sharply in February to a peak on February 27. The percentage of recently-hatched larvae reached its peak on January 29 and then declined over the month of February despite the increasing catch. This shows that the spawning peak probably came in late January or early February.

During both years catches remained low during March, but increased later in Spring. In 1966 there were three

Figure 4.--Catches of Bairdiella chrysura, temperatures, and salinities for Little Shark River, 1966-1967.

Catch/1000 m<sup>3</sup>    ●——●  
Temperature    ●- - -●  
Salinity        ●.....●

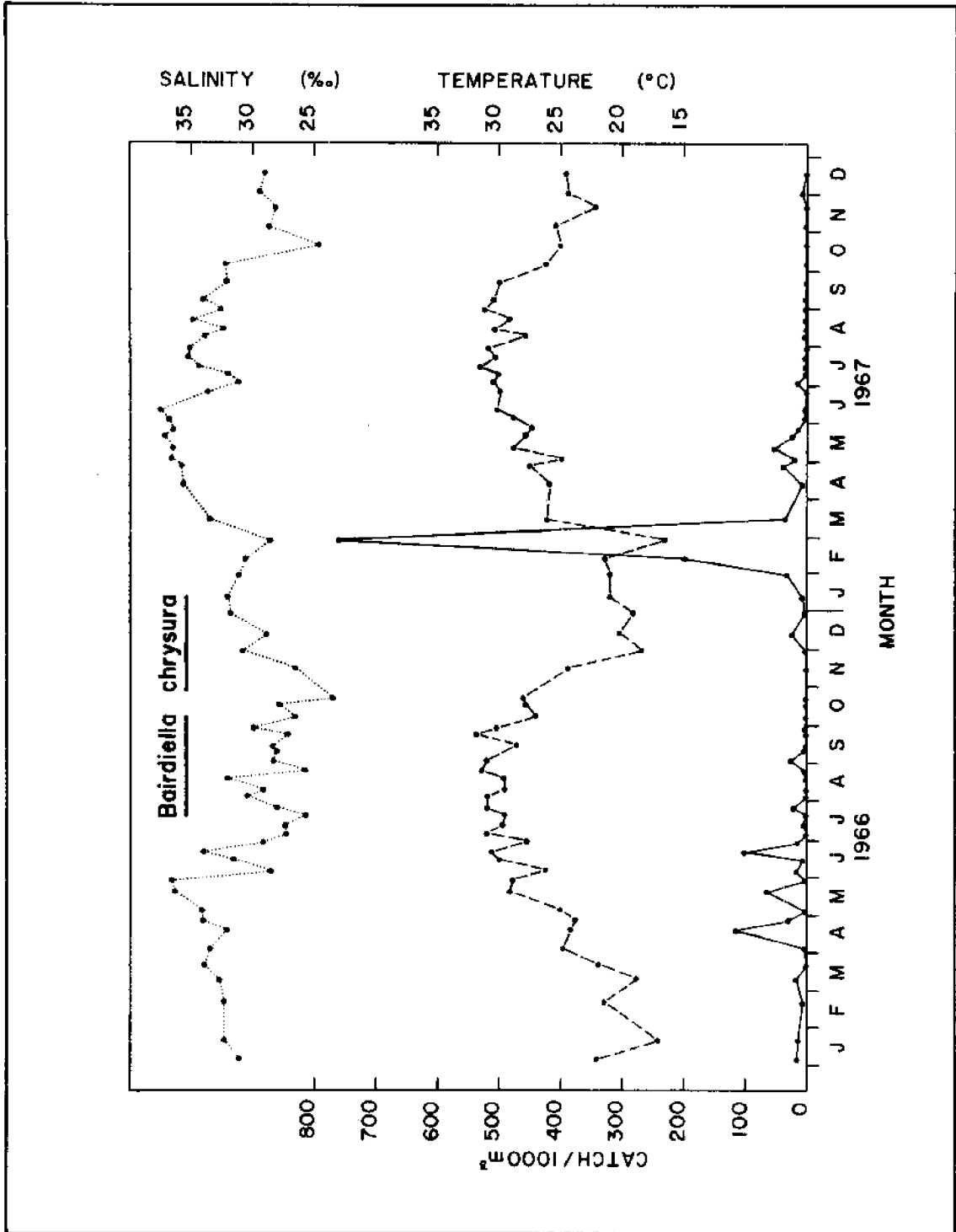
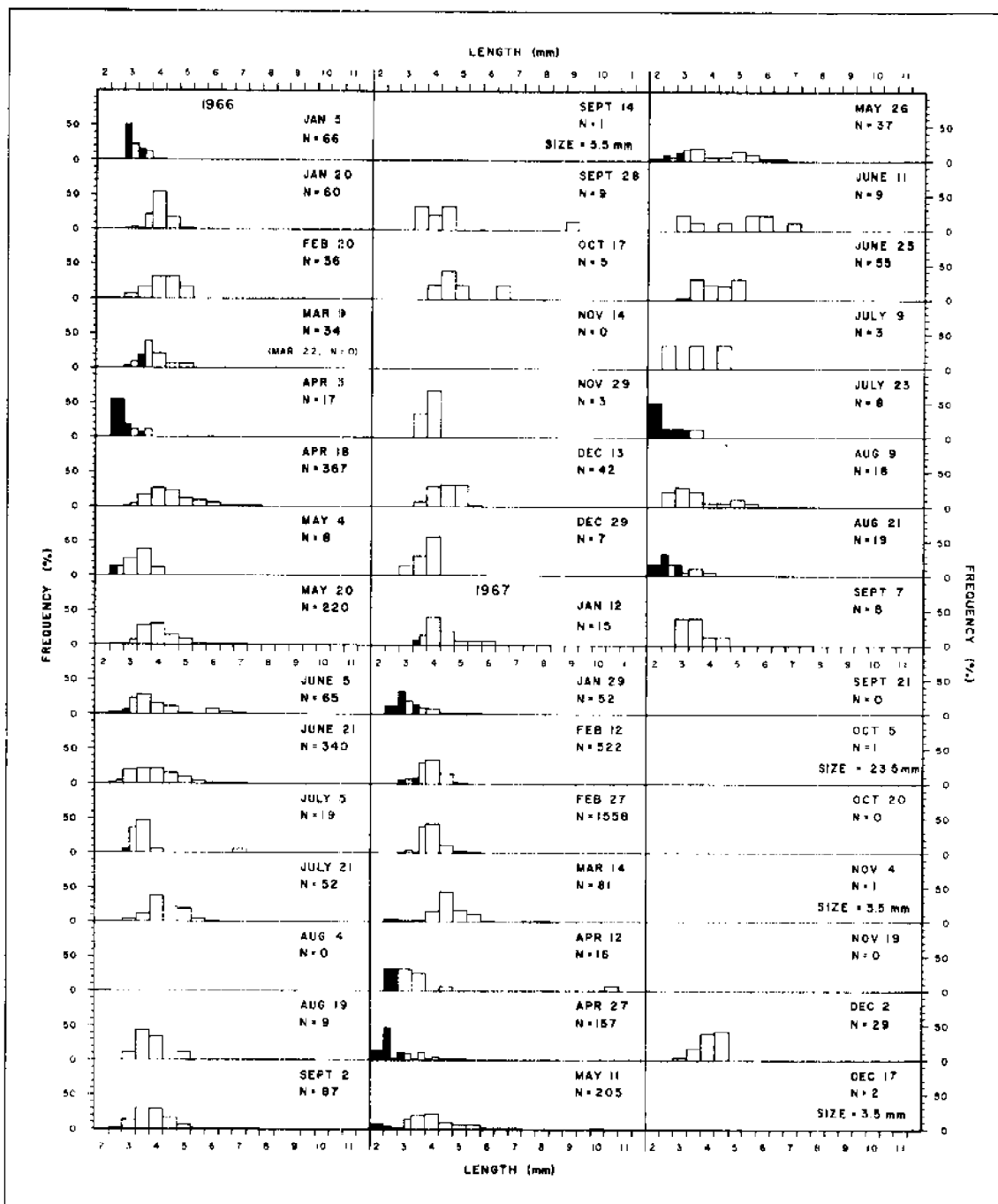


Figure 5.--Length-frequency for Bairdiella chrysur.

Open boxes represent fish measured to SL and shaded ones represent those measured to NL. When all fish caught are in one size category, all measurements are to SL. No fish longer than 4.0 mm were measured to NL. Samples collected less than 12 days apart were combined as indicated in Table 4. Combined samples are plotted according to the first sampling date.



separate peaks, in April, May, and June (Figure 4). The number of recently-hatched larvae was low during each of these three peaks, but the distribution of sizes indicates moderate spawning. In 1967 catches during April and May were lower than during 1966, but recently-hatched larvae dominated the catches (Figure 5), which suggests significant spawning, but not as intensive as in 1966.

During summer of both years, catches were low (Figure 4), and although the percentages of recently-hatched larvae were high in some samples (Figure 5), one must conclude that only limited spawning occurred. Spawning declined further at the end of August, but minor amounts continued throughout the fall. In December catches rose again temporarily, showing that a new spawning season had begun.

The year 1967 is probably the more representative one because then the observations coincided with those of Tabb and Manning (1961), and Roessler (1967, unpublished). The former reported catching running ripe adults in Conchie Channel, Everglades National Park, on February 28. Roessler sampled juveniles 25 mm and longer; seventy-five per cent of the 2,076 silver perch he caught were taken from March through May. Stewart (1961, unpublished) reported catching "very young" silver perch on June 18, 1960, but he gave no size data.

If the time of heaviest spawning was delayed by two months in 1966, air (Table 2) and water temperature

TABLE 2  
 MONTHLY AND YEARLY DEVIATIONS OF TEMPERATURES FROM  
 THEIR MEANS DURING THE YEARS 1965-1967  
 AT EVERGLADES CITY, FLORIDA<sup>a</sup>

Month	1965 (°F)	1966 (°F)	1967 (°F)
January	-0.5	-3.1	0.7
February	1.4	-1.2	-3.4
March	1.5	-2.4	0.8
April	1.0	-1.9	-2.1
May	-1.8	0.1	-1.8
June	-1.5	-2.1	-3.2
July	-1.5	-0.1	-0.8
August	-0.4	-1.4	-2.6
September	-0.2	-0.6	-2.1
October	-1.4	1.5	-3.3
November	0.6	-3.3	-3.2
December	-1.2	-4.5	-1.5
Year	-0.3	-1.6	-2.0

<sup>a</sup>U.S. Department of Commerce, 1965-1967.



records (Figure 4) provide no indication why this happened. Tabb and Manning (1961) have reported that spot, Leiostomus xanthurus, come to the Park only during cold winters, so the capture of this species only during 1966 suggests that that year had a severe winter which delayed the spawning of Bairdiella chrysura. Spotted seatrout, Cynoscion nebulosus and sand seatrout C. arenarius also spawned later during 1966 than during 1967.

Other possible explanations for the apparent lack of spawning by Bairdiella chrysura during the winter of 1966 are (1) the winter peak occurred during December 1965; (2) the winter peak came in between sampling dates during January and February; (3) the larval mortalities were high during 1966; and (4) the adults spawned in another area.

The data from the present study indicate that the spawning season for silver perch is longer and the peak of spawning is earlier in the year at Everglades National Park than in other parts of its range. Springer and Woodburn (1960) reported that silver perch spawn for only one month at Tampa Bay, Florida, because they caught 13.0-15.9 mm fish during May only. They believe that the 16.0-18.9 mm juveniles they caught through August were either stunted or had been recruited from other areas. These are the only authors who have suggested a short spawning season. At Beaufort, North Carolina, Hildebrand and Cable (1930) reported that the spawning season begins in April and ends in

mid-July. Kuntz (1914), Welsh and Breder (1924), Hildebrand and Schroeder (1928), and Pearson (1941) have reported slightly shorter seasons in other mid-Atlantic states. Williams and Deubler (1968b) reported catching larval silver perch as late as October. In northern Florida, Reid (1954), Kilby (1955), and Joseph and Yerger (1956) reported data which suggests spawning occurs from May to September. The reproductive season in Texas and Louisiana is similar to that in northern Florida (Gunter, 1938 and 1945; Simmons, 1951a; Miller, 1965).

#### Cynoscion nebulosus

Spotted seatrout were collected in every month of the year, but most commonly from early April through October. The spawning season began in late winter or early spring, as shown by high percentages of recently-spawned larvae in April 1966 and March 1967 catches (Figures 6 and 7). The small catches and the consistently high percentage of very young larvae indicate low intensity spawning during early spring. In late April 1967 catches rose sharply and remained at or near this high level until early May. Although there was no comparable increase in catch during these months in 1966, the significant percentage of recently-hatched larvae shows that spotted seatrout were spawning at this time. In 1966 the peak catch occurred in early June.

During summer, catches were variable for both years. The presence of very young fish in nearly all samples is

Figure 6.--Catches of Cynoscion nebulosus, temperatures, and salinities for Little Shark River, 1966-1967.

Catch/1000 m<sup>3</sup> ●——●  
Temperature ●- - - ●  
Salinity ●.....●

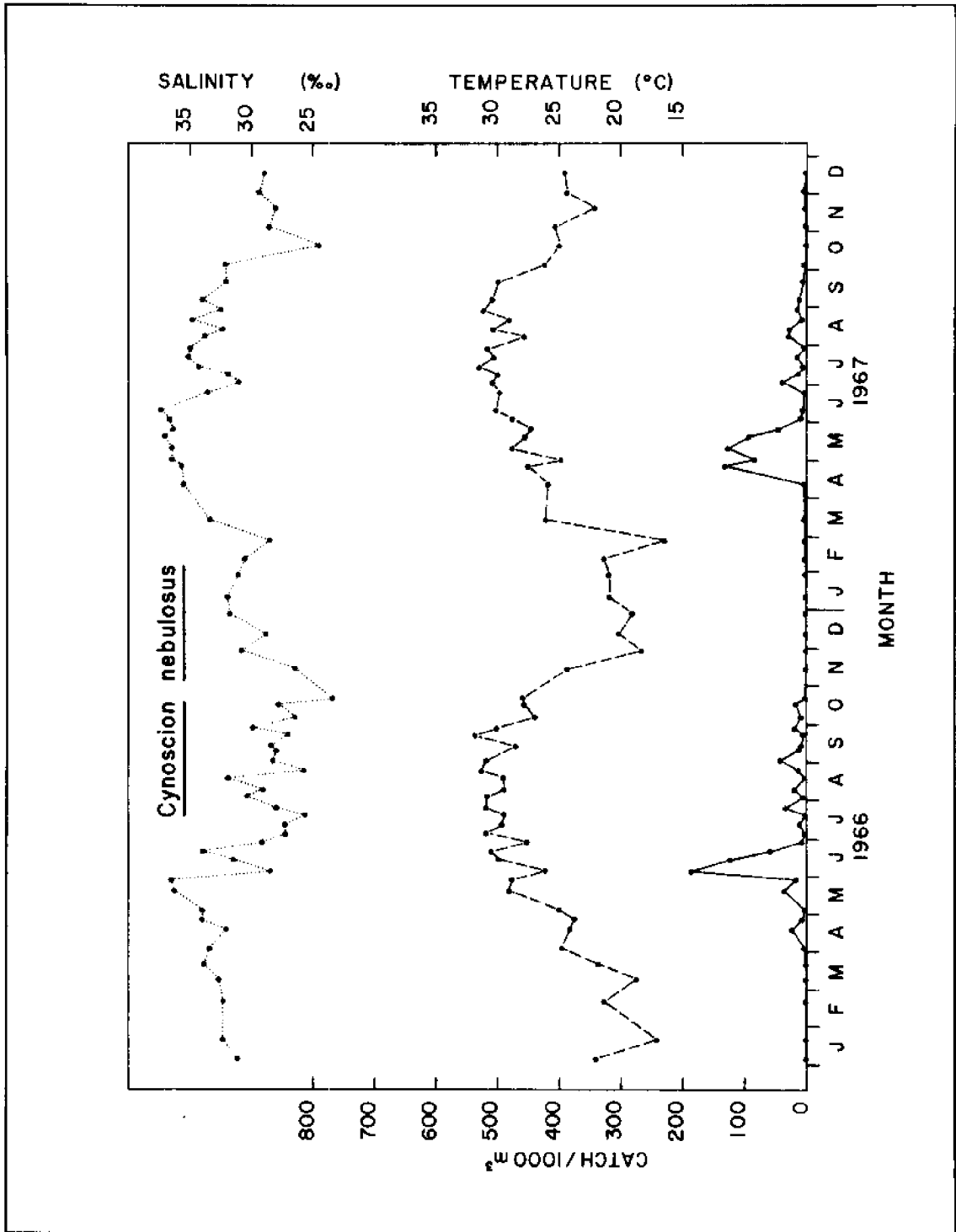
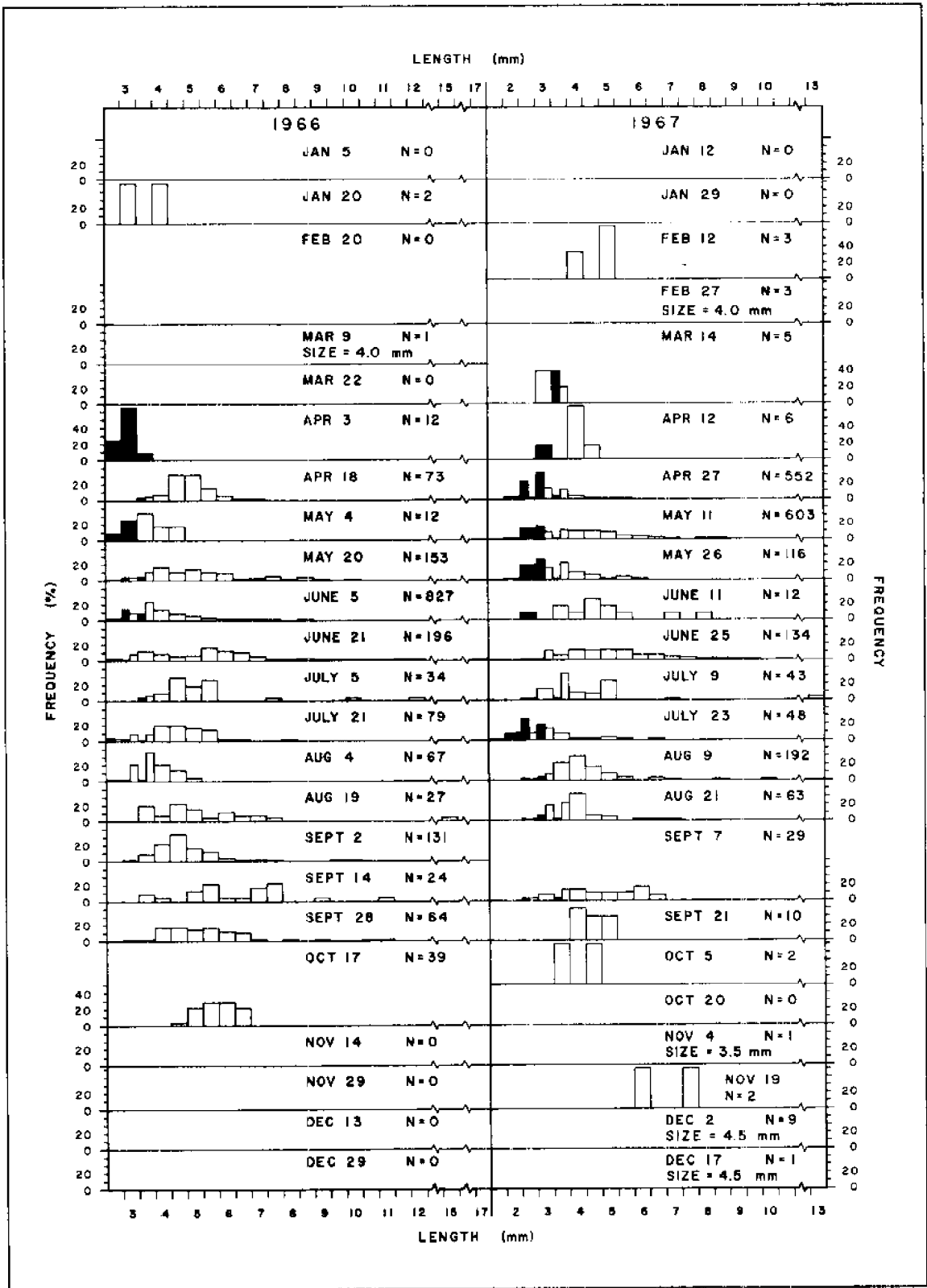


Figure 7.--Length-frequency for Cynoscion nebulosus

Open boxes represent fish measured to SL and shaded ones represent those measured to NL. When all fish caught are in one size category, all measurements are to SL. No fish longer than 3.5 mm were measured to NL. Samples collected less than 12 days apart were combined as indicated in Table 4. Combined samples are plotted according to the first sampling date.



evidence that low to moderate spawning continued throughout the summer. After September, catches fell to very low levels, but the fishes caught ranged in size from 3-5 mm. These fish were probably newly-hatched larvae. They indicate that spawning occurs year-round, although it is much reduced during late fall and winter.

The results of this study fit the trends shown by work in other areas and agree with other studies in Everglades National Park. In the mid-Atlantic states, the spotted seatrout is primarily a spring and summer spawner (Welsh and Breder, 1924; Williams and Deubler, 1968b), but at the Indian River in Florida, the spawning season is extended from mid-April until October (Tabb, 1961). Throughout the Gulf of Mexico north of Everglades National Park, the spawning period extends from late March or early April until October (Pearson, 1929; Gunter, 1945; Miles, 1950, unpublished, and 1951, unpublished; Moody, 1950; Simmons, 1951a; Reid, 1954; Joseph and Yerger, 1956; Klima and Tabb, 1959; Springer and Woodburn, 1960; Moffett, 1961). Gunter (1945) and Miles (1951, unpublished) caught ripe females during November in Texas. In Everglades National Park the most important part of the reproductive period coincides with that in the rest of the Gulf and on the east coast of Florida, but reproduction in the Park continues year-round. Stewart (1961, unpublished) has shown that spotted seatrout living in the Park are ripe throughout the

year. The present study has shown that this species does spawn throughout the year there. Stewart (1961, unpublished) and Roessler (1967, unpublished) have shown that intense spawning begins in March. Stewart believed that it continued through June and that the peak was in May. The data from the present study do not contradict this, but they show that the time of the peak is variable. The late summer spawning peak predicted by Stewart (1961, unpublished) and Higman (1967) did not materialize in either year, perhaps because of high water temperatures.

#### Sciaenops ocellata

Red drum spawn from mid-September until mid-February (Figures 8 and 9), but there is considerable variation in the time when spawning begins and ends. During 1966 sizeable catches were made in late September, whereas in 1967 sizeable catches were not made until mid-October. During 1967 there was more spawning later in the year and it may have continued into the next year as it did during the 1965 spawning season. The peak of spawning appears to be in October.

Red drum spawn in late summer and early fall in the mid-Atlantic states (Mansuetti, 1960; Williams and Deubler, 1968b). Yokel (1966, unpublished) has concluded that spawning may start in July or earlier. In Florida red drum spawn in fall (Welsh and Breder, 1924; Kilby, 1955; Springer



Figure 8.--Catches of Sciaenops ocellata, temperatures, and salinities for Little Shark River, 1966-1967.

Catch/1000 m <sup>3</sup>	●——●
Temperature	●— — —●
Salinity	●.....●

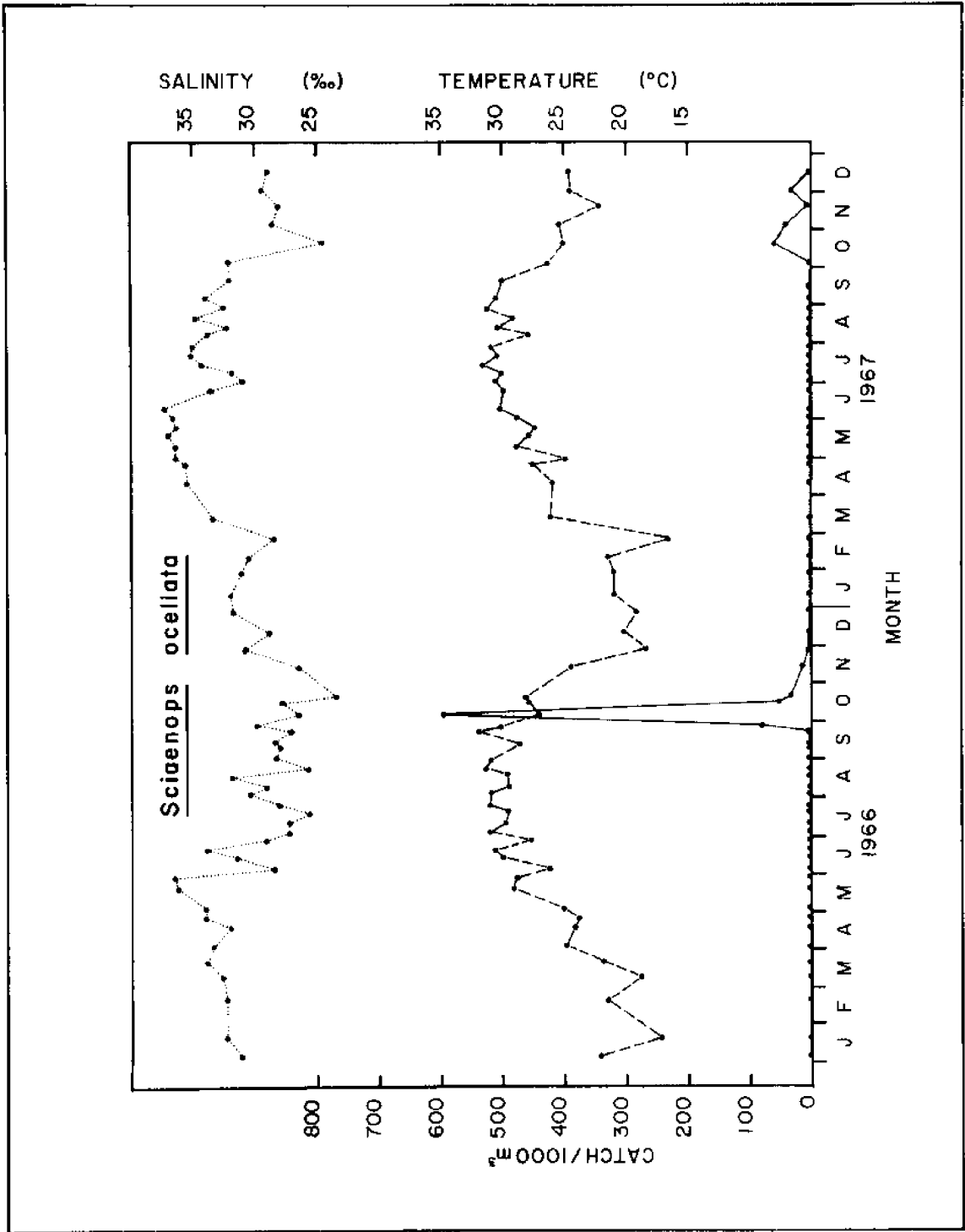
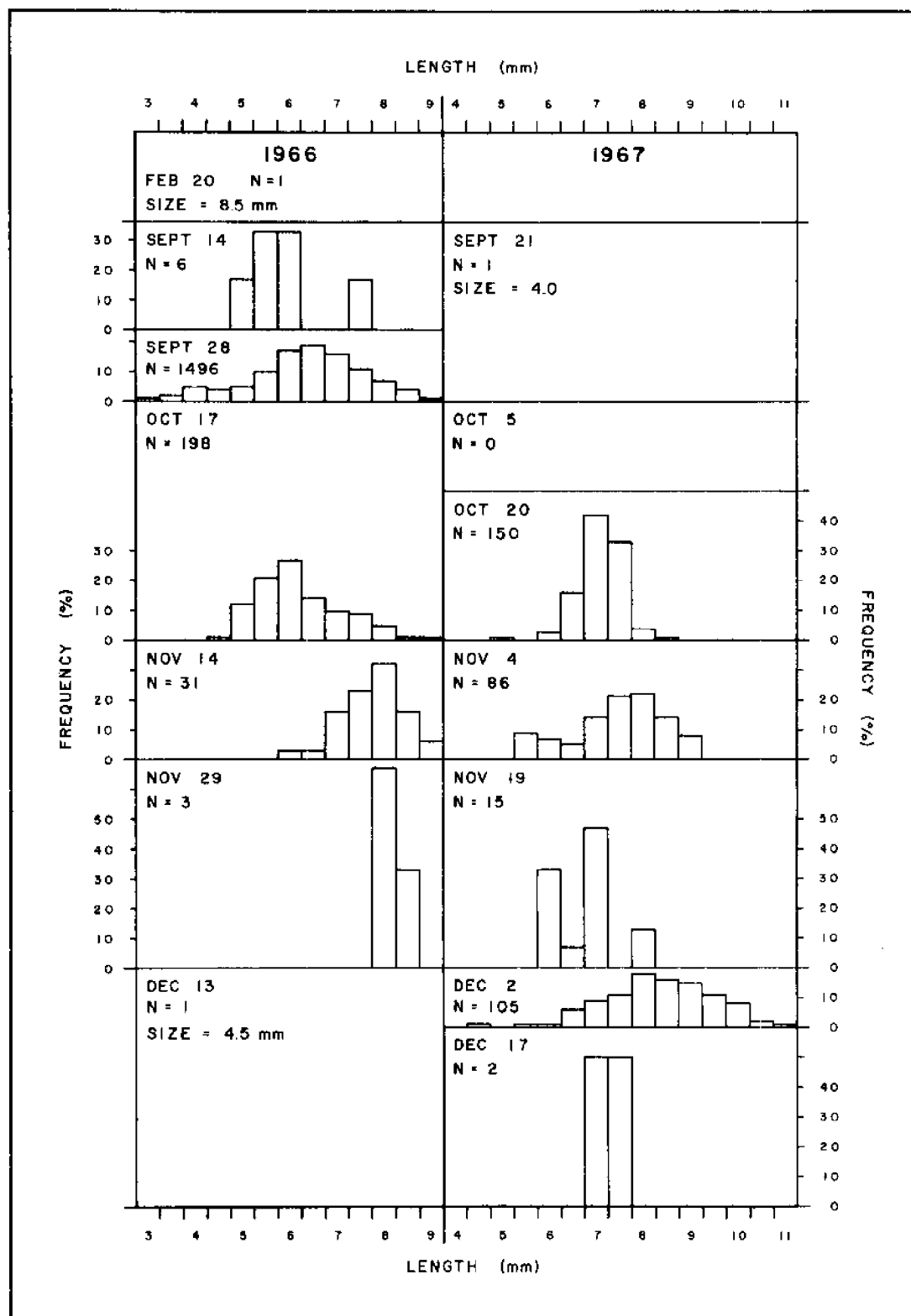


Figure 9.--Length-frequency for Sciaenops ocellata.

All fish caught were measured to SL. Samples collected less than 12 days apart were combined as indicated in Table 4. Combined samples are plotted according to the first sampling date.



and Woodburn, 1960; Yokel, 1966, unpublished; Roessler, 1967, unpublished), and the peak probably occurs in October (Yokel, 1966, unpublished). Yokel has also shown that there is possibly a late-winter to spring spawn on the east coast of Florida. Pearson (1929) said that spawning occurs primarily during October in Texas. Gunter (1945) and Miles (1950, unpublished and 1951, unpublished) agree.

The data from the present study show that spawning near Everglades National Park coincides with spawning of other Gulf populations, rather than with that of Atlantic populations, except that near the Park it continues later than in northern parts of the Gulf. There is no evidence of any spring or summer spawning in the Park.

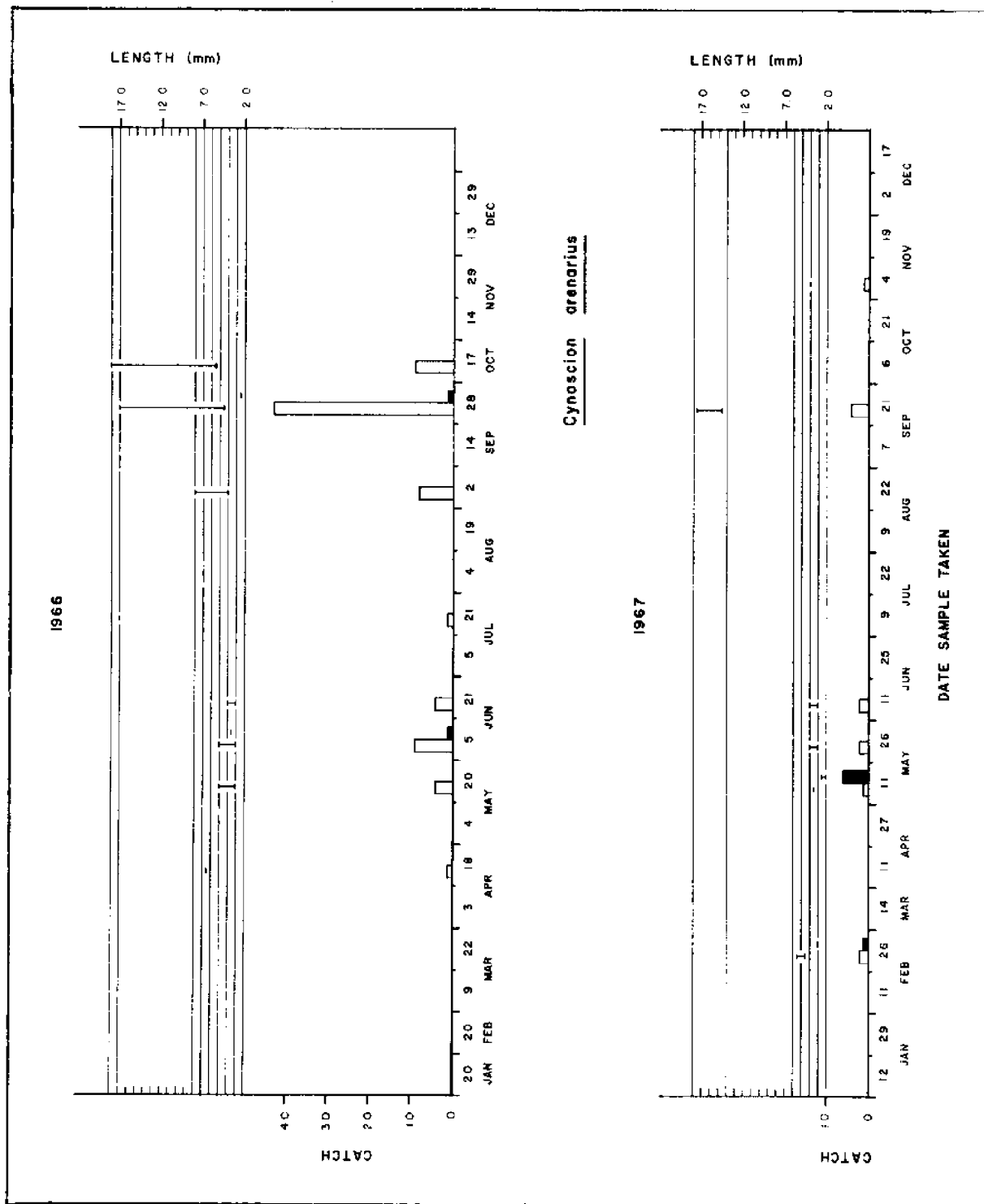
#### Cynoscion arenarius

The spawning season for the sand seatrout is long (Figure 10). In 1967 it began in mid-February, but in 1966 it did not begin until April. Since the spawning of other sciaenids was delayed in 1966, the spawning of the sand seatrout probably begins in mid-February normally. Spawning probably stopped in mid or late October during both years.

Spawning begins earlier in the Park than it does in the northern Gulf of Mexico. Gunter (1938 and 1945), Simmons (1951a), Hildebrand (1954), Reid (1954), Kilby (1955), Copeland (1965) and Miller (1965) found that spawning occurs between March or April and September. At Tampa Bay, Florida,

Figure 10.--Seasonal abundance and size-range of Cynoscion arenarius.

Open boxes indicate fish measured to SL and shaded boxes indicate those measured to NL.



Springer and Woodburn (1960) caught a ripening female in February, but these authors did not collect any larvae at this time.

Figure 10 indicates that there may have been spring and fall peaks in spawning, with a lull during the summer months. The first peak was observed during May and June. This was the period when most of the recently-hatched larvae were caught, when the smallest fish were caught, and when the catches were most consistent. Reports in the literature agree with a spring spawning peak (Simmons 1951a; Copeland, 1965). During July and August spawning appeared to diminish or even stop. Simmons (1951b) and Stewart (1961, unpublished) have alluded to a similar decline in spawning for the spotted seatrout. When the temperature began to decline in the fall, catches increased. This second peak may have been caused by an increase in spawning, by an exodus of larvae and small juveniles from the estuary, or by an artifact from the small sample size. In Texas, Copeland (1965) found that there was a second peak in the number of adult and juvenile sand seatrout leaving the estuary during late fall.

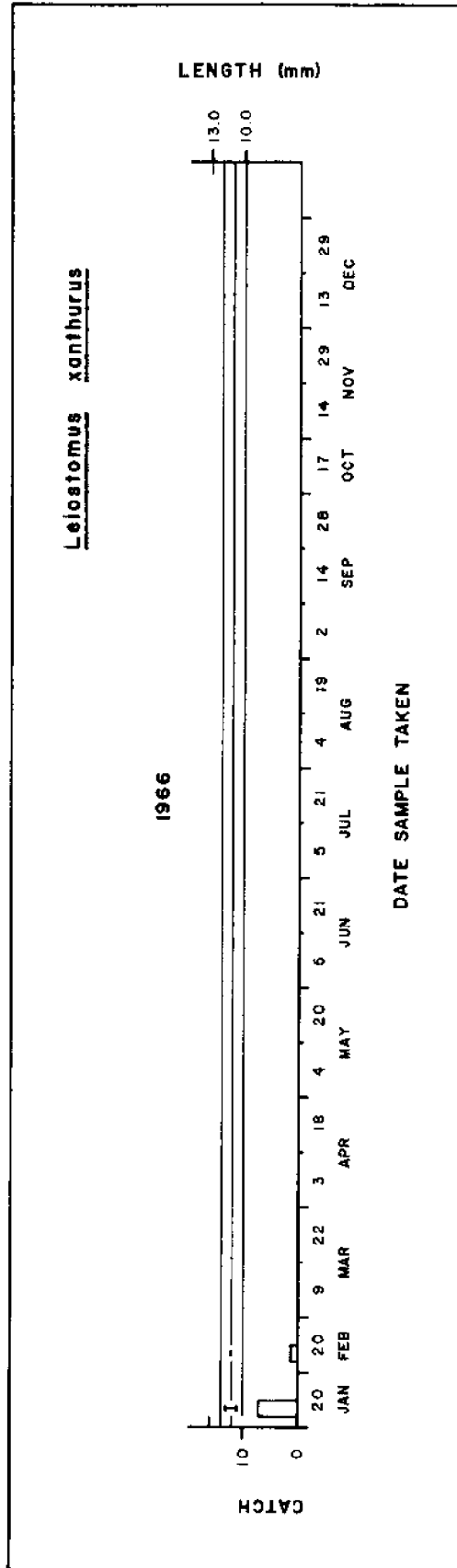
#### Leiostomus xanthurus

Spot were collected only twice, once in January and once in February of 1966 (Figure 11). The growth rate of larval spot is not known, but these fish were probably



Figure 11.--Seasonal abundance and size-range of Leiostomus xanthurus.

Open boxes indicate fish measured to SL.



spawned in December and January, respectively. Since this species occurs in Everglades National Park only when cold weather forces them to go there (Tabb and Manning, 1961 and 1962), these catches do not indicate the whole spawning season. Most investigators have shown that spot spawn from December until late March in Florida (Reid, 1954; Kilby, 1955; Joseph and Yerger, 1956; Townsend, 1956; Springer and Woodburn, 1960; Sykes and Finucane, 1965; Zilberberg, 1966; Kelly and Dragovich, 1968).

The large size of these fish poses the question of whether these juveniles were spawned nearby or were driven south by cold weather. Tabb and Manning (1961) found no evidence of spawning in Florida Bay, even though the fish were present during their spawning season. This suggests that the young may have been driven to the Park by cold weather. Tabb and Manning may have missed the spawning population, because spot spawn in deep water (Hildebrand and Schroeder, 1928; Pearson (1929); Roelofs, 1951; Townsend, 1956; Dawson, 1958). A deep-water spawning site accounts for the large size of the fish caught, but it also means that the young are at sea longer, which allows more opportunity to encounter adverse weather. The fish would have to have been driven south twice, however, once at a time when temperatures were starting to rise, so spot probably spawned near the Park.

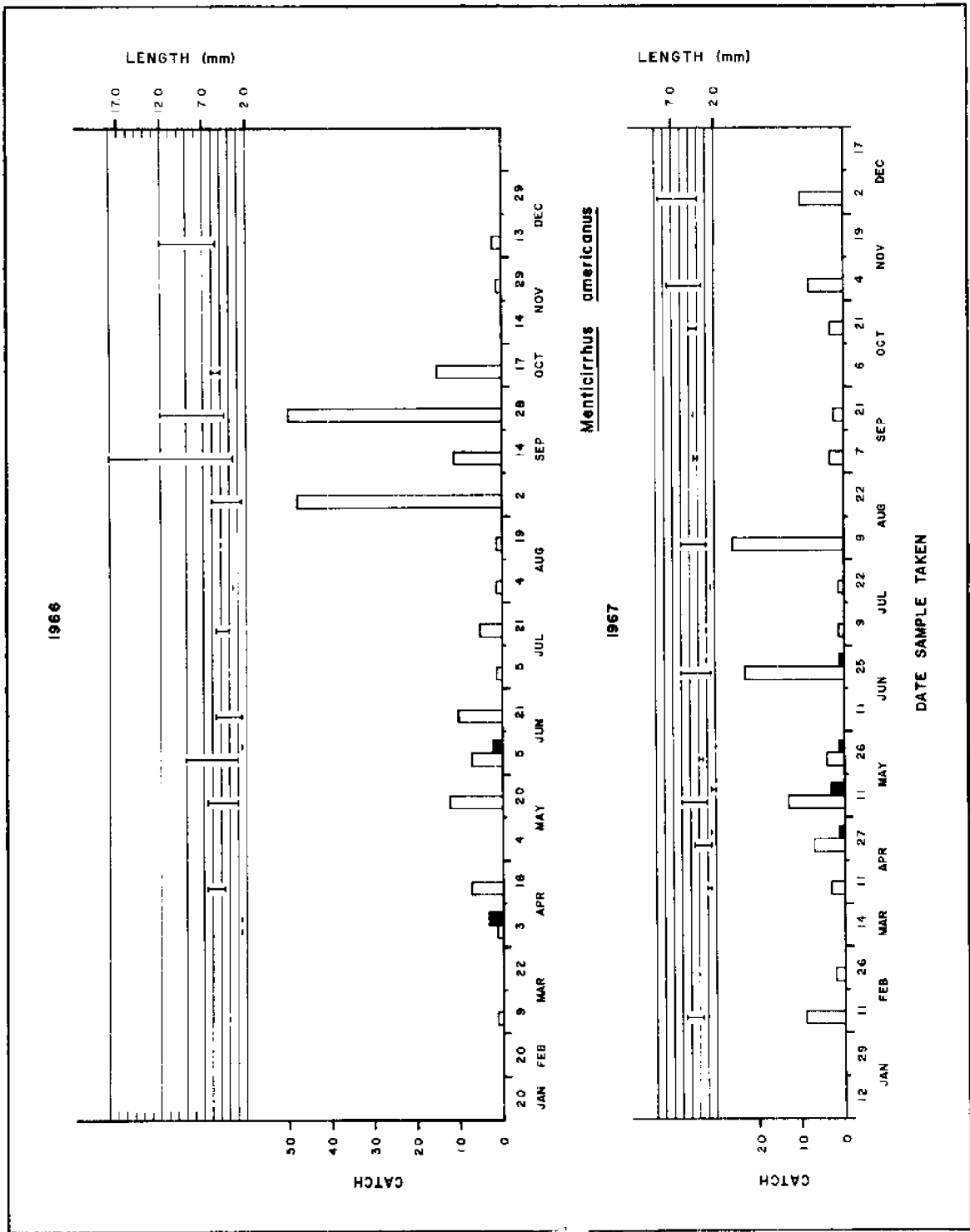
Menticirrhus americanus

During this sampling program young southern kingfish were collected during all seasons except early winter (Figure 12). Spawning starts in mid to late winter, but probably does not reach its peak until spring, when recently-hatched larvae were most common. During the summer of 1966, catches were low, but during this same season in 1967 the highest catches for the year were recorded. In 1966 the peak catch was delayed until September. The September 1966 catches included the largest individuals of this species which were caught, but smaller fish dominated the catches indicating recent spawning. Fish from 3.5 to 12.0 mm were caught for the duration of fall. For reasons discussed earlier these fish are believed to be recently spawned individuals, not slow-growing or stunted ones. The larger individuals may be leaving the estuary because Tabb and Manning (1961 and 1962), Roessler (1967, unpublished) and Clark (1970, unpublished) did not find any juvenile southern kingfish.

The data from this study, suggest almost year-long spawning, although this has not been reported in the literature. Most authors suggest that southern kingfish spawn from April or May until September on both the Atlantic coast (Hildebrand and Schroeder, 1928; Hildebrand and Cable, 1934; Pearson, 1941; Bearden, 1963; Williams and Deubler, 1968b) and the Gulf coast (Gunter, 1938; Reid, 1954; Joseph and Yerger, 1956; Springer and Woodburn, 1960), but there are

Figure 12.--Seasonal abundance and size-range of Menticir-  
rhus americanus.

Open boxes indicate fish measured to SL and shaded  
boxes indicate those measured to NL.



a few who disagree. At Fernandina Beach, Florida, Welsh and Breder (1924) suggest a double spawning season, one peak in spring and one in fall. Gunter (1945) concurs for the Texas coast. Welsh and Breder (1924) and Miller (1965) suggest a single spawning season from late fall to early winter for Gulf populations.

#### Menticirrhus saxatilis

Although the data for the northern kingfish are meager, they suggest fall and winter spawning (Figure 13). Springer and Woodburn (1960) caught their smallest specimens of this species in October and November, but because slightly larger young were more abundant in May and June, they concluded that northern kingfish spawn in spring at Tampa Bay, Florida.

In the northern Atlantic states, spawning of the northern kingfish occurs from May or June until August and may continue until September (Welsh and Breder, 1924; Bigelow and Schroeder 1953; Schaeffer, 1965). In the mid and south Atlantic states the spawning season is probably April through May (Hildebrand and Cable, 1934, Bearden, 1963).

#### Pogonias cromis

Black drum spawn in late fall and winter so only one complete spawning season was sampled (Figure 14). Larvae were caught from November 14, 1966 until March 14, 1967

Figure 13.--Seasonal abundance and size-range of Menticir-  
rhus saxatilis.

Open boxes indicate fish measured to SL.



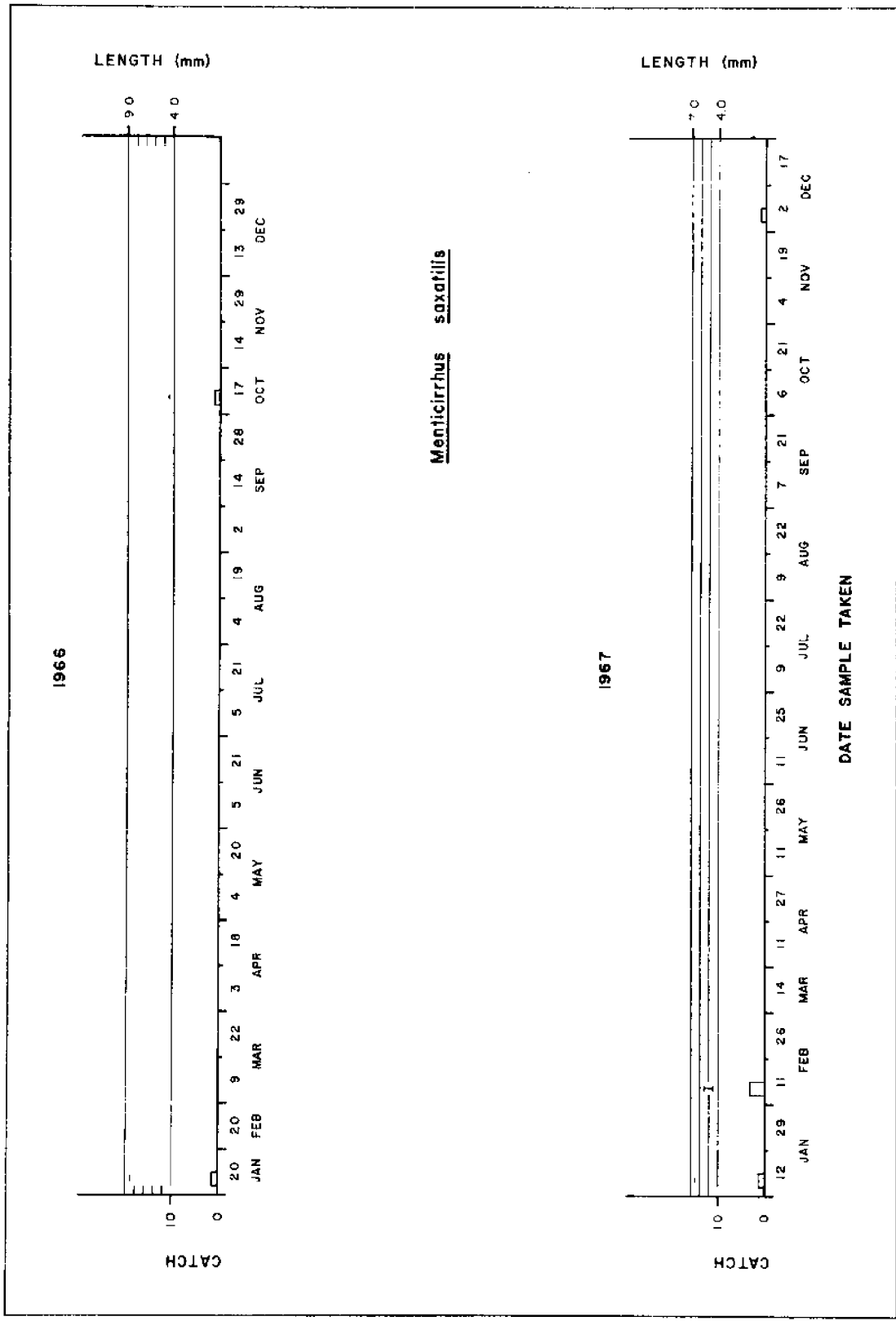
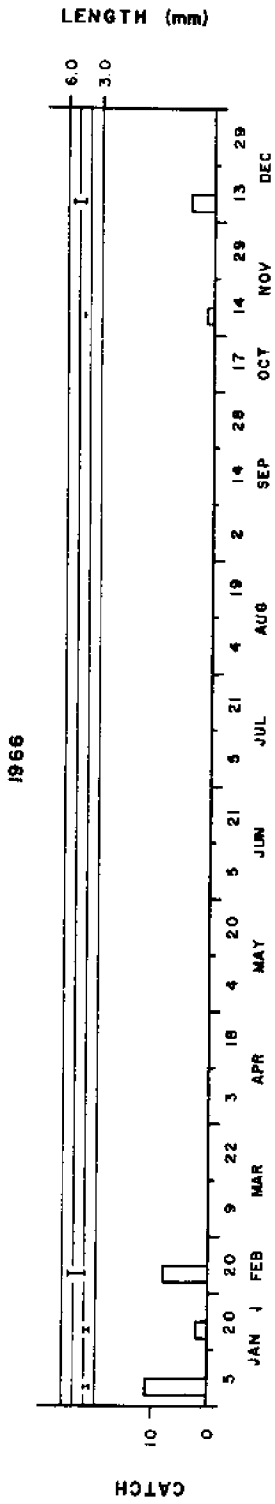
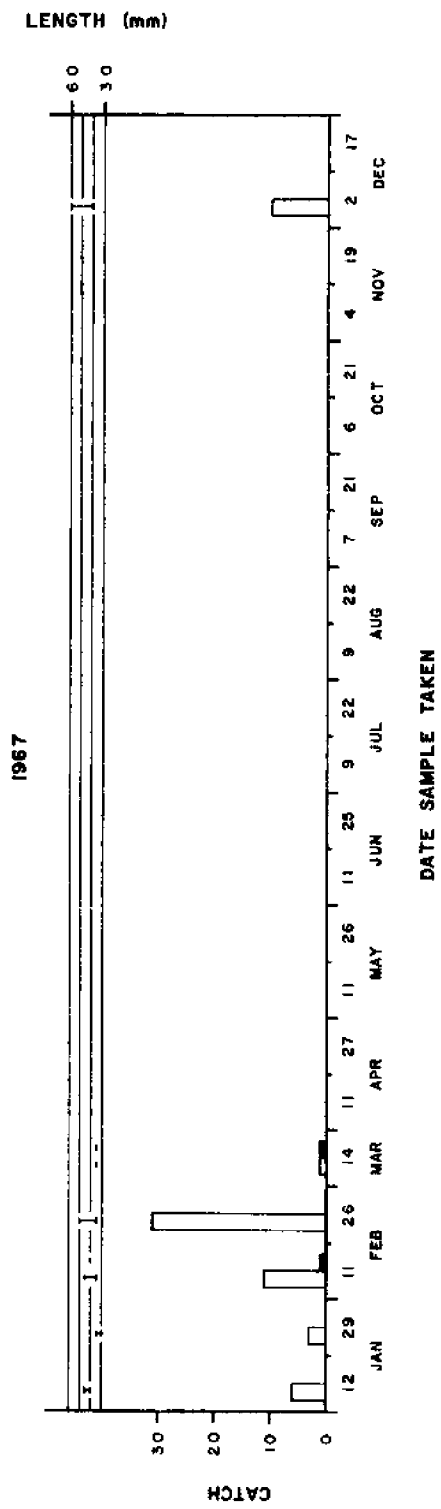


Figure 14.--Seasonal abundance and size-range of Pogonias cromis.

Open boxes indicate fish measured to SL and shaded ones indicate those measured to NL.



Pogonias cromis



during this season. The catches in the two half-seasons were not as extensive as for the 1966-1967 season, but these data suggest the same spawning time. Fish without hypural bones were not caught until February 11, 1967, just before spawning stopped. This may be the result of the small samples, it may indicate an increase in spawning, or it may indicate movement of spawning schools closer to the sampling site.

Published spawning data from Everglades National Park is limited, but it too indicates fall and winter spawning. Tabb and Manning (1961) found a running ripe male black drum on November 11, Roessler (1967, unpublished) caught a 49 mm specimen in March, and Yokel (personal communication) caught a ripe male in January.

Data collected from the northern part of Florida suggest winter to early spring spawning (Reid, 1954; Kilby, 1955; Joseph and Yerger, 1956; Springer and Woodburn, 1960; Sykes and Finucane, 1965, quoting data from Springer and Woodburn, 1960). In Texas, Pearson (1929) and Simmons (1951b) suggested two spawning seasons, one from February to May, based on gonadal development and occurrence of larvae, and the other from late July until November, based on gonadal development alone. Breuer (1957) and Simmons (1957) have confirmed Pearson's first season, but not his second one. No evidence of summer to fall spawning was found during the present study.

## Species Not Caught

The following sciaenids have been reported from southwestern Florida (Briggs, 1958), but were not captured during this sampling program: Bairdiella batabana, Equetus lanceolatus, Menticirrhus littoralis, Micropogon undulatus, and Stellifer lanceolatus. Their life histories largely excluded them from the brackish water parts of Everglades National Park. Bairdiella batabana occurs in Everglades National Park, but it is rare where the salinity is below 27 parts per thousand (Robins and Tabb, 1965). Clark (1970, unpublished) has found one young specimen of B. batabana in Oyster Bay, Everglades National Park. Equetus lanceolatus is mainly a coral reef species (Welsh and Breder, 1924; Randall, 1968). When it does occur in the Park, its eastward movement is limited by high turbidities and low salinities (Tabb and Manning, 1962). Menticirrhus littoralis is primarily a surf dweller. Tabb and Manning (1962) have reported this species from a localized high salinity community east of East Cape Sable, Everglades National Park. Micropogon undulatus does not normally live or spawn in the Park, it occurs there only when driven south by cold weather (Tabb and Manning, 1961). Stellifer lanceolatus prefers open waters (Smith, 1907; Hildebrand and Cable, 1934; Gunter, 1938 and 1945; Joseph and Yerger, 1956; Anderson, 1968). Hildebrand and Cable (1934) and Reid (1955) have reported juvenile star drum in estuaries, and Tabb

(unpublished manuscript) has reported a single specimen from the mouth of the Chatham River, Everglades National Park.

#### Spawning Site

It is unlikely that larval sciaenids caught during this survey were spawned in the brackish water part of Everglades National Park. The almost complete absence of eggs and newly-hatched larvae in the samples indicates that spawning did not occur either at the estuarine end of the pass, or within the pass itself. Fish spawned further up the estuary are probably not swept out to sea. Pritchard (1952) has shown that in bar-built estuaries currents drop off rapidly on the estuarine sides of the pass, limiting their effect on animals living there. Furthermore, during winter and spring the net flow of water is into the Park's estuaries (Table 3), which would minimize seaward dispersal of planktonic larvae. Larval silver perch become demersal when they grow to 5 mm (Pearson, 1941), and larval red drum and spotted seatrout seek shelter in grass beds after they enter estuaries (Miles, 1950, unpublished), which will minimize the effect currents have on them. Pearcy (1962a) found that 30% of the water volume in the Mystic River estuary was removed seaward each day whereas only 3% of the larval flounders were dispersed seaward per tidal cycle, and most of the larvae lost were planktonic. Older larvae

TABLE 3

WATER FLOW VOLUMES AT SHARK RIVER STATION,  
7.0 MILES UPSTREAM FROM MOUTH OF RIVER,  
OCTOBER 1964 TO SEPTEMBER 1965<sup>a</sup>

Month	Down Stream (10 <sup>6</sup> cu. ft.)	Up Stream (10 <sup>6</sup> cu. ft.)
October	115	99
November	116	99
December	109	104
January	102	109
February	97	109
March	94	107
April	94	112
May	93	116
June	104	114
July	118	116
August	124	115
September	135	100

<sup>a</sup>U.S. Dept. Interior, 1965.

were concentrated on the bottom where the net water flow carried them up the estuary.

The spawning site is probably close to the Park, however. Miles (1951, unpublished) reports that Baughman has observed what appeared to be schools of adult red drum, milling about 3/4-1 mile offshore from the Texas coast. Since the smallest red drum caught during this survey are comparable in size to those caught by Pearson (1929) and Miles (1950, unpublished), spawning in south Florida probably occurs in a similar location. Furthermore, there is no evidence of strong, steady currents which could carry the larvae to the passes from distant offshore spawning grounds (Koczy, Rinkel, and Niskin, 1959; Rinkel and Dunlop, unpublished MS; Rehrer, Jones, and Roessler, 1967). Koczy et al., (1959) and Rinkel and Dunlop (unpublished MS) have reported that a wedge of water moves out of Florida Bay, up the west coast of Florida. This could carry the larvae up to the Little Shark River from spawning grounds reported off Flamingo and Cape Sable by Tabb and Manning (1961). The spawning of spotted seatrout in Florida Bay is not extensive or dependable, however, so additional spawning must have occurred west of Cape Sable. The currents and possible spawning grounds north and west of the Little Shark River have not been studied.

Of the eight species caught the only ones which spawn primarily within bays are Cynoscion nebulosus (Tabb,



1966) and Pogonias cromis (Breuer, 1957). Cynoscion arenarius (Copeland, 1965), Leiostomus xanthurus (Dawson, 1958), Menticirrhus americanus (Hildebrand and Cable, 1934), M. saxatilis (Hildebrand and Cable, 1934), and Sciaenops ocellata (Yokel, 1966) all appear to spawn outside the estuary. Bairdiella chrysura spawns both inside and outside of the estuaries (Hildebrand and Cable, 1934; Simmons, 1951a; Springer and Woodburn, 1960).

Stewart (1961, unpublished) and Tabb and Manning (1961) indicated that some spawning of Cynoscion nebulosus probably took place in the tidal inlets of Florida Bay, but the evidence suggested that the area was not a primary or dependable spawning ground. The most important area is in the bays and lagoons far above the maximum reach of the daily tides so long as salinity is high (Tabb, 1966). The present study indicates that considerable spawning by this species does take place outside the estuary. The spotted seatrout was the second most abundant species in the samples, trailing only silver perch.

Pearson (1929) believed that in Texas black drum spawn at the mouths of passes because that was where he found spent fish. He reported, however, that fishermen believed black drum spawn in bays. Breuer (1957) agrees with the latter theory. He caught ripe fish, spent fish, and sciaenid eggs which he believed to be black drum eggs from Laguna Madre, Texas. He also reported that Oso Bay

has been long recognized as a spawning site for this species.

The results from the present survey indicate that black drum spawn outside the estuarine part of Everglades National Park, but the amount of spawning there may be small since less than 100 specimens were caught, compared to more than 4,000 specimens of silver perch. Yokel (personal communication) caught a running ripe male off the mouth of Big Sable Creek, Everglades National Park.

#### Length-Frequency

The length-frequency diagrams (Figures 5, 7, and 9) show the sizes of silver perch, spotted seatrout, and red drum caught. Silver perch ranged in size from 2.0 mm NL to 23.5 mm SL, but more than 99 percent were between 2.0 and 6.5 mm. Spotted seatrout had a similar distribution, but larger fish made up a much higher percentage of the catch and the smallest size was 1.5 mm NL. Significant numbers of larvae without hypural bones were caught for both species. Red drum were much larger than either of the other two species; the mode for red drum was at least 6.5 mm SL in all but two samples, whereas it was well below 6.5 mm SL in nearly all samples of the other two species. Furthermore all red drum could be measured to standard length.

The slight increase in mean size of larval silver perch and red drum as the spawning seasons progress should not be interpreted as the growth-rate of the larvae, because young sciaenids grow more rapidly (Kuntz, 1914; Hildebrand and Cable, 1934; Miles, 1950, unpublished and 1951, unpublished; Mansueti, 1960; Roessler, 1967, unpublished). Furthermore, even though Roessler (1967, unpublished) caught juvenile silver perch, spotted seatrout, and red drum which were 20 mm SL and larger in Buttonwood Canal, it is doubtful that large numbers of these species live in the passes because ecological studies on young silver perch (Breuer, 1957; Springer and Woodburn, 1960), spotted seatrout (Miles, 1950, unpublished; Tabb, 1966), and red drum (Miles, 1950, unpublished; Schultz, 1961; Simmons and Breuer, 1962) have shown that most of the young seek shallow, quiet water rather than stay in the passes.

#### Vertical Distribution

For each of the three most abundant species, comparisons were made between the mean sizes of fishes caught near the surface and those caught near the bottom, and between the numbers of fish caught at both depths. Wilcoxon's t-test showed no significant difference at the 95% level of significance between the mean size of Bairdiella chrysur ( $Z = 0.984$ ), Cynoscion nebulosus ( $Z = 0.927$ ), and Sciaenops ocellata (Wilcoxon's  $t = 32$ ) caught in surface and bottom

nets. Also, there was no significant difference at the same level of significance between the catch/1000 m<sup>3</sup> at the surface and at the bottom for B. chrysura (Z = 0.306) and C. nebulosus (Z = 0.691), but there was a significant difference between the surface and bottom catch/1000 m<sup>3</sup> for S. ocellata (Wilcoxon's t = 24).

Although larval silver perch and spotted seatrout are demersal after they enter the estuary (Pearson 1941; Miles, 1950, unpublished), they are pelagic while they move through the passes. Red drum on the other hand have assumed a demersal habitat by the time they start entering the estuary. Yokel (1966) caught 9 red drum 8-12 mm total length in surface flood tide tows taken at night. He caught no young red drum in mid-water or bottom tows, so he concluded that larval drum enter the estuaries on swifter surface currents. The data from the present study indicate that Yokel's small sample size led him to a false conclusion.

Roessler (1967, unpublished) found significant differences between the salinities and temperatures of surface and bottom water in Buttonwood Canal. For salinity this difference was 0.07 ppt and for temperature it was 0.09° C. Similar conditions probably exist in the Little Shark River, since it, too, is a shallow channel with a strong current. Although these differences are statistically different, they probably do not affect the distribution of the fish.

Relationship of Catch to  
Salinity and Temperature

There is no apparent relationship between catch and the salinity or temperature at the time of capture for Bairdiella chrysur, Cynoscion nebulosus, or Sciaenops ocellata (Figures 4, 6, and 8). Williams and Deubler (1968a) came to the same conclusion for three species of flounders on the basis of data collected over 10 years. Roessler (1967, unpublished) found that season and rainfall influenced catches of juvenile fishes most and that temperature often interacted with season and rainfall to affect catches, but that salinity had no significant effect on catch, even in an interaction. Simmons (1951b) found that moderate changes in salinity had no effect on the catches of adult spotted seatrout, and that changes in temperature had little effect unless the new temperature crossed the limit of a preferred range. Both Simmons (1957) and Tabb (1966) report that the rate of salinity change is far more important than the amount of the change. Reid and Hoese (1958) found that drastic changes in salinity distribution within an estuary did not change the size-depth distribution of young fishes living in it. The apparent lack of correlation between catch and the salinity or temperature at the time of capture suggests that neither spawning nor the abundance of young depends upon vagaries of salinity and temperature as long as these variables remain within the range normally encountered.

An account is given below of the salinity and temperature conditions in the Little Shark River when the three most common species were spawning, and of salinity and temperature ranges in the pass when their larvae were moving through.

### Salinity

Bairdiella chrysura.--Because spawning of the silver perch was delayed in 1966, the salinity was markedly different each year when the larvae were most abundant (Figure 4). In 1966 larvae were abundant when the salinity was at its peak and during the early stages of the decline, whereas during 1967 the young were most abundant while the salinity was rising. For both years, catches were lowest when the salinity curve was in late stages of its decline and was at its minimum. The salinity range over which young silver perch were caught is 23.5 to 37.4 ppt.

Cynoscion nebulosus.--Catches of this species were highest when salinity was nearing its peak or just after it, and smaller during the summer and fall when salinity declined (Figure 6). Catches were lowest during the salinity minimum and the early stages of the spring increase. The salinity range over which young spotted seatrout were caught was 23.5-37.4 ppt.

Tabb (1966) reported that spotted seatrout spawn in southern Florida during the dry season when the salinity of

estuaries and lagoons is between 30 and 35 parts per thousand. Although spawning occurred during the summer of 1966 when the salinity was below 30 parts per thousand, the data for the year generally support this statement (Figure 6). The number of larvae without hypural bones was substantially lower for the summer of 1966 than for the summer of 1967, when the salinity was between 30 and 35 parts per thousand. In 1967 the peak of spawning occurred when the salinity in the passes was well over 35 parts per thousand, however. Since the pass is probably not a spawning site, this may not be indicative of the conditions encountered by the spawning population.

Tabb also reports that survival was low if salinity was significantly below 36 ppt. This may be true for upper reaches of the lagoons and estuaries, but it is not true for the tidal passes because most fish were caught when the salinity was less than 36 ppt.

Sciaenops ocellata.--Young red drum enter estuaries during the yearly salinity minimum (Figure 8). The salinity range over which red drum were caught was 23.5-32.4 ppt.

#### Temperature

Bairdiella chrysura.--In 1966 the spawning peak occurred after the water temperature had risen well above the winter minimum (Figure 4). In 1967 it occurred when the water temperature was near the winter minimum. The

catch peak on February 27 coincided with the lowest temperature of the survey period, but these fish had been spawned a week or two earlier (Figure 5). The possible delay in spawning as a result of low temperatures has been discussed in another section. As temperatures approached the summer maxima, catches declined to a minimal level. Although the catches were reduced, there was still some active spawning because larvae without hypural bones were caught in July 1966, and July and August 1967. Spawning did not increase when the water cooled in the fall. The temperature range over which young silver perch were caught was 16.4 to 31.8° C.

Cynoscion nebulosus.--This species probably spawns all year long, but catch and length-frequency data (Figures 6 and 7) indicate that spawning was low until the water temperature had risen substantially in spring. The temperature necessary for large scale spawning appears to be 24° C (Figure 6). Simmons (1951b) has shown that after the water temperature had increased from 19.7° C to 28.3° C there was a 7-fold increase in catch of spotted seatrout. Furthermore he has shown that ripe adults moved into bays when the water temperature went above 23.3° C, but they stopped if it fell below this temperature. Tabb (1958) has observed that spawning began in spring when the temperatures averaged 25.5° C. Stewart (1961, unpublished) doubted that there was a threshold below which there was no spawning. He is probably correct, but Figure 6 shows that the delay in the



spawning peak during 1966 correlated with a minimum water temperature of  $24^{\circ}$  C. During 1967 the peak in spawning occurred more than a month after the temperature rose above  $24^{\circ}$  C. These data show that warm water is necessary to allow the spring spawning peak, but it is not the sole factor in determining when the peak occurs, nor is it necessary for all spawning.

Stewart (1961, unpublished) reported that a bimodal peak in percentage of ripe adults correlated with a water temperature range of  $28^{\circ}$  C to  $30^{\circ}$  C, and Simmons (1951b) has shown that seatrout become less active when the water temperature exceeds  $30^{\circ}$  C. The results from the present study do not support Stewart's lower temperature limit because spawning was nearly complete in the spring when the water temperature reached  $28^{\circ}$  C. Tabb (1958) has reported similar observations for other parts of Florida. Temperatures above  $30^{\circ}$  C did coincide with reduced summer spawning. Furthermore, the water temperature did not fall below  $30^{\circ}$  C until late September or early October and the fall spawning peak proposed by Stewart never materialized, which suggests that high temperatures prevented the second peak.

The temperature range over which young spotted seatrout were caught was  $16.4$ - $31.8^{\circ}$  C.

Sciaenops ocellata.--Red drum entered Everglades National Park when the temperature was falling and ceased to enter by the time the water temperature reached its winter

minimum (Figure 8). The maximum and minimum temperatures which young red drum encountered during their migration through Little Shark River were 18.3-31.8° C.

#### Results from the 24-Hour Sampling Trips

During July 1967 the sampling station was occupied for a 24 hour period during each moon phase. The sampling methods were the same as those for the nighttime, flood-tide samples except that one sample was taken each hour, regardless of tide or light.

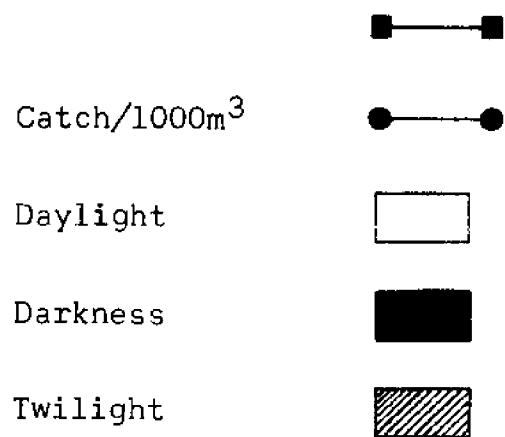
These samples were collected when postlarval shrimp are abundant, but not when young sciaenids are abundant. As a result the numbers of fish caught were usually too small for statistical analysis. Moreover, the catches and behavior of the fish may not be indicative of those at the peak of spawning. Nevertheless, these data give some insight into the behavior of larval fishes and suggest ways of organizing future sampling programs.

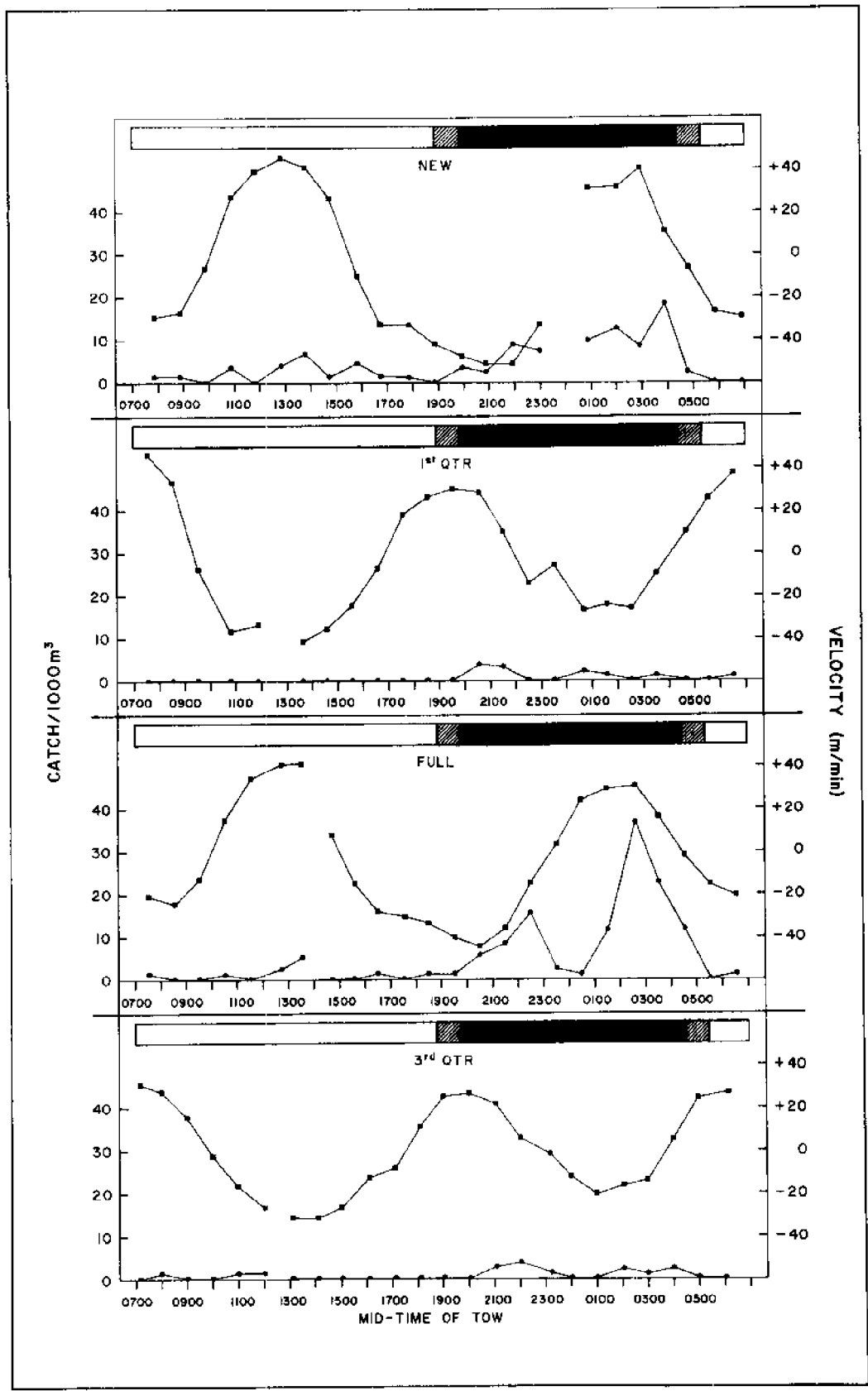
Bairdiella chrysur, Menticirrhus americanus, and Cynoscion nebulosus were caught during this series of samples, but only C. nebulosus occurred in sufficient numbers to permit analysis. The catches of all three species are presented in Tables 11-14.

The pattern of catch of spotted seatrout larvae during four twenty-four hour periods is shown in Figure 15.

Figure 15.--Diel catch of Cynoscion nebulosus on the four major moon phases.

Current velocity (positive velocity = flood tide)





Catch declined in the morning with the beginning of nautical twilight and remained low until about 1100 hours when it rose irregularly. The catch reached its peak in early afternoon, declined thereafter, and remained low until after dark. Catches rose slowly at night until the tidal current changed direction, then fell sharply. After the new current had picked up speed, catches rose again. The catch was lowest during the times when light and current were undergoing their most profound changes and was highest when conditions had been somewhat constant for a while.

#### Effect of Moon Phase on Catch

The data from the twenty-four hour sampling trips show differences in catch/1000 m<sup>3</sup> of spotted seatrout among moon phases (Figure 15), but are insufficient for statistical analysis, so evening flood-tide samples taken from June to October 1966 and May, July, and August 1967 were used instead. Samples taken in April and May 1966 and June and September 1967 were excluded from the calculation because each lacked data for one moon phase, and the missing data could not be generated mathematically, using the method of Yates (1933) (as quoted by Steel and Torrie, 1960). Friedman's randomized complete-block design (Steel and Torrie, 1960) indicated that there were no significant differences in catches among moon phases for evening flood tides at the 95% level of significance ( $\chi^2 = 1.35$ ). This suggests that there were no significant

differences among catches on different moon phases for any other time of day.

Williams and Deubler (1968a) found that catches of the flounder, Paralichthys dentatus, were significantly larger on the new moon than on the full moon, but that two closely related species, P. lethostigma and P. albigutta did not show such a difference. These authors have stressed the importance of long term sampling when studying marine organisms, and collected data for 10 years during their study. Perhaps more data are necessary for the spotted seatrout before a difference is detectable, but the present data do not even indicate a trend in the catches (Tables 5-8).

#### Effect of Light on Catch

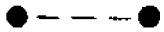






Daytime catches of ichthyoplankton are usually markedly smaller than nighttime ones, and this has been attributed to net avoidance (Bridger, 1956; Deubler, 1958; Isaacs, 1964). Isaacs (1964) noted similarity between daytime catches and the natural mortality rate of sardine larvae, and suggested that fish caught during the day are dead, dying, or weak; consequently they could not avoid the net. Percy (1962a), however, found no evidence that nighttime catches of larval winter flounder (Pseudopleuronectes americanus) were consistently higher than daytime ones or that nighttime catches contained larger larvae than daytime ones.

During this sampling program nighttime catches exceeded daytime ones (Figure 15), but because the Little Shark River is murky enough to severely limit vision, the difference in catch could reflect activity of the larvae rather than ability to avoid the net. Furthermore catches rose very slowly after nautical twilight had ended in the evening (Figure 15), whereas if the fish were active during the day, catches should have risen sharply when darkness fell. The length-frequency data were tested for a significant difference between size of fish caught during daylight and darkness. Twilight samples were omitted. A test for skewness (Snedecor and Cochran, 1967) showed that the nighttime catches were significantly skewed, but daytime ones were not. This may be attributed to the presence of large fish in nighttime samples and their absence in daytime ones, therefore, darkness is required before net avoidance ceases to be a problem.

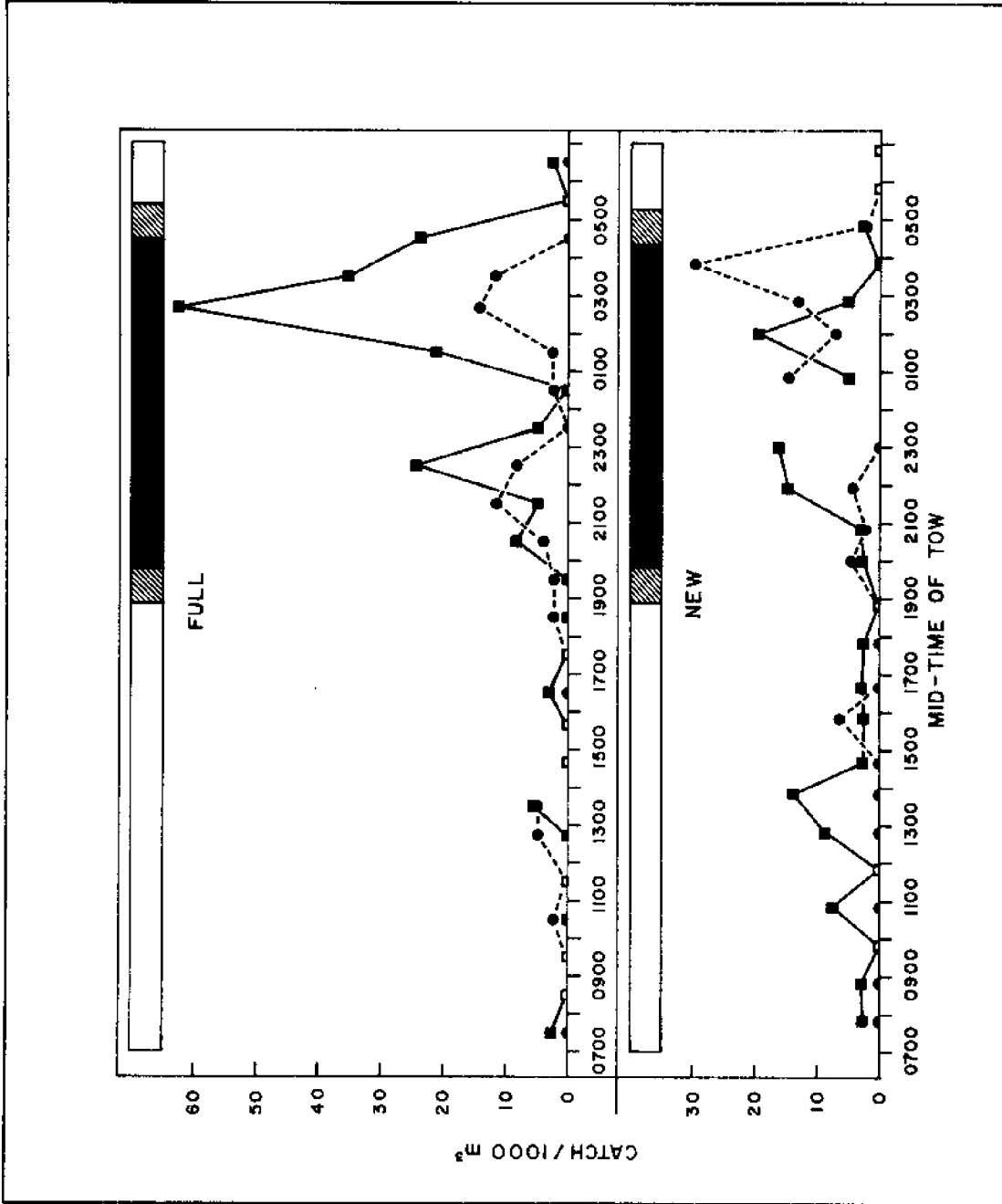
Despite significant net avoidance, several larvae were caught during daylight and the catches had a pattern which was consistent for the new and full moon phases (Figure 15). The time of peak daytime catches was during the afternoon flood tides.

Light appeared to affect the vertical distribution of the larvae also. For daylight samples in which fish were caught, the bottom catches exceeded surface ones in 17 of 23 samples (Tables 12 and 14; Figure 16). Pearson (1941) and

Figure 16.--Effect of moonlight and daylight on the vertical distribution of the catch.

Surface catch	
Bottom catch	
Coinciding points	
Daylight	
Darkness	
Moonlight	
Twilight	





Hildebrand and Cable (1930 and 1934) found that young fish are more common in deeper water during daytime, but none of their data have been tested statistically. Pearcy (1962a) found that larval winter flounder were vertically distributed by numbers and by size, more fish and larger ones being on the bottom. Pearson (1929) reports that small juvenile sciaenids attempting to enter passes in Texas were swimming at or very near the surface. The young were trying to breast the pass on an ebb tide, hugging the sides of the channel for slower currents and the counter-wash from Gulf surf, so this behavior may be anomalous.

Moonlight also appeared to reduce surface catches. At night during the quarter moon phases the bottom catches exceeded those on the surface when the moon was shining, but the surface catches exceeded those on the bottom after the moon had set (Tables 12 and 14). For the new moon bottom catches exceeded surface ones in only 4 of 8 samples and the mean surface and bottom catches were about equal, whereas for the full moon bottom catches exceeded those at the surface for 6 of 8 samples and the mean bottom catch is much higher than that for the surface (Figure 16). The data do not indicate whether the smaller surface catch during moonlit nights is due to net avoidance or to fewer fishes at the surface.

Despite the apparent correlation between light and higher bottom catches, Wilcoxon's t-test has shown that there

is no significant difference between surface and bottom catch on the full moon, either for all full-moon, flood-tide samples during 1966 and 1967 or for all nighttime samples taken on July 22-23, 1967. In both cases, however, the numbers of samples were small.

#### Effect of Current on Catch

On all moon phases, daylight and nighttime catch peaks were higher on flood tides than on their respective ebb tides (Figure 15). Total catches for flood tides were also larger than those for ebb tides. The larvae appear to have been consistently more active on flood tides than ebb tides, which means that the net transport of larvae is into the estuary even if more than one tidal cycle were required to move through the pass. This behavior would also enable the larvae entering the estuary in the summer and fall to counter the net outflow of water. Pearson (1929) has also reported that larvae and small juveniles are active during ebb tides.

Regardless of the direction the tidal current flowed, the catches reached their peak at or just after the peak velocity of the current, and were at their minimum during slack water (Figure 15). There is no apparent reason why catch peaks were delayed while the current increased in velocity, especially since the young are active on both ebb and flood tides.

The reason why catches dropped during slack tide is not known either. Bishai (1960) has shown that larval herring orient themselves into currents, but when the current stops, they swim at random or rest near the surface. His data do not indicate that fish larvae behave in such a manner as to make themselves unavailable to the sampling gear when there is no current.

## SUMMARY AND CONCLUSIONS

Despite a recent increase in studies of the fishes of Everglades National Park the larval stages have been neglected. Furthermore, the ecology of larval fishes is poorly known; what ecological data is available on larval sciaenids has been collected primarily as supplementary data during taxonomic studies. The present study has filled in some gaps in the information for species of the family Sciaenidae, a commercially important group whose larvae generally depend upon estuaries as nursery grounds. The objectives were (1) to identify the larval sciaenids which enter Everglades National Park; (2) to record their seasonal abundance; (3) to investigate the relation between catch and physical variables of the three most abundant species; and (4) to investigate the diel variation in catch of spotted seatrout (Cynoscion nebulosus).

The fish used in this study were collected from January 1966 until December 1967 during a postlarval shrimp sampling program. The sampling site was in the Little Shark River, a tidal channel which connects one of the estuarine bays of Everglades National Park to the Gulf of Mexico. Samples were taken with 471 mesh nylon plankton nets with one meter mouth-diameters. Two nets were fished, one near the bottom and one near the surface. During spring

and summer, tows were made on all major moon phases and during winter, tows were made only on new and full moon phases. Samples were taken on flood tides, at 45-60 minute intervals, during darkness, and before the maximum tidal velocity, except during July 1967 when the station was sampled hourly for 24 hours. Temperature and salinity data were taken at the mid-time of each 10 minute tow. Surface and bottom current velocity were measured before and after the tow. Samples were preserved in 10% buffered formalin, sorted, stored in 3% buffered formalin, and then transferred to 40% isopropanol.

To facilitate identification of the larvae, a list of juveniles and adults occurring in Everglades National Park and adjacent areas was compiled, descriptions and drawings of larval sciaenids were collected from the literature, juveniles of nearly all sciaenids which occur in Florida's waters were cleared and stained, preserved specimens of young juveniles were obtained, and a reference collection was compiled from the samples by comparing small specimens with larger, identified ones.

The data from nighttime, flood-tide samples were summarized for each species in three ways: (1) a size-frequency summary; (2) a summation of catch for each trip; and (3) for the three most common species an adjusted mean size calculation. For the size-frequency summary, weekly data were combined to give approximately two week intervals

for plotting. The adjusted mean size was calculated using only standard length data because regression analysis showed that there were seasonal differences in the NL:SL ratio for Bairdiella chrysur.

The following species were collected: Bairdiella chrysur, Cynoscion nebulosus, Sciaenops ocellata, Cynoscion arenarius, Leiostomus xanthurus, Menticirrhus americanus, M. saxatilis, and Pogonias cromis. The first three were the most common in the samples. Other species reported in the study area, but not found in the present samples are Bairdiella batavana, Equetus lanceolatus, Menticirrhus littoralis, Micropogon undulatus, and Stellifer lanceolatus. The marine character of this latter group largely excludes them from the brackish areas of the Park.

The seasonal abundance is shown for each of the eight species caught. In Everglades National Park, spawning generally begins earlier and ends later than for more northerly populations. Also, spawning peaks are generally somewhat earlier. Spawning of Bairdiella chrysur, Cynoscion arenarius, and C. nebulosus appears to have been delayed in 1966 compared to 1967. The appearance of Leiostomus xanthurus during this same year suggests that cold weather delayed spawning, but air and water temperature data do not support this.

There was little or no increase in size of the larvae as season progressed, which suggests that larger fish were

able to avoid the net or that they moved through the pass rapidly. Probably the river is simply a pass through which larvae travel to the preferred habitats of the inner bays and lagoons.

There was no relation apparent between catch of the three most common species and salinity or temperature at the time of sampling. The salinity ranges over which these species were caught were: Bairdiella chrysura 23.5-37.4 ppt, Cynoscion nebulosus 23.5-37.4 ppt, and Sciaenops ocellata 23.5-32.4 ppt. The temperature ranges over which these species were caught were: Bairdiella chrysura 16.4-31.8° C, Cynoscion nebulosus 16.4-31.8° C, and Sciaenops ocellata 18.3- 31.8° C.

A temperature of about 24° C appeared to be necessary to permit the spring spawning peak of Cynoscion nebulosus, but it was not the sole factor, nor was it necessary for all spawning. The lack of a second spawning peak for Cynoscion nebulosus in September may have been due to high temperatures at that time.

None of the three most abundant species exhibited significant differences between the mean size of larvae caught at the surface and that of larvae caught at the bottom. Only Sciaenops ocellata showed a significant difference between the number of larvae caught at the surface and the number caught at the bottom; bottom catches exceeded surface ones.



Catches during the diel study were often too small to draw definite conclusions, but they suggest possible relations between spotted seatrout and their environment, and suggest ways to organize future sampling programs. Data from the diel study suggested that catch of spotted seatrout varied with moon phase, but an analysis of all nighttime, flood-tide data showed no significant differences in catch among moon phases. Nighttime catches of Cynoscion nebulosus exceeded daytime ones and contained more large larvae. During daytime or moonlit hours, bottom catches usually exceeded surface ones, but the difference was not statistically significant. Daylight and nighttime flood-tide catches exceeded their respective ebb-tide ones. Catch peaks occurred at or just after the peak tidal velocity and dropped sharply during slack water.

## APPENDIX

TABLE 4  
 SAMPLES COMBINED FOR THE  
 LENGTH-FREQUENCY HISTOGRAMS

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1966	
April 18-19	and April 27
May 20-21	and May 29
June 5	and June 14
June 21	and June 28
July 5	and July 12
July 21	and July 26
August 4	and August 10
August 19	and August 26
September 2	and September 10
September 14-15	and September 23
September 28-29	and October 7
October 17	and October 22

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1967	
April 27	and May 2
May 11	and May 20
May 26	and June 3
June 26	and July 2
July 9	and July 16
July 23	and July 30
August 9	and August 15
August 21-22	and August 30

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TABLE 5  
SALINITY, TEMPERATURE, MOON PHASE, CURRENT VELOCITY,  
AND WATER-VOLUME DATA FOR 1966

Date	Mean Salin. (‰)	Mean Temp (C)	Moon Phase	Mean Current Velocity (m/min)		Volume Filtered (m <sup>3</sup> )	
				Surface	Bottom	Surface	Bottom
5-6 Jan	31.2	22.1	Full	39.6	36.5	1,064.9	1,142.3
20-21 Jan	32.4	17.2	New	37.7	35.7	2,564.1	2,008.3
20-21 Feb	32.4	21.4	New	35.4	30.5	1,775.9	1,328.6
9 Mar	32.7	18.7	Full	29.3	29.9	1,113.3	1,942.5
22-23 Mar	33.9	21.8	New	36.3	34.3	1,327.1	1,280.7
3-4 Apr	33.5	24.7	Full	38.8	33.5	2,077.7	1,835.4
18-19 Apr	32.1	24.2	New	30.0	27.0	1,542.5	1,208.9
27 Apr	34.1	23.7	1st Qtr	24.6	21.1	823.3	851.5
4-5 May	34.1	25.0	Full	31.0	28.2	685.9	701.4
20-21 May	35.3	29.2	New	25.4	26.1	1,747.3	1,588.9
29 May	36.6	28.8	1st Qtr	30.7	24.1	1,060.6	983.2
5 June	28.5	26.2	Full	26.2	23.0	1,516.7	1,378.0
14 June	31.5	29.9	3rd Qtr	29.3	25.6	1,226.7	1,197.0
21 June	34.0	30.5	New	33.8	30.5	1,719.4	1,319.7
28 June	29.2	27.7	1st Qtr	29.3	23.1	1,541.9	1,388.4
5 July	27.3	32.9	Full	33.1	28.0	1,715.2	1,392.2
12 July	27.3	23.7	3rd Qtr	36.3	27.0	1,645.4	1,235.2
21 July	25.7	29.5	New	41.9	32.5	368.1	398.4
26 July	28.1	30.9	1st Qtr	37.8	21.3	1,303.5	1,036.0
4 Aug	30.4	30.8	Full	34.9	22.4	1,514.9	1,364.9
10 Aug	29.1	29.5	3rd Qtr	25.3	18.3	1,585.4	1,447.4
19 Aug	32.0	29.6	New	38.8	35.8	1,184.5	1,155.1
26 Aug	25.7	30.1	1st Qtr	30.1	19.7	1,169.4	1,048.0
2 Sept	28.3	30.9	Full	41.9	32.3	1,660.8	1,395.4
10 Sept	28.1	-	3rd Qtr	27.5	20.4	437.9	398.0
14-15 Sept	28.4	28.6	New	42.5	37.1	1,046.9	911.2
23 Sept	27.1	31.8	1st Qtr	35.2	23.4	1,717.0	1,132.1
28-29 Sept	29.9	33.1	Full	42.8	33.5	1,455.2	1,063.2
7 Oct	26.5	27.0	3rd Qtr	29.1	15.7	1,303.6	960.3
17 Oct	27.8	27.8	New	35.8	30.0	1,126.4	1,072.9
22 Oct	23.5	28.0	1st Qtr	33.3	25.2	1,336.5	1,461.0
14-15 Nov	26.5	24.4	New	40.2	34.9	1,315.8	1,126.8
29-30 Nov	30.8	18.3	Full	37.1	32.7	925.7	950.4
13-14 Dec	28.8	20.2	New	35.4	28.6	1,024.6	755.0
29-30 Dec	31.7	19.1	Full	40.2	31.1	1,299.4	976.5

TABLE 6

SALINITY, TEMPERATURE, MOON PHASE, CURRENT VELOCITY,  
AND WATER-VOLUME DATA FOR 1967

Date	Mean Salin (‰)	Mean Temp (C)	Moon Phase	Mean Current Velocity (m/min)		Volume Filtered (m <sup>3</sup> )	
				Surface	Bottom	Surface	Bottom
12-13 Jan	32.0	20.8	New	38.6	28.3	1,094.5	890.5
-29 Jan	31.2	20.9	Full	34.6	27.6	869.1	993.0
12 Feb	30.6	21.3	New	40.7	31.3	1,086.9	1,277.2
27 Feb	28.6	16.4	Full	41.3	32.7	1,054.5	1,032.4
14 Mar	33.4	26.1	New	40.8	31.4	1,161.2	1,119.7
12 Apr	35.6	25.9	New	33.1	29.1	1,036.7	1,135.4
27 Apr	35.7	27.5	Full	33.1	26.1	1,486.6	1,489.3
2 May	36.5	24.8	3rd Qtr	21.4	15.4	1,029.4	1,093.6
11 May	36.5	28.7	New	25.1	20.9	1,187.1	1,135.2
20 May	37.1	27.7	1st Qtr	33.1	28.4	1,697.8	1,720.5
25 May	36.4	27.3	Full	28.4	22.7	1,100.4	1,101.9
3 June	36.7	28.7	3rd Qtr	25.8	20.6	1,481.0	1,303.4
11 June	37.4	30.1	New	36.3	29.8	1,284.3	1,150.4
25 June	33.6	29.8	Full	30.1	28.1	1,258.6	1,165.5
2 July	31.1	30.4	3rd Qtr	29.1	20.2	1,911.5	1,470.7
9 July	31.9	30.0	New	31.1	27.4	1,653.3	1,438.2
16 July	34.3	31.5	1st Qtr	17.7	19.8	868.0	836.4
23 July	35.2	30.3	Full	28.3	21.6	1,675.4	1,503.5
30 July	35.0	30.7	3rd Qtr	20.3	15.7	1,282.0	1,076.0
9 Aug	33.8	27.8	New	36.1	25.5	2,104.2	1,765.7
15 Aug	32.3	30.3	1st Qtr	29.8	22.8	1,786.2	1,330.1
21-22 Aug	34.8	29.1	Full	36.7	27.2	2,420.9	1,690.2
30 Aug	32.5	31.2	3rd Qtr	28.2	22.0	1,612.9	1,434.6
7 Sept	34.0	30.4	New	36.9	31.8	1,455.3	1,443.5
21 Sept	32.1	29.9	Full	34.5	27.0	958.7	773.3
5-6 Oct	32.2	26.2	New	46.9	34.7	1,659.2	1,215.0
20-21 Oct	24.6	25.0	Full	35.7	23.1	1,512.3	1,060.0
4-5 Nov	28.6	25.3	New	37.6	30.5	1,246.3	911.2
19-20 Nov	28.1	22.2	Full	34.0	28.4	1,367.8	1,099.7
2-3 Dec	29.4	24.4	New	44.0	33.9	1,862.5	1,448.0
17 Dec	29.0	24.6	Full	38.8	29.2	1,280.8	1,093.2

TABLE 7  
 CATCH STATISTICS FOR BAIRDIELLA CHRYSURA, CYNOSCION NEBULOSUS,  
 AND SCIAENOPS OCELLATA DURING 1956

Date	Catch					
	Bairdiella chrysura		Cynoscion nebulosus		Sciaenops ocellata	
	Surface	Bottom	Surface	Bottom	Surface	Bottom
5-6	8	30	0	0	0	0
20-21 Jan	31	31	2	0	0	0
20-21 Feb	5	17	0	0	0	1
9 Mar	34	0	1	0	0	0
22-23 Mar	0	0	0	0	0	0
3-4 Apr	17	0	12	0	0	0
18-19 Apr	236	82	45	15	0	0
27 Apr	20	30	6	6	0	0
4-5 May	3	0	2	0	0	0
20-21 May	102	115	41	77	0	0
29 May	4	0	35	0	0	0
5 June	21	26	406	129	0	0
14 June	11	7	201	94	0	0
21 June	216	91	99	79	0	0
28 June	11	34	2	19	0	0
5 July	0	1	1	4	0	0
12 July	14	5	17	13	0	0
21 July	0	0	0	0	0	0
26 July	20	23	16	62	0	0
4 Aug	0	0	1	10	0	0
10 Aug	0	0	43	13	0	0
19 Aug	0	0	2	1	0	0
26 Aug	4	5	7	18	0	0
2 Sept	43	40	87	38	0	0
10 Sept	3	1	6	2	0	0
14-15 Sept	0	0	7	9	0	0
23 Sept	1	0	1	7	5	1
28-29 Sept	2	4	17	29	78	95
7 Oct	2	1	9	10	694	653
17 Oct	0	2	15	21	52	61
22 Oct	3	0	3	1	36	55
14-15 Nov	0	0	0	0	25	7
29-30 Nov	1	2	0	0	2	1
13-14 Dec	36	8	0	0	0	1
29-30 Dec	2	5	0	0	0	0

TABLE 8  
 CATCH STATISTICS FOR BAIRDIELLA CHRYSURA, CYNOSCION NEBULOSUS,  
 AND SCIAENOPS OCELLATA DURING 1967

Date	Catch					
	<u>Bairdiella chrysura</u>		<u>Cynoscion nebulosus</u>		<u>Sciaenops ocellata</u>	
	Surface	Bottom	Surface	Bottom	Surface	Bottom
12-13						
Jan	9	6	0	0	0	0
Jan	26	34	0	0	0	0
Feb	254	214	0	0	0	0
Feb	631	958	2	1	0	0
Mar	64	18	4	1	0	0
12						
Apr	11	7	4	2	0	0
Apr	48	67	174	213	0	0
May	10	33	59	117	0	0
May	55	70	157	135	0	0
May	43	38	174	142	0	0
May	5	26	35	61	0	0
June	5	2	4	19	0	0
June	7	2	1	11	0	0
June	0	0	0	7	0	0
July	37	18	87	42	0	0
July	1	1	27	11	0	0
July	0	1	1	5	0	0
July	6	1	13	31	0	0
July	1	0	5	0	0	0
Aug	8	5	63	47	0	0
15						
Aug	2	2	17	68	0	0
21-22	3	10	6	18	0	0
Aug	5	1	28	11	0	0
Sept	3	5	15	14	0	0
Sept	0	0	5	4	1	0
5-6						
Oct	0	1	1	1	0	0
20-21	0	0	0	0	31	120
4-5	1	0	1	0	48	39
19-20	0	0	0	2	3	13
2-3	13	16	9	0	28	77
17	0	2	0	1	1	1

TABLE 9  
 MEAN SIZES AND STANDARD DEVIATIONS OF BAIRDIELLA CHRYSURA, CYNOSCION  
 NEBULOSUS AND SCIAENOPS OCELLATA CAUGHT DURING 1966

Date	Bairdiella Chrysuræ			Cynoscion nebulosus			Sciaenops ocellata			Maximum Number of Iterations
	Mean Size (mm)	S.D.	No. of Fish	Mean Size (mm)	S.D.	No. of Fish	Mean Size (mm)	S.D.	No. of Fish	
5-6 Jan	3.18	0.25	11	-	-	0	-	-	0	1
20-21 Jan	3.97	0.32	55	3.50	0.71	2	-	-	0	4
20-21 Feb	4.30	0.52	20	-	-	0	8.50	0.0	1	2
9 Mar	3.59	0.32	23	4.0	0.0	1	-	-	0	3
22-23 Mar	-	-	0	-	-	0	-	-	0	1
3-4 Apr	3.25	0.29	4	-	-	0	-	-	0	1
18-19 Apr	4.20	0.47	259	4.81	0.44	55	-	-	0	5
27 Apr	4.26	1.06	44	4.61	0.74	9	-	-	0	3
4-5 May	3.67	0.29	3	4.25	0.35	2	-	-	0	1
20-21 May	3.82	0.43	174	4.75	0.94	91	-	-	0	5
29 May	3.88	0.63	4	4.12	0.60	25	-	-	0	4
5 June	3.46	0.52	42	3.72	0.43	353	-	-	0	4
14 June	4.89	1.26	18	3.82	0.64	168	-	-	0	4
21 June	3.73	0.67	283	5.04	1.27	151	-	-	0	7
28 June	4.92	0.57	37	5.38	1.41	17	-	-	0	5
5 July	7.00	0.0	1	8.10	2.86	5	-	-	0	1
12 July	3.28	0.26	16	4.83	0.51	26	-	-	0	2
21 July	-	-	0	-	-	0	-	-	0	1
26 July	4.26	0.48	45	4.36	0.77	66	-	-	0	3
4 Aug	-	-	0	3.70	0.48	10	-	-	0	1
10 Aug	-	-	0	3.63	0.50	50	-	-	0	3
19 Aug	-	-	0	5.83	1.55	3	-	-	0	1
26 Aug	3.62	0.35	8	4.58	0.86	20	-	-	0	4
2 Sept	3.77	0.48	75	4.49	0.56	114	-	-	0	4
10 Sept	6.00	1.47	4	6.81	1.39	8	-	-	0	1
14-15 Sept	-	-	0	6.04	0.97	14	-	-	0	4
23 Sept	5.50	0.0	1	5.88	1.85	8	5.92	0.86	6	1
28-29 Sept	3.83	0.41	6	5.01	0.89	43	4.20	0.44	150	3
7 Oct	6.00	2.60	3	5.37	0.72	15	5.64	0.73	1180	4
17 Oct	5.25	1.77	2	5.76	0.54	30	5.69	0.43	98	4
22 Oct	4.67	0.29	3	5.17	0.58	3	5.61	0.87	88	3
14-15 Nov	-	-	0	-	-	0	7.86	0.58	29	3
29-30 Nov	3.83	0.29	3	-	-	0	8.17	0.29	3	1
13-14 Dec	4.44	0.48	41	-	-	0	4.50	0.0	1	2
29-30 Dec	3.71	0.39	7	-	-	0	-	-	0	1



TABLE 10  
 MEAN SIZES AND STANDARD DEVIATIONS OF BAIRDIELLA CHRYSURA, CYNOSCION  
 NEBULOSUS AND SCIAENOPS OCELLATA CAUGHT DURING 1967

Date	<u>Bairdiella chrysura</u>			<u>Cynoscion nebulosus</u>			<u>Sciaenops ocellata</u>			Maximum Number of Iterations
	Mean Size (mm)	S.D.	No. of Fish	Mean Size (mm)	S.D.	No. of Fish	Mean Size (mm)	S.D.	No. of Fish	
12-13 Jan	4.04	0.35	11	-	-	0	-	-	0	4
29 Jan	3.34	0.41	19	-	-	0	-	-	0	3
12 Feb	3.90	0.36	379	4.50	0.71	2	-	-	0	2
27 Feb	3.86	0.34	1437	4.00	0.0	3	-	-	0	3
14 Mar	4.64	0.45	70	3.17	0.29	3	-	-	0	4
12 Apr	3.22	0.26	9	4.10	0.22	5	-	-	0	3
27 Apr	3.28	0.45	30	3.18	0.24	108	-	-	0	5
2 May	3.40	0.39	10	3.56	0.32	45	-	-	0	5
11 May	4.18	0.74	100	4.60	0.71	238	-	-	0	6
20 May	3.47	0.42	57	3.24	0.25	99	-	-	0	4
26 May	3.57	0.76	21	3.58	0.50	46	-	-	0	3
3 June	5.43	0.67	7	3.97	0.88	15	-	-	0	2
11 June	4.89	1.45	9	4.44	0.68	9	-	-	0	3
25 June	-	-	0	3.90	1.24	5	-	-	0	1
2 July	4.22	0.62	55	4.81	1.43	112	-	-	0	4
9 July	4.00	0.71	2	4.03	0.77	32	-	-	0	3
16 July	2.50	0.0	1	3.33	0.52	6	-	-	0	1
23 July	2.50	0.0	1	3.00	0.39	14	-	-	0	3
30 July	3.50	0.0	1	5.00	1.28	5	-	-	0	1
9 Aug	3.50	1.06	14	3.92	0.35	95	-	-	0	4
15 Aug	3.50	0.41	4	4.23	0.76	64	-	-	0	4
21-22 Aug	2.75	0.35	2	3.69	0.46	21	-	-	0	4
30 Aug	3.20	0.67	5	3.65	0.48	30	-	-	0	3
7 Sept	3.50	0.53	8	4.69	1.17	27	-	-	0	3
21 Sept	-	-	0	4.50	0.43	9	4.00	0.0	1	1
5-6 Oct	23.50	0.0	1	4.00	0.71	2	-	-	0	1
20-21 Oct	-	-	0	-	-	0	7.10	0.36	137	3
4-5 Nov	3.50	0.0	1	3.50	0.0	1	7.47	1.00	86	2
19-20 Nov	-	-	0	6.75	1.06	2	6.77	0.68	15	1
2-3 Dec	4.12	0.38	28	4.50	0.0	9	8.35	0.97	99	4
17 Dec	3.50	0.0	2	4.50	0.0	1	7.25	0.35	2	1

TABLE 11  
DATA FROM 24-HOUR SAMPLING TRIPS

July 9, 1967  
New Moon

Mid-time of Tow	Tide	Current Velocity (m/min)		Volume Filtered (m <sup>3</sup> )		Bairdiella chryseura		Cynoscion nebulosus		Menticirrhus americanus	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
		Number of Fish Caught									
0051	Flood	35.6	28.6	479.4	427.0	0	1	7	2	0	0
0200	Flood	32.0	31.8	427.9	358.1	0	0	3	7	1	0
0253	Flood	43.1	38.3	306.2	393.5	0	0	4	2	0	0
0351	Flood	13.9	12.6	439.8	259.6	1	0	13	0	0	0
0447a	Slack	7.9	5.2	443.2	401.9	0	1	1	1	0	0
0550b	Ebb	33.1	20.4	470.3	337.1	0	0	0	0	0	0
0653	Ebb	33.1	25.7	450.5	405.6	0	0	0	0	0	0
0752	Ebb	32.5	25.9	435.6	354.6	0	1	0	1	0	1
0851	Ebb	29.0	25.5	425.5	348.8	0	0	0	1	0	0
0951	Slack	7.9	4.6	461.2	382.8	0	0	0	0	0	0
1052	Flood	28.5	25.5	445.5	398.6	0	0	0	3	0	0
1149	Flood	43.7	34.7	444.6	382.4	0	2	0	0	0	0
1250	Flood	51.1	39.3	401.5	342.3	0	1	0	3	0	0
1346	Flood	43.8	38.7	449.0	438.8	1	1	0	6	0	1
1443	Flood	25.1	27.9	417.8	374.8	0	0	0	1	0	0
1549	Ebb	12.9	7.1	479.8	406.4	0	1	3	1	0	0
1644	Ebb	36.5	29.4	437.1	359.2	0	0	0	1	0	0
1751	Ebb	39.8	27.0	497.8	431.5	0	0	0	1	0	0
1851c	Ebb	47.4	36.7	446.8	379.5	0	0	0	0	0	0
1956d	Ebb	53.1	42.7	457.1	386.1	0	1	2	1	0	0
2052	Ebb	56.9	46.4	446.1	345.1	0	0	1	1	0	0
2155	Ebb	55.1	48.2	491.7	409.2	1	0	2	6	0	0
2259	Ebb	37.3	29.3	461.9	370.4	0	0	0	6	0	0

<sup>a</sup>Nautical twilight begins at 0420.

<sup>d</sup>Nautical twilight ends at 1950.

<sup>b</sup>Sun rises at 0516.

<sup>e</sup>Plotted as an ebbing current in Figure 15.

<sup>c</sup>Sun sets at 1853.

TABLE 12  
DATA FROM 24-HOUR SAMPLING TRIPS  
July 15-16, 1967  
First Quarter

Mid-time of Tow	Tide	Current Velocity (m/min)		Volume Filtered (m <sup>3</sup> )		Bairdiella chrysurus		Cynoscion nebulosus		Menticirrhus americanus	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
		Number of Fish Caught									
1339 <sup>a</sup>	Ebb	43.8	39.1	453.7	362.3	0	0	0	0	0	0
1434	Ebb	39.5	31.9	432.2	345.8	0	0	0	0	0	0
1534	Ebb	27.5	22.0	460.2	406.4	0	0	0	0	0	0
1633	Ebb	7.3	7.8	435.4	375.7	0	0	0	0	0	0
1733	Flood	20.6	15.8	438.0	372.3	0	0	0	0	0	0
1831 <sup>b</sup>	Flood	27.4	24.6	430.6	358.8	0	0	0	0	0	0
1931 <sup>c</sup>	Flood	31.8	27.9	435.0	401.7	0	0	0	0	0	0
2033	Flood	29.4	27.3	430.2	366.5	0	1	1	2	0	0
2132	Flood	6.0	12.3	437.8	469.9	0	0	0	0	0	0
2232	Ebb	15.0	13.2	480.0	420.3	0	0	0	0	0	0
2331	Ebb	7.5	4.1	467.3	461.1	0	1	0	0	0	0
0040 <sup>d</sup>	Ebb	25.9	27.1	503.8	412.7	1	0	1	0	0	0
0135	Ebb	20.9	27.4	475.3	261.2	1	0	1	0	0	0
0232	Ebb	29.8	22.4	418.5	351.9	0	0	0	0	0	0
0330	Ebb	15.0	4.3	442.6	377.2	0	0	0	1	0	0
0440 <sup>e</sup>	Flood	9.4	10.9	389.2	342.4	0	0	0	0	0	0
0534 <sup>f</sup>	Flood	26.6	25.0	476.7	402.7	0	0	0	0	0	0
0631	Flood	40.5	34.3	489.6	424.4	0	0	0	0	1	0
0734	Flood	48.6	43.4	349.1	274.3	0	0	0	0	0	0
0831	Flood	34.7	31.6	449.3	400.2	0	0	0	0	0	0
0931	Slack <sup>g</sup>	3.3	12.4	458.9	415.0	0	0	0	0	0	0
1048	Ebb	35.7	27.4	491.4	412.4	0	0	0	0	0	0
1153	Ebb	36.5	31.0	466.5	400.3	0	0	0	0	0	0

<sup>a</sup>Moon rises at 1301.

<sup>b</sup>Sun sets at 1852.

<sup>c</sup>Nautical twilight ends at 1949.

<sup>d</sup>Moon sets at 0028.

<sup>e</sup>Nautical twilight begins at 0423.

<sup>f</sup>Sun rises at 0519.

<sup>g</sup>Plotted as an ebbing current in Figure 15.

TABLE 13  
DATA FROM 24-HOUR SAMPLING TRIPS

July 22-23, 1967  
Full Moon

Mid-time of Tow	Tide	Current Velocity (m/min)		Volume Filtered (m <sup>3</sup> )		Number of Fish Caught							
		Surface	Bottom	Surface	Bottom	<u>Bairdiella</u>		<u>Cynoscion</u>		<u>Menticirrhus</u>			
						chrysuræ	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
1442	Flood	6.0	9.5	421.4	413.8	0	0	0	0	0	0	0	0
1536	Ebb	21.3	8.9	431.9	375.2	0	0	0	0	0	0	0	0
1630	Ebb	34.9	21.0	435.4	328.1	0	0	0	1	0	0	0	0
1733	Ebb	33.3	27.7	453.5	366.5	0	0	0	0	0	0	0	0
1830a	Ebb	39.4	28.1	440.9	350.0	0	0	1	0	0	0	0	0
1932b	Ebb	47.0	33.6	448.1	352.1	0	0	1	0	0	0	0	0
2031c	Ebb	47.8	37.7	504.5	365.1	0	1	2	3	0	0	0	0
2132	Ebb	41.6	30.6	522.4	421.7	1	0	6	2	0	1	0	0
2231	Ebb	18.8	11.0	489.7	410.0	0	0	4	10	0	0	0	0
2331	Slack <sup>g</sup>	2.6	4.3	434.7	420.2	0	0	0	0	0	0	0	0
0032	Flood	26.7	21.1	426.5	388.6	1	0	1	1	0	0	0	0
0132	Flood	32.7	25.2	403.9	379.7	1	0	1	8	0	0	0	0
0236	Flood	35.7	25.3	419.1	367.8	4	1	6	23	1	0	0	0
0331	Flood	18.1	14.9	425.9	367.4	0	1	5	13	0	0	0	0
0433d	Ebb	1.9	2.8	395.0	375.9	0	2	0	9	0	0	0	0
0532e	Ebb	17.9	13.5	420.9	358.0	0	0	0	0	0	0	0	0
0633f	Ebb	28.5	13.1	445.9	401.1	0	1	0	1	0	0	0	0
0733	Ebb	22.9	19.4	425.6	383.1	0	1	0	1	0	0	0	0
0833	Ebb	28.0	21.0	428.6	369.1	0	0	0	0	0	0	0	0
0931	Ebb	16.6	9.9	403.3	364.7	0	0	0	0	0	0	0	0
1030	Flood	14.6	14.9	446.2	414.8	0	0	0	1	0	0	0	0
1132	Flood	30.3	35.6	427.7	383.7	0	0	0	0	0	0	0	0
1245	Flood	46.0	36.2	415.1	373.0	0	0	2	2	0	0	0	0
1334	Flood	46.1	35.7	406.9	368.1	0	0	2	2	0	0	0	0

<sup>a</sup>Sun sets at 1851.

<sup>e</sup>Sun rises at 0522.

<sup>b</sup>Nautical twilight ends at 1946.

<sup>f</sup>Moon sets at 0657.

<sup>c</sup>Moon rises at 1956.

<sup>g</sup>Plotted as a flooding current in Figure 15.

<sup>d</sup>Nautical twilight begins at 0427.

TABLE 14  
DATA FROM 24-HOUR SAMPLING TRIPS

July 30-31, 1967  
Third Quarter

Mid-time of Tow	Tide	Current Velocity (m/min)		Volume Filtered (m <sup>3</sup> )		Number of Fish Caught							
		Surface	Bottom	Surface	Bottom	Bairdiella		Cynoscion		Menticirrhus			
						chrysurus	Surface	Bottom	Surface	Bottom	Surface	Bottom	
1308	Ebb	35.0	27.8	487.4	415.8	0	0	0	0	0	0	0	0
1408a	Ebb	35.3	28.4	487.7	404.9	0	0	0	0	0	0	0	0
1504	Ebb	28.9	24.7	485.0	396.2	0	0	0	0	0	0	0	0
1607	Ebb	15.4	10.1	487.7	417.8	0	0	0	0	0	0	0	0
1707	Ebb	4.0	7.4	506.3	417.7	0	0	0	0	0	0	0	0
1807b	Flood	13.0	9.8	523.3	414.6	0	0	0	0	0	0	0	0
1903c	Flood	28.6	22.1	461.2	368.1	0	0	0	0	0	0	0	0
2002	Flood	30.0	23.0	459.7	400.3	0	0	0	0	0	0	0	0
2105	Flood	24.0	19.4	427.8	274.7	0	0	2	0	0	0	0	0
2202	Flood	7.0	4.7	394.5	401.0	1	0	3	0	0	0	0	0
2314	Slack <sup>9</sup>	1.8	2.1	433.9	414.5	0	0	1	0	0	0	0	0
0003d	Ebb	15.7	7.8	411.1	364.5	0	0	0	0	0	0	0	0
0101	Ebb	25.7	15.8	516.3	367.3	0	0	0	0	0	0	0	0
0204	Ebb	17.3	16.0	516.7	402.2	0	0	2	0	0	0	0	0
0300	Ebb	17.4	10.8	502.7	408.1	0	0	1	0	0	0	0	0
0400e	Slack <sup>h</sup>	2.3	8.3	492.6	369.8	0	0	0	0	2	0	0	0
0502f	Flood	26.9	21.6	493.4	405.9	0	0	0	0	0	0	0	0
0602	Flood	30.9	23.3	472.4	413.0	0	0	0	0	0	0	0	0
0710	Flood	34.7	27.4	453.6	373.0	0	0	0	0	0	0	0	0
0801	Flood	32.0	23.4	433.8	352.9	0	1	0	0	1	0	0	0
0901	Flood	17.6	13.7	455.8	384.9	0	1	0	0	0	0	0	0
0959	Slack <sup>9</sup>	2.4	2.9	429.2	385.2	0	1	0	0	0	0	0	0
1101	Ebb	22.4	11.4	409.4	353.3	0	0	0	1	0	0	0	0
1203	Ebb	33.0	20.4	447.9	337.0	0	0	0	0	1	0	0	0

<sup>a</sup>Moon sets at 1305.

<sup>b</sup>Sun sets at 1847.

<sup>c</sup>Nautical twilight ends at 1941.

<sup>d</sup>Moon rises at 0010.

<sup>e</sup>Nautical twilight begins at 0432.

<sup>f</sup>Sun rises at 0527.

<sup>g</sup>Plotted as an ebbing current in Figure 15.

<sup>h</sup>Plotted as a flooding current in Figure 15.

Figure 17.--Bairdiella chrysura.

(A) 2.0 mm. (B) 5.0 mm. In Figures 17-24 stippled chromatophores represent deep-lying pigmentation or that covered by the pectoral fin, and solid black chromatophores represent surface pigmentation.

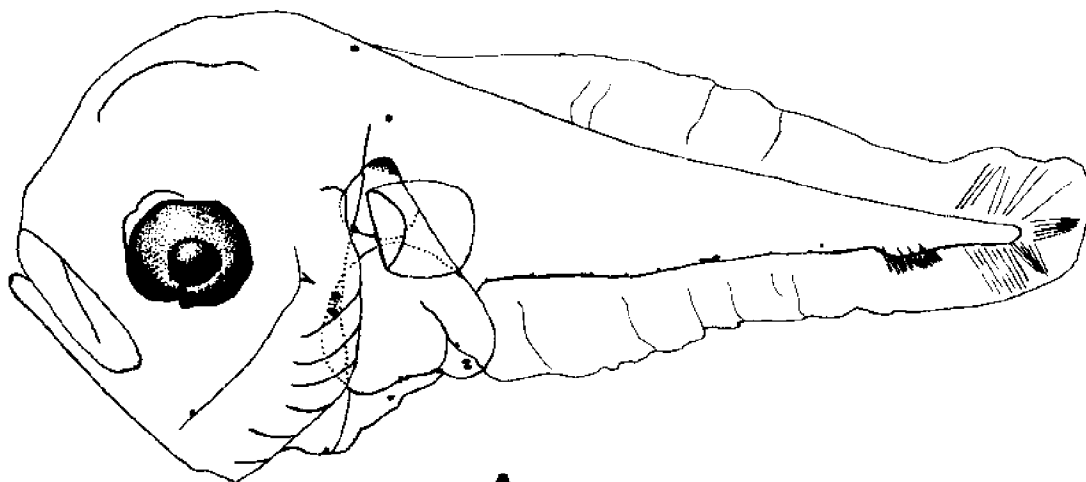
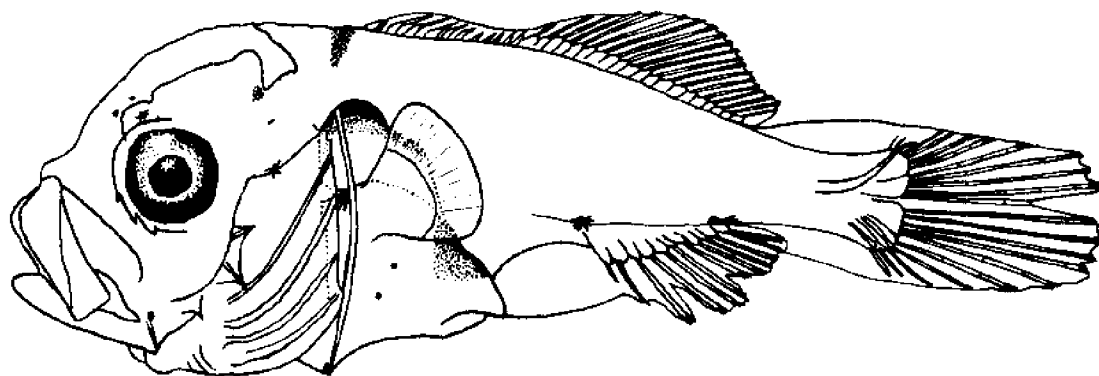
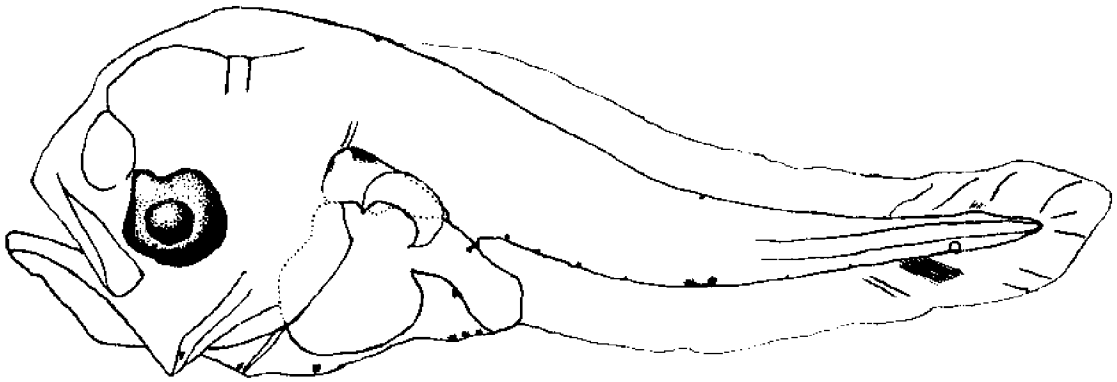
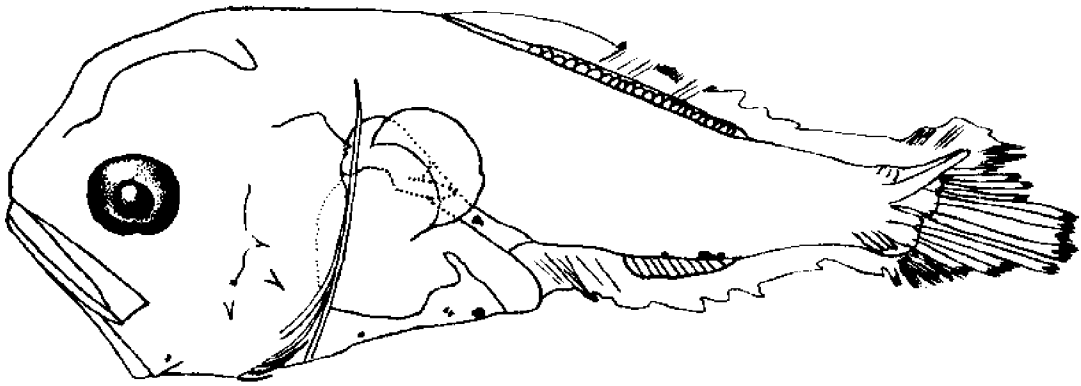
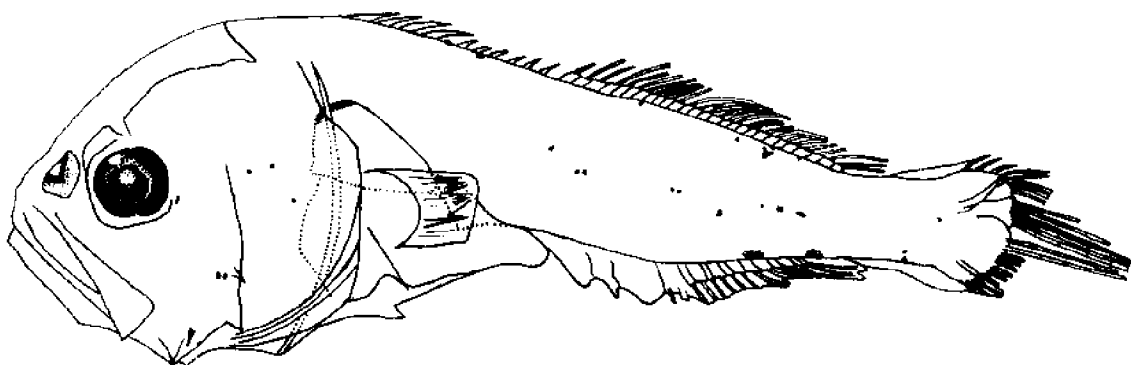
**A****B**

Figure 18.--Cynoscion arenarius.

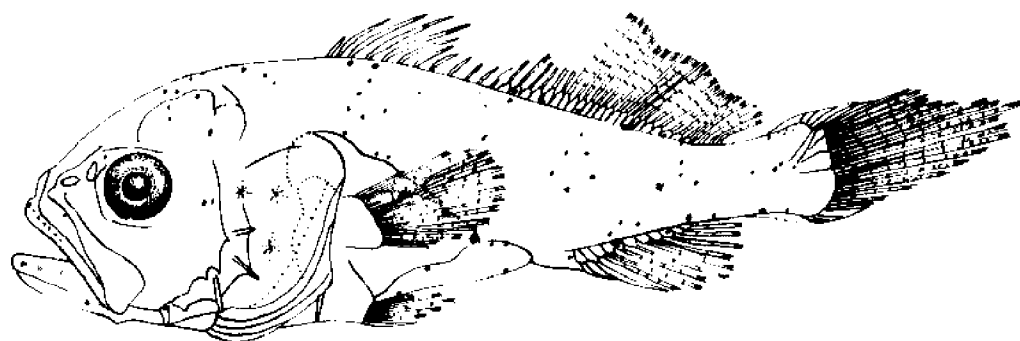
(A) 2.0 mm. (B) 3.5 mm. (C) 6.5 mm. (D) 10.5 mm.



**A****B**



C



D

Figure 19.--Cynoscion nebulosus.

(A) 3.0 mm. (B) 5.0 mm.

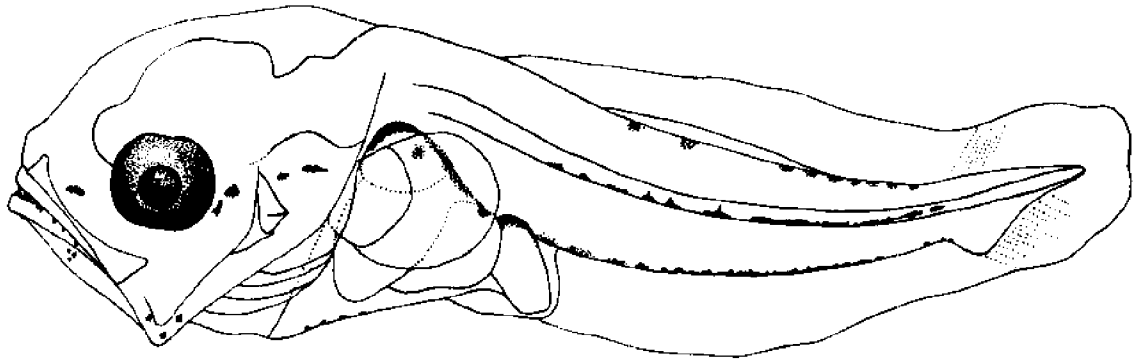
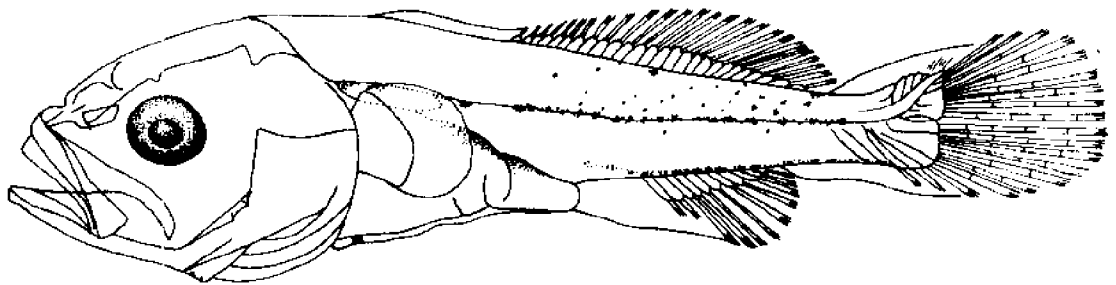
**A****B**

Figure 20.--Leiostomus xanthurus.

A composite drawing based on two 11 mm specimens.

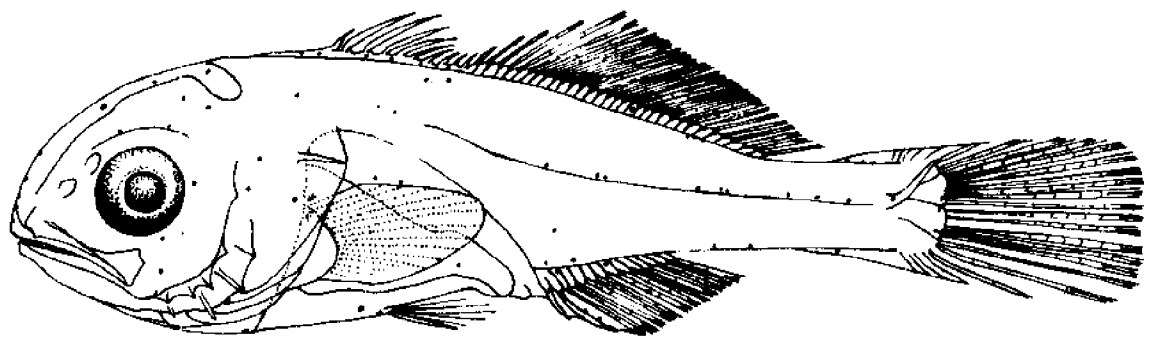
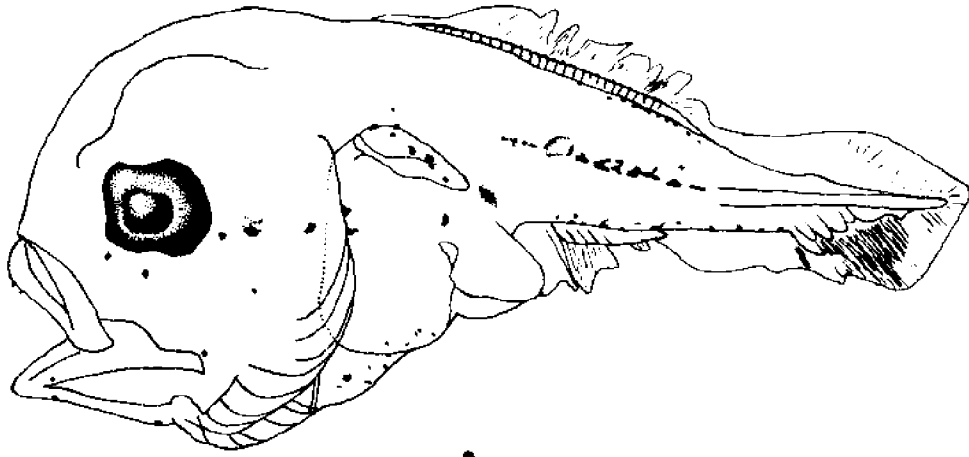
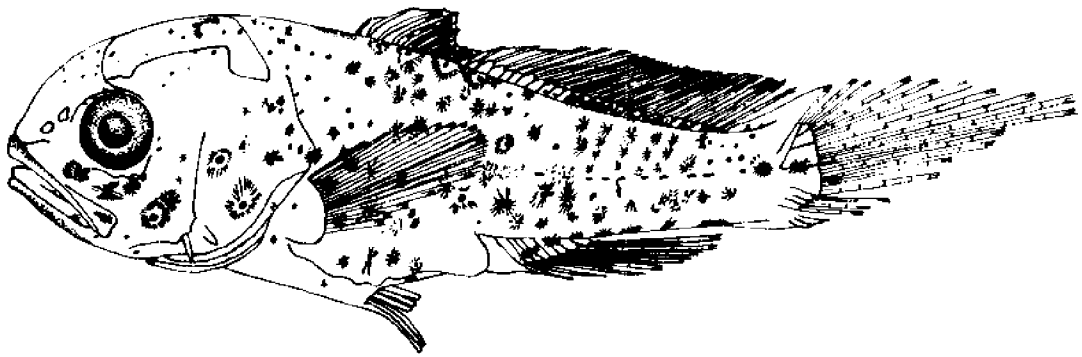


Figure 21.--Menticirrhus americanus.

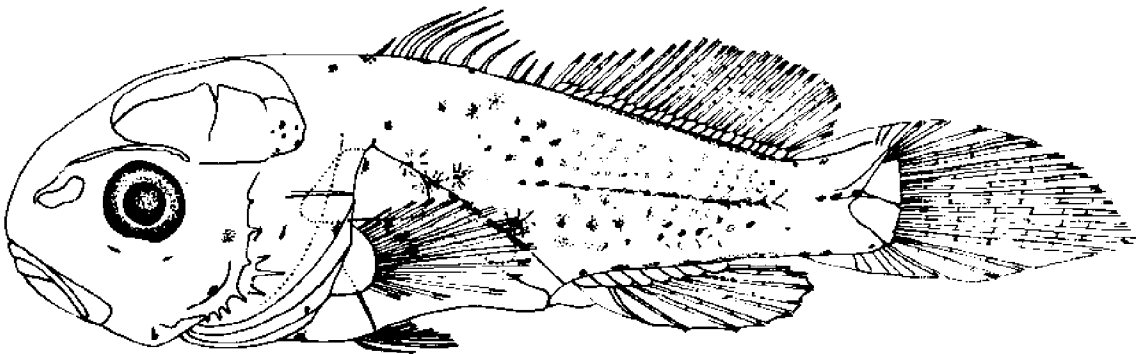
(A) 2.5 mm. (B) 6.0 mm. (C) 6.0 mm. Specimens B and C illustrate part of the difficulty in identifying species in this genus because they have different tail shapes, although they are the same size. Both specimens were identified as M. americanus, however, because Hildebrand and Cable (1934) have shown that 5.8 mm specimens of M. americanus have blunt tails, but develop pointed ones by the time they reach 8.0 mm. Specimens B and C fall in the transition phase and a difference in developmental stage may account for the difference in tail shape. The pigment pattern of specimen C falls well within the range of variation found in M. americanus. There were very few specimens with well preserved caudal fins so the development of this fin could not be followed.



A



B

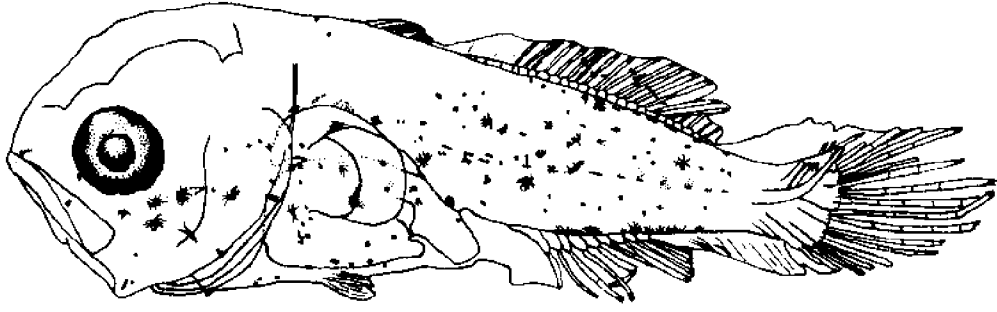


C

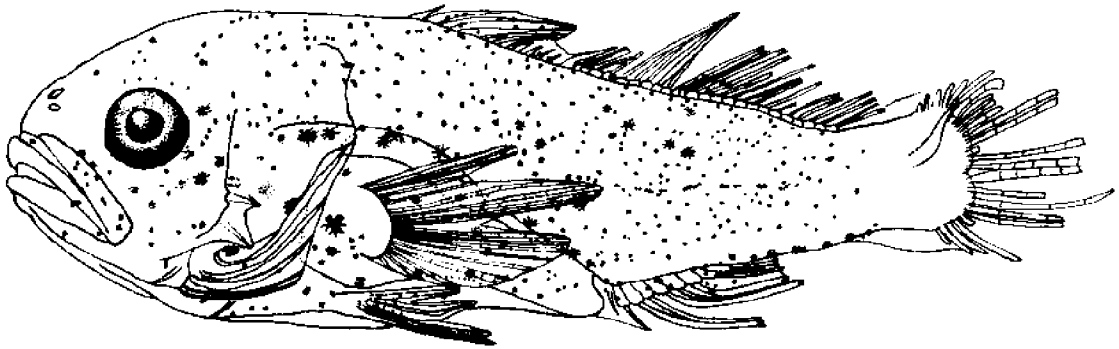


Figure 22.--Menticirrhus saxatilis.

(A) 5.0 mm. (B) 8.0 mm.



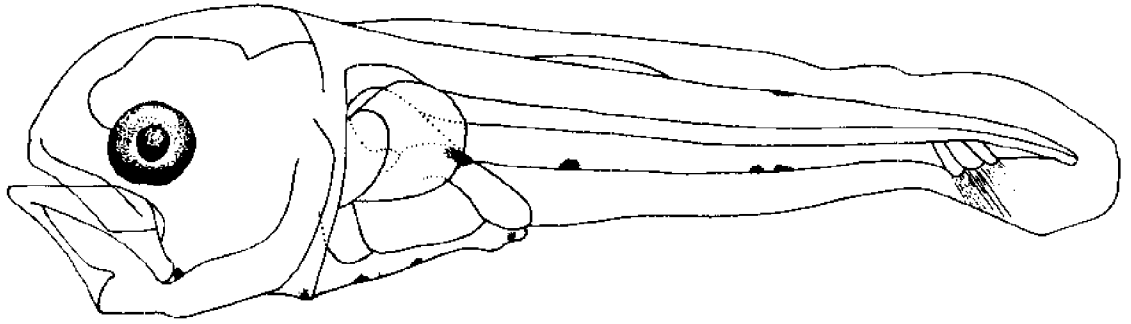
A



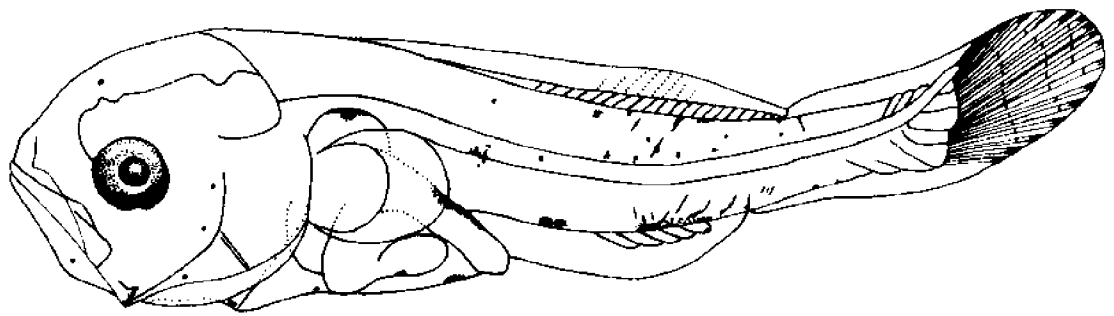
B

Figure 23.--Pogonias cromis.

(A) 3.5 mm. (B) 5.5 mm.



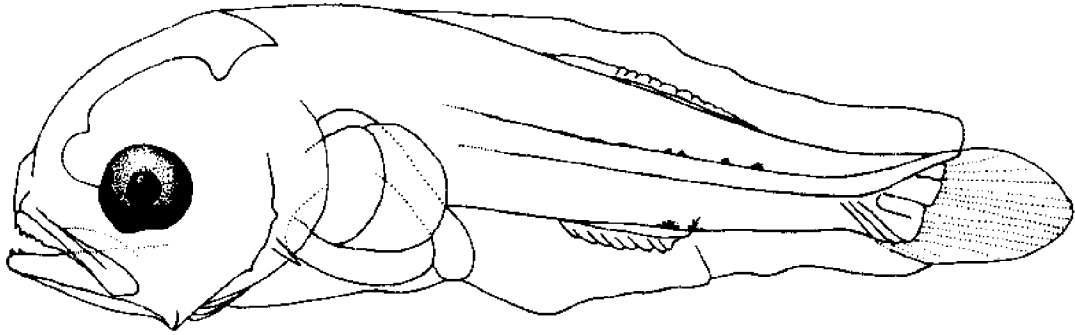
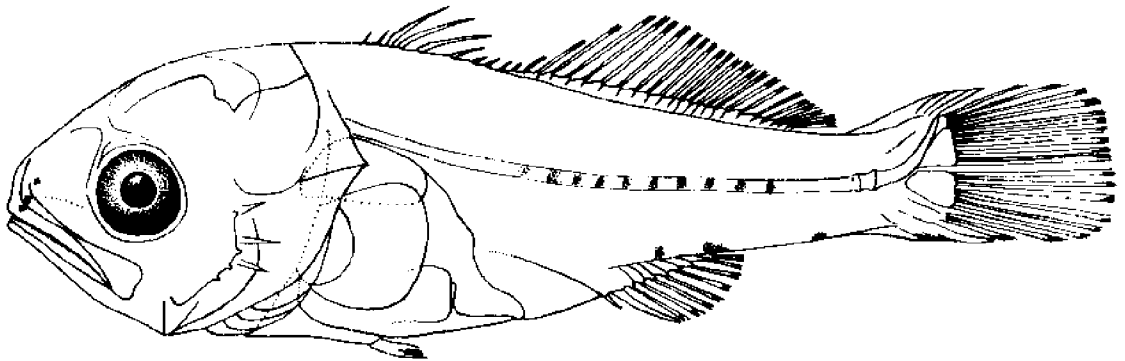
**A**



**B**

Figure 24.--Sciaenops ocellata.

(A) 3.5 mm. (B) A composite drawing based on two  
6.5 mm specimens.

**A****B**

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