

# DELAWARE BAY REPORT SERIES



**Volume 7**  
**Pictorial Guide to Fish Larvae**  
**of Delaware Bay**

LEWIS N. SCOTTON, ROBERT E. SMITH, NANCY S. SMITH,

KENT S. PRICE and DONALD P. de SYLVA

DELAWARE BAY REPORT SERIES

Volume 7

PICTORIAL GUIDE TO FISH LARVAE OF DELAWARE BAY

with information and bibliographies  
useful for the study of  
fish larvae

by

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This series was prepared under a grant from the  
National Geographic Society

Report Series Editor  
Dennis F. Polis

Spring 1973

College of Marine Studies  
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19711

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Citation for this work should be as follows:

Scotton, L. N., R. E. Smith, N. S. Smith, K. S. Price, and D. P. de Sylva. (1973), Pictorial guide to fish larvae of Delaware Bay, with information and bibliographies useful for the study of fish larvae. Delaware Bay Rep. Series, Vol 7, College Marine Studies, Univ. of Delaware. 206 pp.

## DEDICATION

This work is affectionately dedicated to the memory of Romeo J. Mansueti, who not only actively encouraged the original concept of this study but also generously provided many original illustrations.

## ABSTRACT

This manual is divided into two parts.

The pictorial guide composing the first part of the manual includes an illustrated table of contents designed to permit quick identification of larval specimens. Following this the larval stages of 56 species of marine fishes collected in the Delaware Bay are illustrated serially (from younger to older). The notes for each species discuss adult characteristics, egg and larval development, spawning, distribution, and pertinent references.

The second part of the manual provides information on several aspects of the study of fish larvae, i.e., laboratory identification; preservation and sorting; laboratory rearing and field sampling methods.

There is a bibliography of selected general references on fish eggs and larvae, followed by literature cited for both parts.

## ACKNOWLEDGMENTS

The authors wish to thank the following persons for advice and encouragement during the preparation of this manual: John Colton, Jr., William Dovel, Bonnie Eldred, Charles Futch, Jerry Hardy, Alice Mansueti Lippson, Charles Mayo, Thomas McKenny, Robert Presley, Richard Schekter, Amy Scotton, Susan Stevens, John Taylor, Robert Trumbull, and Peter Wilkens.

The authors are especially grateful to the following for reviewing the methods sections and the general format of the guide: Edward D. Houde, and William J. Richards. The latter reviewer kindly allowed use of information from unpublished manuscripts and from many personal communications.

The authors thank Ann Le Cates for typing several sections, Bernice Williams for typing and checking the final manuscript, Frank Danberg for Figure 1, Susan Stevens for Figure 2, and Linda Patille for assembling the illustrated table of contents.

Funds for the survey of the fish larvae (ichthyoplankton) of Delaware Bay were provided by the National Science Foundation (NSF Grant G-8774) to de Sylva. Much of the illustration work was supported by funds obtained by Carl N. Shuster, Jr.. Grants for writing and publication were given by the University of Delaware Research Foundation and the National Geographic Society.

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## I. INTRODUCTION

During the past several decades, much research has been conducted on the developing stages of fishes, termed the larval stages. The published research is often presented in the form of dichotomous keys consisting of a small number of species, frequently without illustrations. The first portion of this manual is a pictorial guide of the developing stages of fishes collected in the Delaware Bay region (Figure 1), located in the Mid-Atlantic Bight. This pictorial guide, together with the methods sections comprising the second part, will hopefully be of value to fish taxonomists and to others whose studies may incidentally involve fish larvae.

The pictorial guide includes serial illustrations of the larval stages of 56 species of marine fishes collected during an ichthyoplankton (larval fish) survey of the Delaware Bay. The program was conducted by the University of Delaware Marine Laboratories, Lewes, Delaware from February 1960 through August 1961, under the direction of Donald P. de Sylva. The preliminary format of this guide was developed during the above program by Robert E. and Nancy S. Smith, and the illustrating was done by Nancy S. Smith, mostly during the three years following. Lewis N. Scotton is responsible for the written material in the guide. Kent S. Price obtained money to support the completion of the guide and provided editorial supervision.

de Sylva, et al. (1962) reported 138 species of adult fishes from the Delaware River Estuary. The majority of the 56 species of

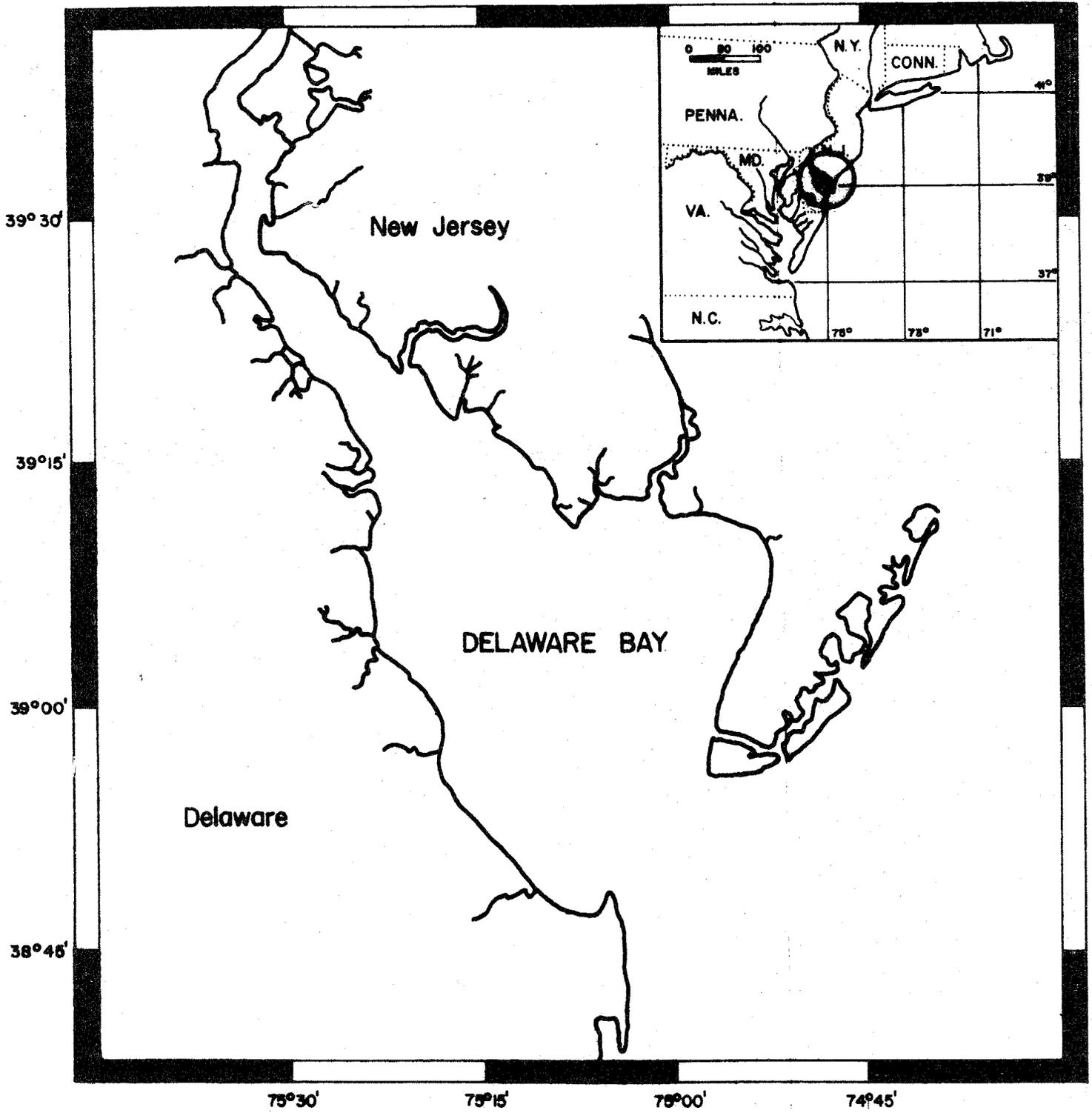


FIGURE I

fishes represented herein as larvae may be considered as relatively common to the region in question; however a few are strays, normally not being spawned in this region but probably being carried into the area via ocean currents. Collections of larvae were made at seven stations in the Delaware Bay using 1-meter and half-meter plankton nets and high-speed samplers. The half-meter net (505  $\mu$  mesh) was used at the surface, at a middle depth, and just off the bottom. When possible, additional surface tows were taken with a 1-meter plankton net (505  $\mu$  mesh) and a high-speed sampler that could be towed at speeds up to 20 knots (Smith et al., 1964).

#### A. Purpose of the Illustrated Portion

In nearly all bony fish species, the females produce eggs which, after being expelled from their bodies, are fertilized by sperm from the male. After the embryos hatch from the egg, most fishes pass through developmental stages of varying lengths of time in which the individuals do not resemble the adults. It is to these larval stages of fish development that this manual is directed.

The principal purpose in publishing this pictorial guide, even though incomplete in its present form, is to enable a worker to identify fish larvae collected in the Delaware Bay area to the species level, using serial illustrations. This will reduce the need for a time-consuming accumulation of the numerous pertinent publications on fish larvae. It should also facilitate fish larvae identification for investigators concerned with associated endeavors, such as zooplankton studies.

## B. Use of the Illustrated Portion

The recommended way to use the guide for identification is to look through the illustrated table of contents until drawings of likely species are found, then to turn to the designated pages within the guide itself. The drawings in the illustrated table of contents and the guide and descriptions are as simple as scientific accuracy will allow, and most are limited to those external features which assist in identification. Order of presentation of the species is artificial and is not intended to fit a phylogenetic scheme.

The species are grouped first for similarity of body form, then for the ratio of snout-vent length to total length; the final separation and verification will result from the more subtle differences such as the pigmentation patterns, fin positions, number of fin rays, pre- and postanal myomere counts, and relative positions of eyes and mouth. Colton and Marak (1969) pointed out that general body shape is often of questionable value in identification of fish larvae, due to damage or changes in shape during preservation. Also, fins are not always helpful characters due to damage or lack of development, and it often results that pigmentation is the best preserved character. However, chromatophores are subject to individual variation and usually fade with time; thus, pigment pattern should be used if possible in combination with more consistent characters (see section on diagnostic characters for identification of fish larvae).

In those cases in which we were unable to obtain illustrations or descriptive notes for all developmental stages of any given species, blank spaces were left, so that when the illustrations or notes become

available they may be entered in the appropriate places by individual workers.

### C. Terminology

The common and scientific names presented are those recommended by the American Fisheries Society (1970). The terms used herein to describe larval stages are those used most commonly in the literature consulted in preparation of the species descriptions and are as follows (see Figure 2):

Yolk-sac larva: "begins at the time of hatching and continues until the yolk-sac is no longer visible," from Mansueti and Hardy, 1967: 6 (also called prolarva by Hubbs, 1943).

Postlarva: larva following the time of absorption of yolk; to be applied only when the structure and form continues to be unlike that of the juvenile, from Hubbs, 1943 (also called larva by Mansueti and Hardy, 1967).

However, the recommended terms below are more relevant to the life histories of many more fishes than the more restricted terms above.

Larva: stage from hatching to completion of formation of the adult complement of rays in all fins (Berry and Richards, in press).

Transitional (or metamorphic) larva: the period in which the larva is acquiring the juvenile shape, structure, and pigmentation (Moser and Ahlstrom, 1970: 6; Ahlstrom, 1968: 649; Bertelsen, 1951: 10); does not occur in life history of many fish species, i.e., development may proceed directly from the

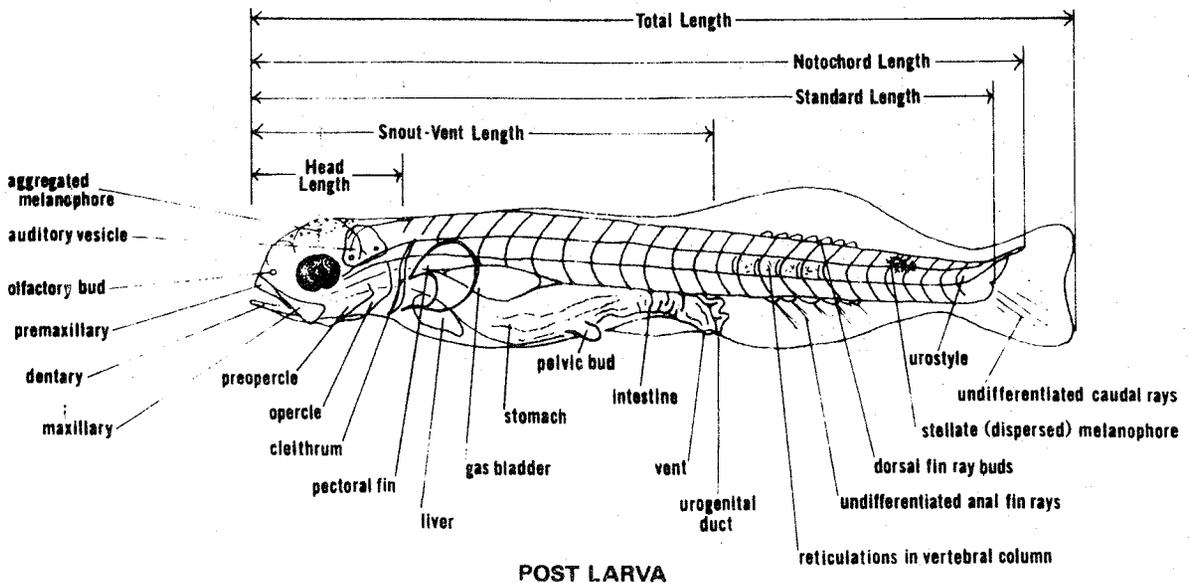
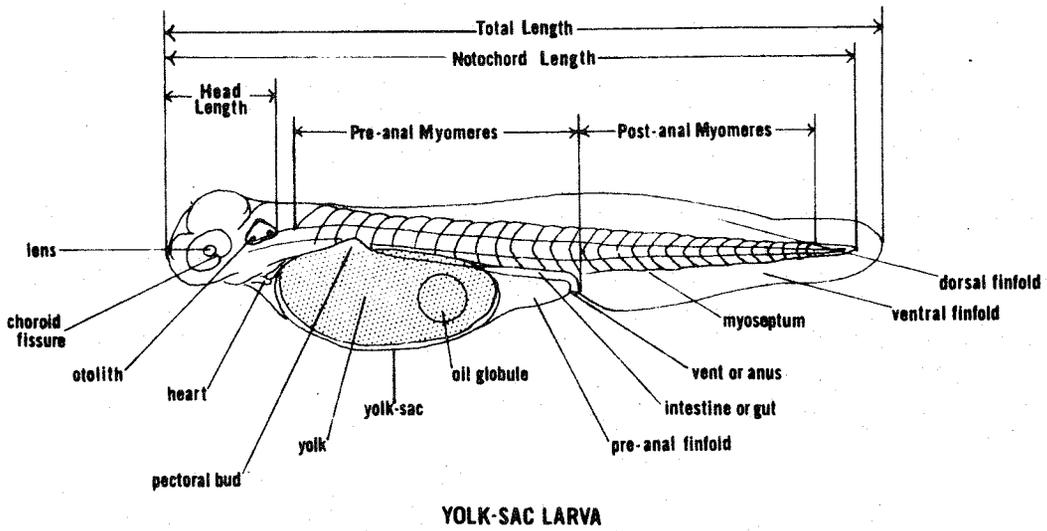
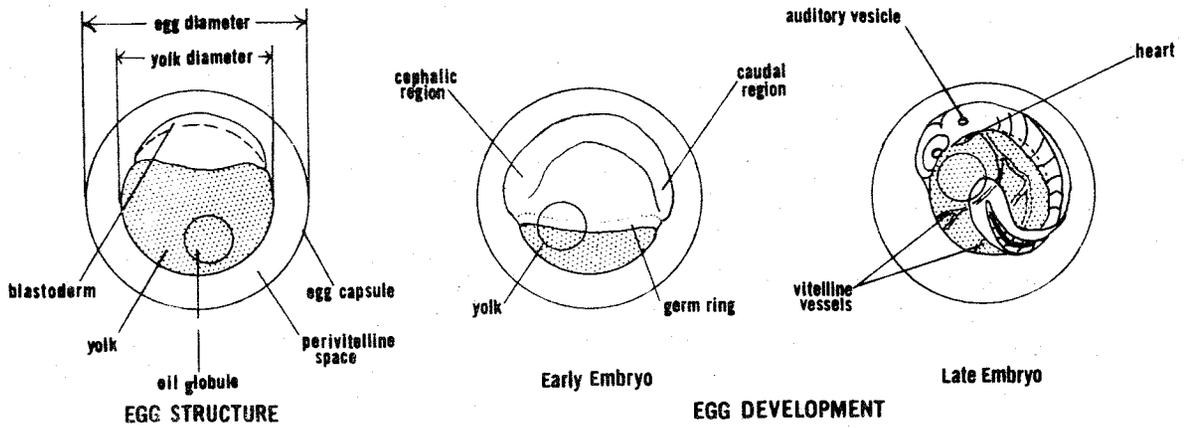


Figure 2 Diagrammatic representation of morphology and development of selected egg and larval stages of a typical teleost ( modified after Mansueti and Hardy , 1967 ).

larva to the juvenile.

Juvenile: the period from the time the fish acquires the adult complement of fin rays and the adult shape until it reaches sexual maturity.

Adult: period from the attainment of sexual maturity.

"The distinction made between juveniles and adults may be imprecise, and may relate more to relative size than to advanced development" (Berry and Richards, in press).

The lengths given for our illustrations, unless otherwise indicated, are total lengths (T.L.), i.e., from the tip of the snout to the tip of the caudal fin or posterior margin of the finfold. Standard length (S.L.), i.e., from the tip of the snout to the base of the caudal fin, and with early larval stages, notochord length (N.L.), i.e., from the tip of the snout to the posterior tip of the notochord, are the preferred measurements for ichthyoplankton work due to the possibility of damage to the caudal fin (see Figure 2). However, much of the literature from which the illustrations have been taken refers to total length, and the authors have followed this convention.

The descriptive technique used in the text is the "static" method, because few references consulted use the preferred "dynamic" technique (see techniques for identification).

Below is an explanation of additional terms used in species descriptions of illustrated portion of guide.

Abbreviations:

- D. for dorsal fin
- A. for anal fin
- C. for caudal fin
- ca. for circa

Proportions:

e.g., Head in S.L.: ratio of the length of the head to the standard length of the fish.

e.g., Eye in head: ratio of the horizontal measurement of the eye to the length of the head.

Fin ray designations:

e.g., D. X-I, 20 : two separate dorsal fins, the first containing 10 spines and the second 1 spine and 20 soft rays.

e.g., A. X, 12 : two anal fins but no distinct separation between them, the first containing 10 spines and the second 12 soft rays.

## D. Purpose of Methods Sections

In addition to the larval fish illustrations, there are supplemental sections on topics of related interest, i.e., identification methods, preservation and sorting of fish larvae, rearing, field sampling techniques and samplers, and a general bibliography. The methods sections are intended to be only brief introductions to the subjects with the bibliography listing pertinent papers. Also

included is a glossary. These sections are included to assist those who are beginning ichthyoplankton or associated studies by providing general information not readily available, which normally must be gained either by time-consuming literature searches, or unfortunately by trial and error.

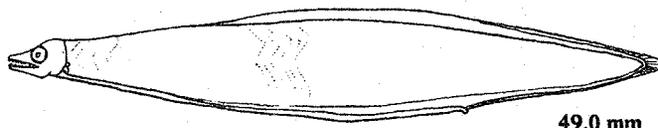
It is hoped that this guide will engender the preparation of similar guides to fish larvae from other areas of the Atlantic and Gulf Coasts to foster a more comprehensive understanding of the developing stages of marine fishes.

Illustrated Table of Contents ►

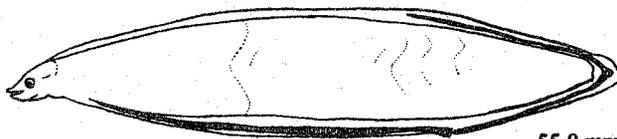
## II. ILLUSTRATED SECTION

- A. Illustrated table of contents by species, in envelope  
← between pp. 16 and 17.
- B. Serial illustrations and species descriptions,  
pp. 18-161.

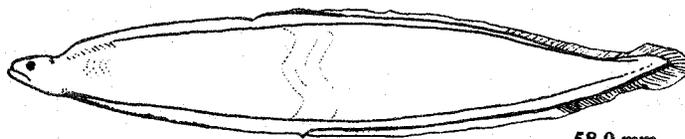
Species No. 1 Anguilla rostrata



49.0 mm



55.0 mm



58.0 mm



61.0 mm

## ANGUILLIDAE

Anguilla rostrata (Lesueur). American eel.

## Adult characteristics:

Myomeres 104-111 (average 107), whereas A. anguilla has 111-119 (average 115) myomeres.<sup>1</sup> Dorsal fin originates far behind pectorals (this character distinguishes it from the conger eel, Conger oceanicus); lower jaw equal to or projects beyond upper.<sup>2</sup>

## Eggs:

## "Leptocephalus" stage:

50 mm TL: body compressed except for head; maximum depth at midpoint of body 16% of TL; preanal length 74% of TL; head 8% of TL. Intestine simple, straight tube reaching to myomere 70; liver long and narrow, between myomeres 12 and 35. Dorsal fin origin at myomere 61; 9 myomeres between dorsal and anal fin origins. Myomeres 104. Pigmentation found only on choroid of eye. Larval teeth prominent, 16 in left side of upper jaw.<sup>3</sup> 52 mm TL: "glass eel" stage, dorsal, anal and caudal fins developed; myomeres 109. A few chromatophores scattered on body; adult teeth developing.<sup>3</sup>

## Spawning:

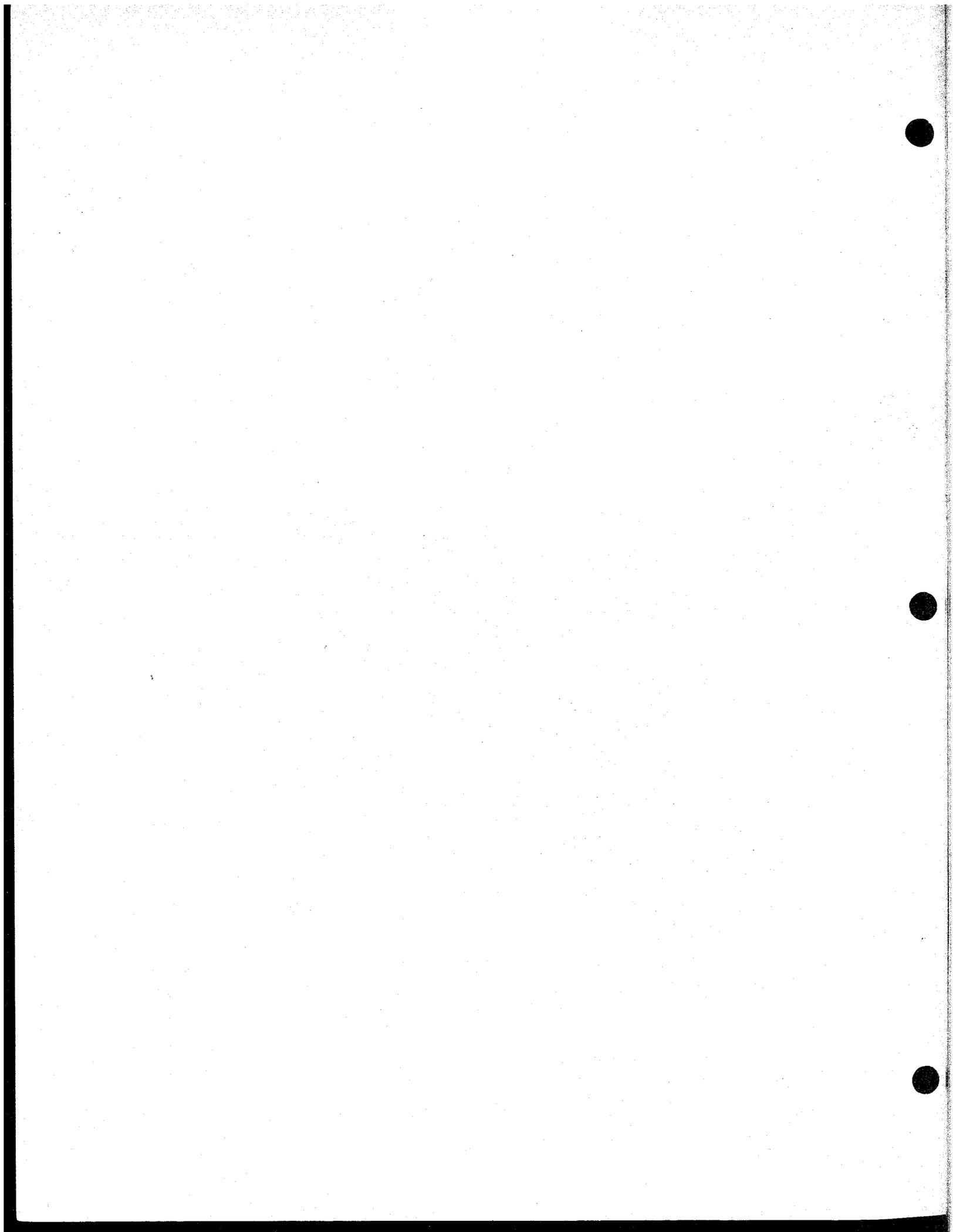
In midwinter,<sup>2</sup> in Straits of Florida larvae abundant from April through August.<sup>1</sup> Spawning grounds believed to be between Lat. 20° and 30° N. and Long. 60° and 75° W.<sup>1,4</sup> Spawns at sea but growth occurs in estuaries or fresh water.<sup>2</sup>

## Distribution:

Adults from Greenland to the Guianas.<sup>3</sup> Still many mysteries surrounding life history of A. rostrata.

## References:

1. Smith, D. G. 1968: 280-293.
2. Bigelow, H. B. and Schroeder, W. C. 1953: 151-154.
3. Eldred, B. 1968a: 4 pp.
4. Schmidt, J. 1925: 311.



Anguilla rostrata (cont.)

Other pertinent references:

Bigelow, H.B. and W.W. Welsh. 1925: 79.

Castle, P.H.J. 1963: 1-14.

Fish, M.P. 1927: 289-324 (eggs and 9-mm leptocephalus identified as A. rostrata but shown to be the pygmy moray eel, Anarchias yoshiae by Eldred, 1968b).

Illustration credits:

49.0 mm, 55.0 mm, 58.0 mm, 61.0 mm Bigelow and Welsh, 1925

Species No. 2 Conger oceanicus



## CONGRIDAE

Conger oceanicus (Mitchill). Conger eel.

## Adult characteristics:

Origin of dorsal fin above or only slightly behind tip of pectoral fin when latter is laid back (best character for distinguishing C. oceanicus from other eels.) Upper jaw usually projects beyond the lower. Snout-dorsal fin distance about  $1/5$  TL.<sup>1</sup>

## Eggs:

Believed to be 2.4 to 2.75 mm diameter; 1 to 6 oil globules.<sup>2</sup>

## "Leptocephalus" stage:

More slender than Anguilla rostrata larva; 140-149 vertebrae in C. oceanicus as opposed to about 107 in A. rostrata; maximum length about 150-160 mm. Metamorphosis consists of thickening of the head and body, development of the swim bladder, permanent teeth, and pigment in the skin.<sup>1</sup>

## Spawning:

Perhaps in summer off coast of New England.<sup>2</sup>

## Distribution:

Continental shelf of eastern America; adults northward to tip of Cape Cod; larval stages to eastern Maine.<sup>1</sup>

## References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 154-157.
2. Bigelow, H.B. and W.W. Welsh. 1925: 86-88.

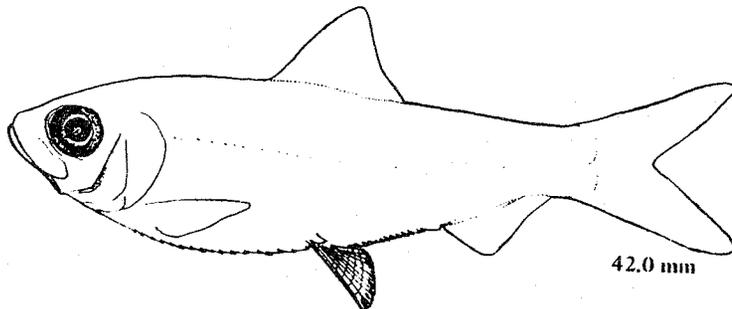
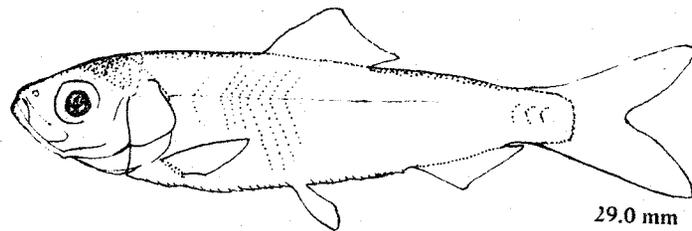
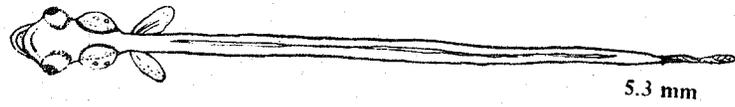
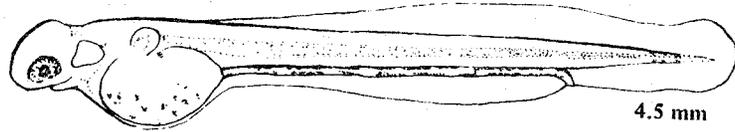
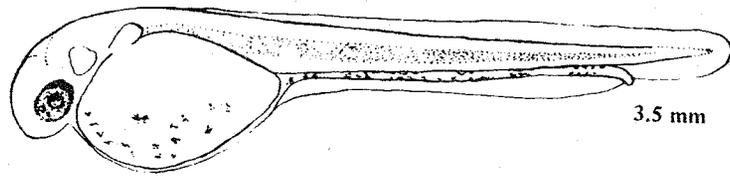
## Other pertinent references:

- Castle, P.H.J. 1964: 1-45.  
Eigenmann, C.H. 1901: 37-44.

## Illustration credits:

9.0 mm, 10.2 mm, 142.0 mm Bigelow and Welsh, 1925

Species No. 3 Alosa pseudoharengus



## Developmental note regarding clupeids:

Important characters of use in identifying clupeid larvae are: position of dorsal fin in relation to anal fin and vent; changes occurring in position of dorsal fin, and to a lesser degree the anal and pelvic fins during metamorphosis;<sup>1</sup> number of preanal and postanal myomeres; number of myomeres between the posterior insertion of the dorsal fin and the anus (all clupeids have at least one myomere here); melanophore patterns not reliable character to distinguish between clupeid species.<sup>2</sup>

## CLUPEIDAE

Alosa pseudoharengus (Wilson). Alewife.

## Adult characteristics:

D. 15-19; A. 15-21; lateral line scales 42-54. Vertebrae 46-50. Percent of SL-. Body depth 23.5-35.5; head length 22.6-34.8; eye diameter 5.0-12.0.<sup>3</sup>

## Spawning:

Late March - April in Maryland; April and May in New England; in rivers, streams or ponds.<sup>3</sup>

## Distribution:

Coastal populations from Gulf of St. Lawrence and Nova Scotia to South Carolina; some land-locked populations.<sup>3</sup>

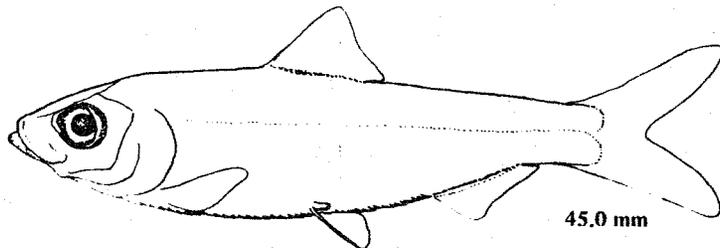
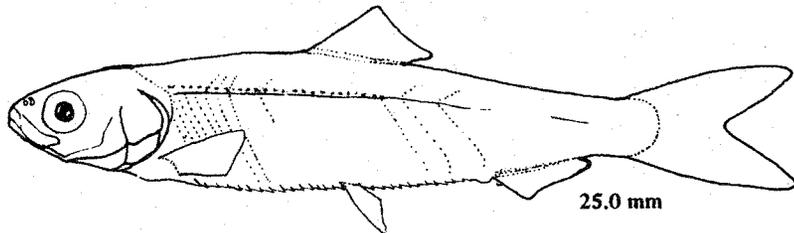
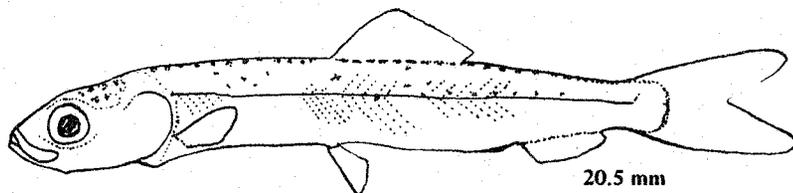
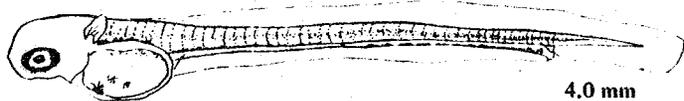
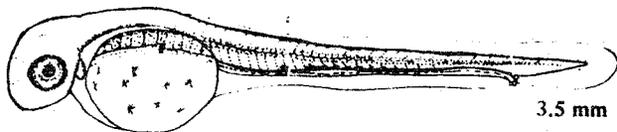
## References:

1. Ahlstrom, E.H. 1968: 648-651.
2. Houde, E.D. and P.L. Fore. In press.
3. Mansueti, A.J. and J.D. Hardy, Jr. 1967: 55-59.

## Illustration credits:

3.5 mm, 4.5 mm, 5.3 mm, 42.0 mm Mansueti and Hardy, 1967  
29.0 mm Hildebrand, 1963

Species No. 4 Alosa aestivalis



## CLUPEIDAE

Alosa aestivalis (Mitchill). Blueback herring.

(see clupeid developmental note above description of A. pseudoharengus).

## Adult characteristics:

D. 15-20; A. 16-21; vertebrae 47-53; gill rakers 41-52. Body depth 3.0-4.6 in SL.<sup>1</sup>

## Eggs:

Demersal, adhesive,<sup>1</sup> semitransparent,<sup>2</sup> average diameter 1.0 mm, oil globules small, unequal, and scattered.<sup>1</sup>

## Yolk-sac larvae:

Hatching length ca. 3.5 mm TL;<sup>2</sup> yolk absorbed completely around fourth day; chromatophores over yolk mass and in a series along intestine.<sup>1</sup>

## Postlarvae:

5.2 mm TL - pigmentation essentially same as in yolk-sac larvae;<sup>1</sup> chromatophores on dorsal aspect of head and anterior trunk and at base of finfold and on ventral aspect of notochord.<sup>2</sup>

## Spawning:

April - May in Potomac River; fresh- and brackish-water rivers.<sup>1</sup>

## Distribution:

Nova Scotia to St. Johns River, Florida.

## References:

1. Mansueti, A.J. and J.D. Hardy, Jr. 1967: 47-50.
2. Kuntz, A. and L. Radcliffe. 1917: 123-126.

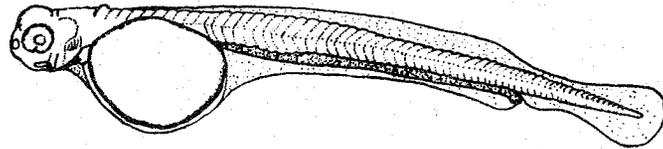
## Other pertinent reference:

Hildebrand, S.F. 1963: 314, 325-329, 331.

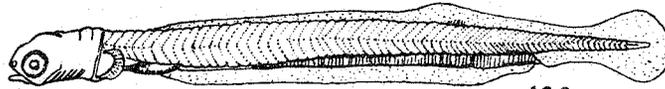
## Illustration credits:

3.5 mm, 4.0 mm, 5.2 mm Kuntz and Radcliffe, 1917  
20.5 mm, 25.0 mm, 45.0 mm Mansueti and Hardy, 1967

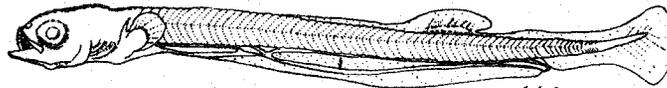
Species No. 5 Alosa sapidissima



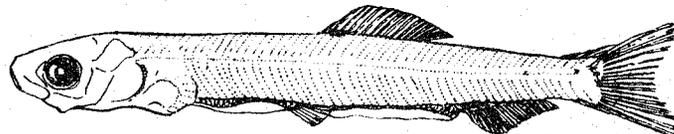
10.0 mm



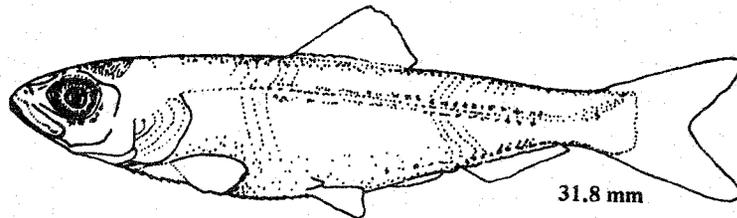
12.0 mm



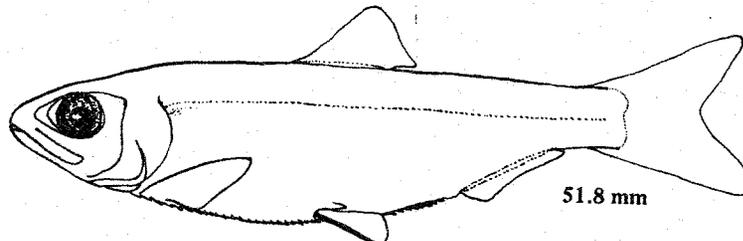
14.0 mm



22.9 mm



31.8 mm



51.8 mm

## CLUPEIDAE

Alosa sapidissima (Wilson). American Shad.

(see clupeid developmental note above description of A. pseudoharengus).<sup>1</sup>

## Adult characteristics:

D. 14-20; A. 18-25; gill rakers 59-76 (first arch lower limb); vertebrae 51-60. Percent of SL- body depth 30.2-48; head length 23-28; eye diameter 3.8-5.7.<sup>1</sup>

## Eggs:

Demersal, non-adhesive; spherical, fertilized eggs, 2.5-3.5 mm. diam.<sup>1</sup>

## Yolk-sac larvae:

Hatching length ca. 7-10 mm TL. Body transparent, yolk-sac covered with stellate chromatophores; double-line pigment ventrally along intestine from ca. 18th myomere to anus.<sup>1</sup>

## Postlarvae:

At 21-22.9 mm, pectorals and ventrals still developing; preanal myomeres 43-47 in specimens to 13 mm, 41-45 at 14-16 mm, 37-44 at 17-22 mm, 34-42 at 23-27 mm. Gas bladder evident by 14 mm. Chromatophore patterns as indicated in figures opposite.<sup>1</sup>

## Spawning:

Mostly in tidal freshwater and river areas. In St. Johns River, Florida in November and later northward; in Maryland from February; in northern localities spawning may continue until May or June.<sup>1</sup> Delaware Bay in May and June.

## Distribution:

Newfoundland to St. Johns River, Florida on east coast.<sup>1</sup>

## References:

1. Mansueti, A.J. and J.D. Hardy, Jr. 1967: 59-64.

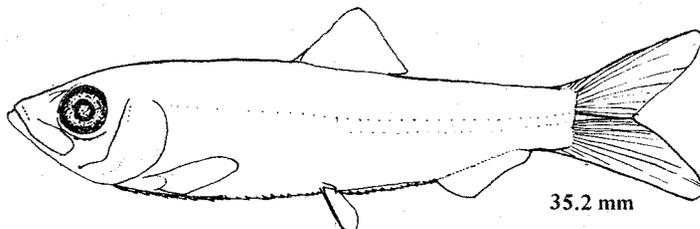
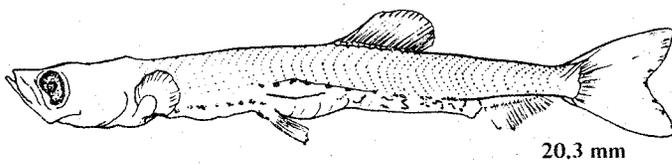
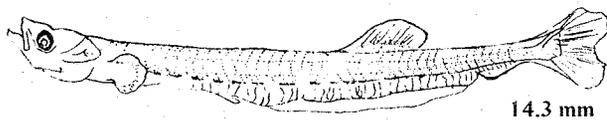
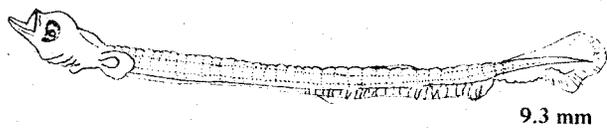
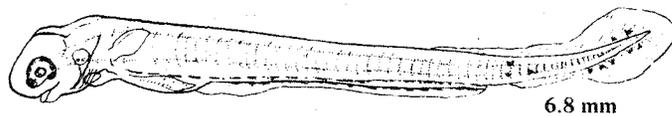
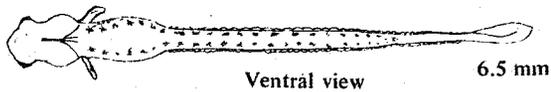
## Other pertinent references:

- Ryder, J.A. 1887: 523-533.  
Massman, W.H. 1952: 78-93.

## Illustration credits:

- 10.0 mm, 12.0 mm, 14.0 mm    Ryder, 1887  
22.9 mm, 31.8 mm, 51.8 mm    Mansueti and Hardy, 1967

Species No. 6 Alosa mediocris



## CLUPEIDAE

Alosa mediocris (Mitchill). Hickory Shad.

(see clupeid developmental note above description of A. pseudoharengus).

## Adult characteristics:

D. 15-20; A. 19-23; vertebrae 53-55; gill rakers 18-23. Depth 3.0-3.75 in SL.<sup>1</sup>

## Eggs:

Demersal, slightly adhesive; fertilized eggs transparent,<sup>1</sup> spherical, diameter 0.96-1.65 mm, a few small oil globules.

## Yolk-sac larvae:

Hatching length (average) 6.1 mm TL, preanal myomeres 37-40 at 1 day. Percent of SL - depth 13-16; snout-vent distance 80-86; head length 9-10. At 1 day, chromatophores on gut and along ventral surface between yolk and anus.<sup>1</sup>

## Postlarvae:

Snout-vent length 80% in SL.<sup>1</sup> Preanal myomeres 39 at 6.5-7.0 mm, 44 at 7.0-7.5 mm and 38 at ca. 18.0 mm.<sup>1</sup> Dorsal fin first evident at ca. 9.0 mm, anal at 14.0 mm, and ventrals at 13.0 mm. Melanophores along gut to anal fin.<sup>1</sup>

## Spawning:

Tidal freshwater from late April through early June.<sup>1</sup>

## Distribution:

Bay of Fundy to Florida.<sup>1</sup>

## References:

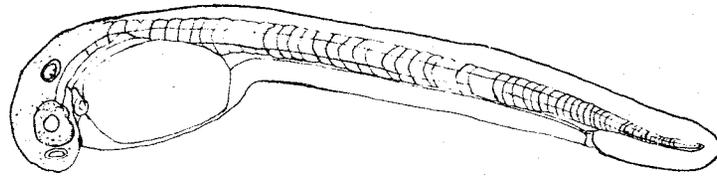
1. Mansueti, A.J. and J.D. Hardy, Jr. 1967: 50-55.

## Other pertinent references:

- Hildebrand, S.F. 1963: 319-321.  
Mansueti, R.J. 1962: 173-205.

## Illustration credits:

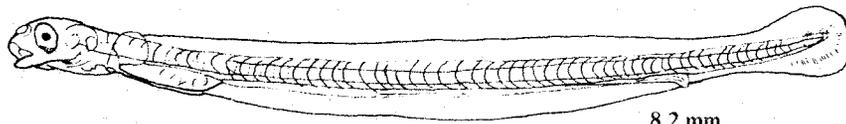
6.5 mm, 6.8 mm, 9.3 mm, 14.3 mm, 20.3 mm, 35.2 mm Mansueti, 1962

Species No. 7 Clupea harengus harengus

4.9 mm



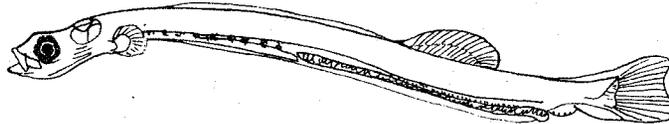
7.0 mm



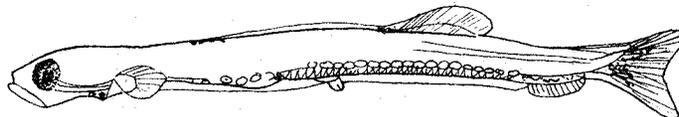
8.2 mm



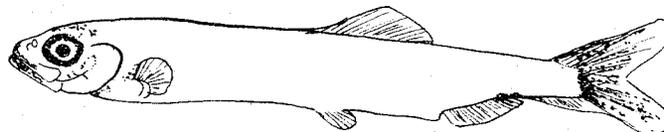
10.0 mm



19.0 mm



29.0 mm



41.0 mm

## CLUPEIDAE

Clupea harengus harengus Linnaeus. Atlantic herring.

(see clupeid developmental note above description of A. pseudoharengus).<sup>1</sup>

## Adult characteristics:

D. 16-21; A. 14-20; vertebrae 49-60; gill rakers (lower limb of first arch.) 37-52. Percent of SL- body depth 20.0-25.8; head length 22.6-26.4; eye diameter 5.3-7.7.<sup>1</sup>

## Eggs:

Demersal, adhesive, in sheets; fertilized eggs 1.0-1.4 mm diameter.<sup>1</sup>

## Yolk-sac larvae:

Hatching length 4.0-10.0 mm TL (hatching length influenced by salinity and temperature, e.g., larvae hatched at lower temperatures are longer and have less yolk). Line of chromatophores between body and intestine on anterior half of body, ventrally along intestine on posterior half; concentration of pigment in vent region.<sup>1</sup>

## Postlarvae:

Preanal myomeres 46-47 at 10-20 mm, 41-46 in individuals longer than 20 mm. Dorsal fin rays first evident at 10.5 mm; anal fin first evident at 16-29 mm. Body transparent, pigment increased in density in region of anus and below pectorals; at 20.2 mm ventral chromatophores on body.<sup>1</sup>

## Spawning:

Variable, depending on locality; New Jersey and Maryland populations may be autumn spawners.<sup>1</sup>

## Distribution:

In western Atlantic, Greenland to Cape Hatteras, North Carolina.<sup>1</sup>

## References:

1. Mansueti, A.J. and J.D. Hardy, Jr. 1967: 69-75.

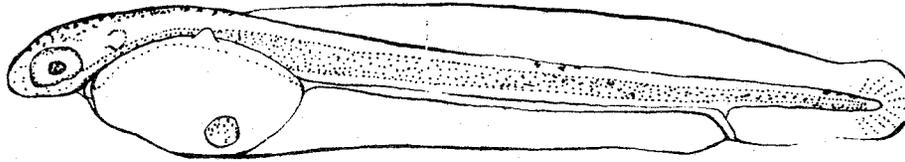
## Other pertinent references:

- Delsman, H.C. 1926: 218-239.  
 Hildebrand, S.F. 1963: 275-283, 290.  
 Mansueti, R.J. 1962: 2.  
 Bigelow, H.W. and W.W. Welsh. 1925: 93-94.

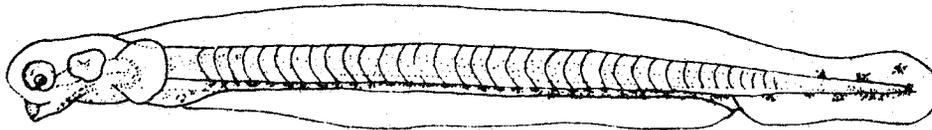
## Illustration credits:

- 4.9 mm, 8.2 mm Mansueti and Hardy, 1967  
 7.0 mm, 10.0 mm, 19.0 mm, 29.0 mm, 41.0 mm Bigelow and Welsh, 1925

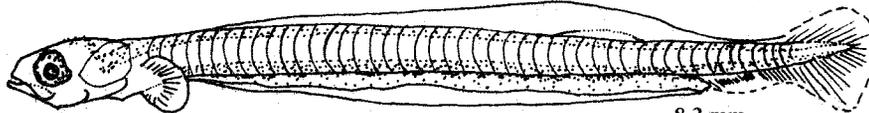
Species No. 8 Brevoortia tyrannus



4.5 mm



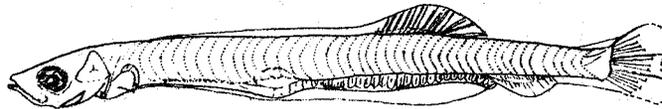
5.0 mm



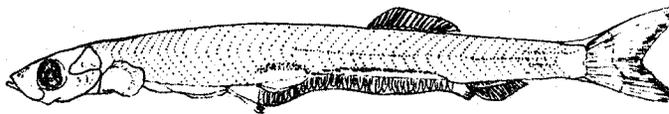
8.3 mm



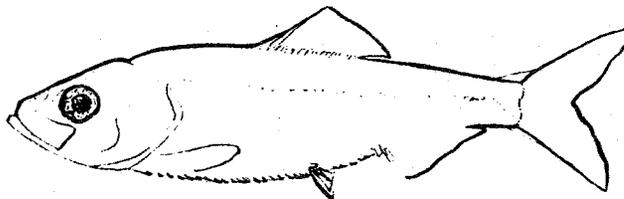
10.7 mm



16.6 mm



23.1 mm



33.0 mm

## CLUPEIDAE

Brevoortia tyrannus (Latrobe). Atlantic menhaden.

(see clupeid developmental note above description of A. pseudoharengus).

## Adult characteristics:

D. 18-24; A. 18-24; vertebrae 45-50. Percent of SL- body depth 30.0-40.0; head length 29.0-36.0; eye diameter ca. 5.0-8.0.<sup>1</sup>

## Eggs:

Pelagic, spherical, transparent, diameter 1.3-1.95 mm;<sup>1</sup> one oil globule 0.12-0.17 mm;<sup>1</sup> (0.14).<sup>2</sup>

## Yolk-sac larvae:

Hatching length 2.4-ca. 4.5 mm; at 3.3 mm TL, ca. 35 preanal myomeres. At ca. 4.5 mm, chromatophores along dorsal surface and scattered through dorsal and ventral finfolds; anus ca. 1/5 TL from tip of tail.<sup>1</sup>

## Postlarvae:

Size range ca. 5.0-23.0 mm TL; D. 16-18; A. 18-20 at 16.6-23.1 mm; C. 19; preanal myomeres 37-40; postanal myomeres 8-10; depth ca. 30 times in TL at 9.0 mm, 21 times in TL at 23 mm; gas bladder first evident at ca. 11.0 mm. Gut initially straight, becoming convoluted with development; D., A., and C. fins differentiating at 8.3 mm;<sup>1</sup> 4 or fewer myomeres (usually 3) between posterior insertion of dorsal fin and anus.<sup>3</sup>

## Spawning:

Chiefly at sea, as much as 40 miles offshore from mouth of Chesapeake Bay; fall and spring peaks in Chesapeake Bay region, nearly every month in some part of range.<sup>4</sup>

## Distribution:

In Delaware Bay larvae 15-22 mm collected in February, June, October, and November.

## References:

1. Mansueti, A.J. and J.D. Hardy, Jr. 1967: 64-69.
2. Kuntz, A. and L. Radcliffe. 1917: 91, 119-123.
3. Houde, E.D. and P.L. Fore. In press.
4. Massmann, W.H., J.J. Norcross, and E.B. Joseph. 1962: 42-45.



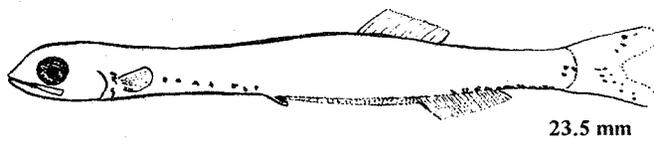
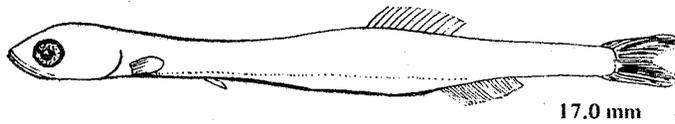
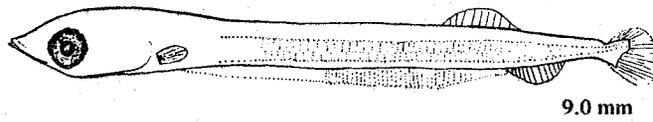
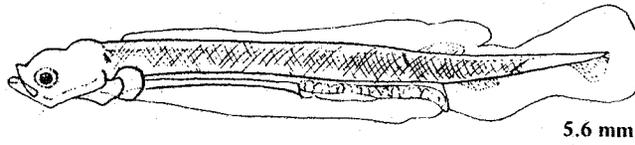
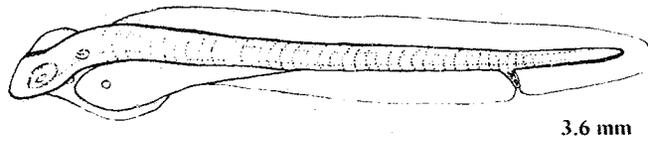
Brevoortia tyrannus (Cont.)

Other pertinent references:

- Hildebrand, S.F. 1963: 346-362.  
June, F.C. and L. Chamberlin. 1959: 41-45.  
Lewis, R.M. and W.C. Mann. 1971: 296-301.  
Reintjes, J.W. 1969: 30 pp.

Illustration credits:

- 4.5 mm, 5.0 mm, 8.3 mm, 10.7 mm, 16.6 mm, 23.1 mm Mansueti  
and Hardy, 1967  
33.0 mm Kuntz and Radcliffe, 1917

Species No. 9 Anchoa hepsetus

## Developmental note regarding engraulids:

Engraulid (anchovy) larvae, in general, may be distinguished from clupeid (herring) larvae by several characteristics: in anchovy larvae the origin of the anal fin is located under some part of the dorsal fin, e.g., in Anchoa mitchilli the origin of the anal fin is about midway under the base of the dorsal fin in young larvae (anal fin migrates slightly forward with an increase in length) and in A. hepsetus the origin of the anal fin is under the posterior insertion of the dorsal fin. In anchovies there are no myomeres separating the posterior insertion of the dorsal fin and the origin of the anal fin as is always the case with the herring larvae. In most herring larvae the anal fin begins to differentiate back near the caudal fin (anal fin may migrate forward with development); it follows that the snout to vent length of clupeid larvae is often 90 percent of TL whereas in engraulid larvae the snout to vent length is only about 70 percent of TL.

Anchoa hepsetus larvae distinguished from A. mitchilli by not only the location of the anal with respect to the dorsal as indicated above but also by the difference in the number of anal fin rays (usually 18-23 in A. hepsetus and 23-30 in A. mitchilli.)

Engraulids and clupeids have, beginning at certain times during development, intestines which have a striated or coiled appearance. These "coils" are really muscle bands on the gut.

## ENGRAULIDAE

Anchoa hepsetus (Linnaeus). Striped anchovy.

## Adult characteristics:

D. 13-16; A. 18-23; vertebrae 40-44; Percent SL- body depth 18.5-22.0; head length 25.0-30.0.<sup>1</sup>

## Eggs:

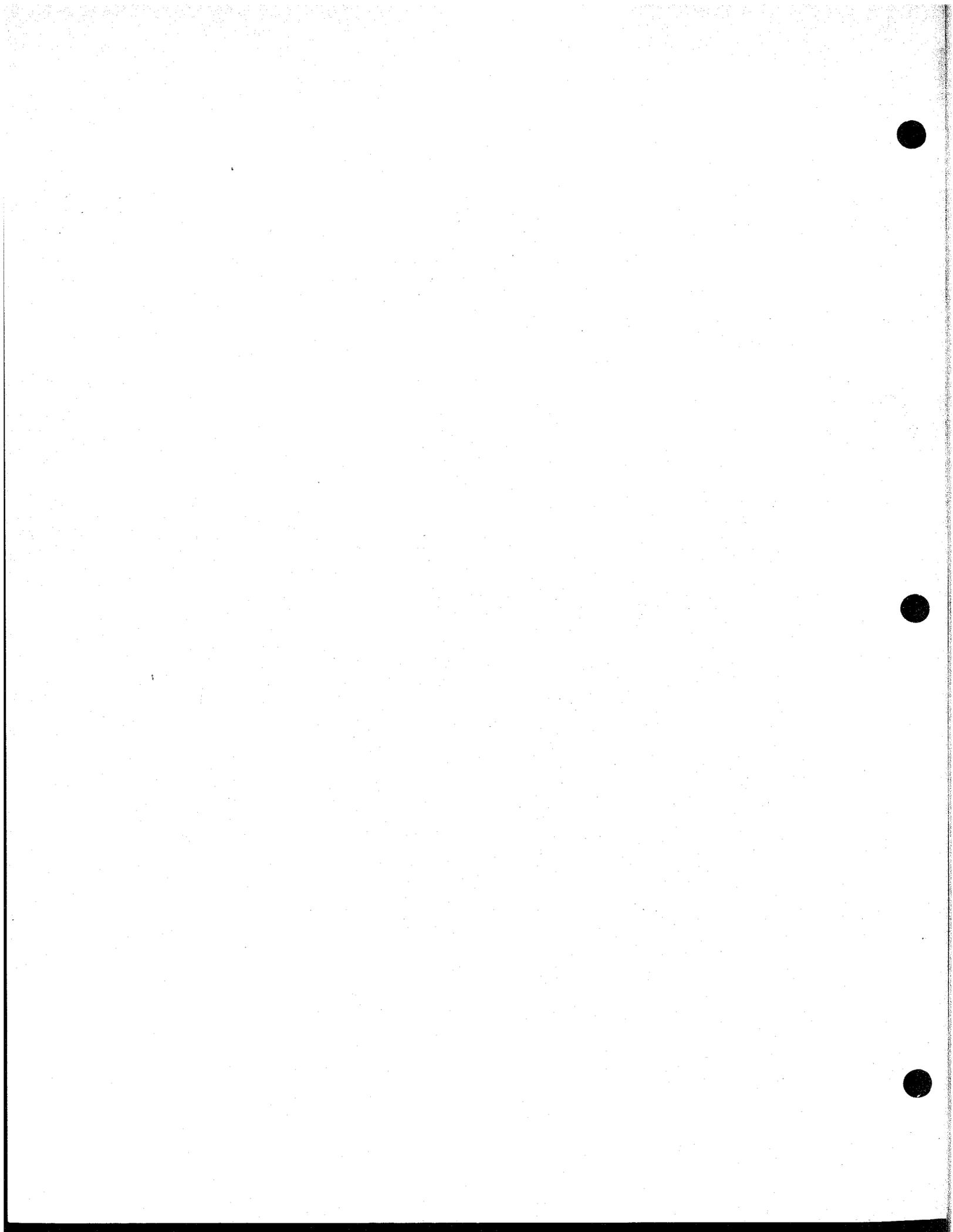
Fertilized eggs - pelagic, transparent, elliptical, major axis 1.2-1.66 mm, minor axis 0.7-0.94 mm.<sup>1</sup>

## Yolk-sac larvae:

Hatching length ca. 3.6-4.0 mm TL; anus behind beginning of posterior 1/4 of body at hatching; fins lacking; body transparent.<sup>1</sup>

## Postlarvae:

About 5.0-13.0 mm TL; D., A., C. and pectoral fins evident but rays not differentiated at 5.0-6.0 mm. A. fin origin under posterior insertion



Anchoa hepsetus (Cont.)

of D. fin. Mouth oblique, gape extending to anterior margin of eye at 10.0 mm. At 10.0<sub>1</sub> mm chromatophores on chest and ventrally from anal base to caudal.<sup>1</sup>

## Spawning:

March to early May in Tampa, Florida; mid-April through July in North Carolina; Delaware Bay, June through August. Not more than 10 miles offshore or in water deeper than 12 fathoms.<sup>1</sup>

## Distribution:

Nova Scotia to Uruguay.<sup>1</sup>

## References:

1. Mansueti, A.J. and J.D. Hardy, Jr. 1967: 83-85.

## Other pertinent references:

- Daly, R.J. 1970: 75-78.  
Hildebrand, S.F. and L.E. Cable. 1930: 388-394.  
de Sylva, D.P., F.A. Kalber, Jr. and C.N. Shuster, Jr. 1962: 20.  
Stevenson, R.A., Jr. 1958: 30.

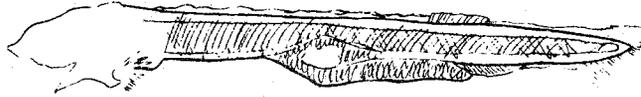
## Illustration credits:

3.6 mm, 5.6 mm, 9.0 mm, 17.0 mm, 23.5 mm Hildebrand and Cable, 1930

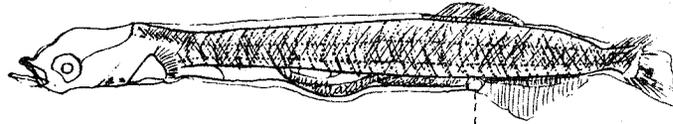
Species No. 10 Anchoa mitchilli



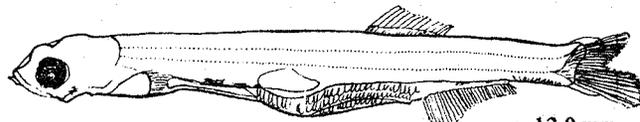
3.7 mm



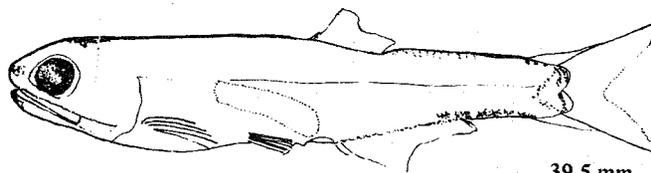
5.4 mm



7.1 mm



12.0 mm



39.5 mm

## ENGRAULIDAE

Anchoa mitchilli (Valenciennes). Bay anchovy.

(see developmental note above description of A. hepsetus).

## Adult Characteristics:

D. 14-16; A. 23-30; vertebrae 38-44; Percent of SL- body depth 16.0-27.0, head length 22.0-26.5; diameter of eye 5.8-8.2. Maxillary extending nearly to opercle. Anal fin origin under or slightly posterior to dorsal fin origin.<sup>1</sup>

## Eggs:

At higher salinities, e.g., above 31‰, buoyant until hatching;<sup>2</sup> at lower salinities eggs buoyant when newly spawned but becoming demersal after about 12-16 hours after fertilization.<sup>3</sup> Fertilized eggs - slightly elongate, major axis 0.65-1.24 mm, minor axis 0.64-1.12 mm, oil globules absent.<sup>1</sup>

## Yolk-sac larvae:

Hatching length 1.8-2.7 mm. Incipient rays in caudal at 3.7 mm; yolk absorbed at about 4.5-5.0 mm.<sup>1</sup>

## Postlarvae:

At 12.0 mm, D. 15-16, A. 23-31. Mouth terminal, posterior region of gut convoluted at 5.0 mm; incipient dorsal and anal fins at 5.0 mm. Body depth increasing with increase in length - 12 times in body at 16 mm, 9 times at 20 mm. Sparse pigmentation often until mature; at about 20.0 mm (juvenile stage) chromatophores from origin of anal fin to the base, ventrally between operculum and ventral fins.<sup>1</sup>

## Spawning:

In estuaries, harbors and sounds near Beaufort, North Carolina, and near Delaware. Late April to early September in North Carolina, peak activity in July; May through August in Chesapeake Bay;<sup>1</sup> June through August in Delaware Bay.<sup>3</sup>

## Distribution:

Gulf of Maine to Yucatán, Mexico.<sup>1</sup>

## References:

1. Mansueti, A.J. and J.D. Hardy. 1967: 86-90.
2. Houde, E.D. Personal communication.
3. Kuntz, A. 1914: 14.



Anchoa mitchilli (Cont.)

Other pertinent references:

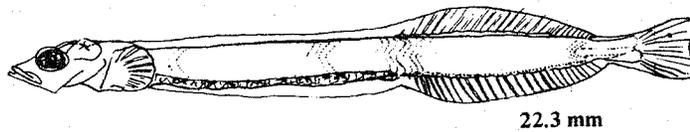
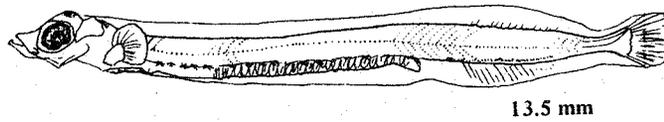
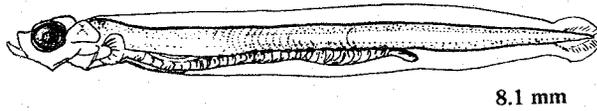
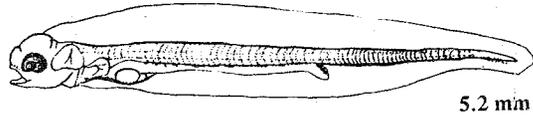
Daly, R.J. 1970: 85-88.

Hildebrand, S.F. 1943: 90-92.

Hildebrand, S.F. and W.C. Schroeder. 1928: 109-110.

Illustration credits:

3.7 mm, 5.4 mm, 7.1 mm, 39.5 mm    Original illustrations by Nancy Smith  
12.0    Mansueti and Hardy, 1967

Species No. 11 Ammodytes americanus

## AMMODYTIDAE

Ammodytes americanus DeKay. American sand lance.

## Adult characteristics:

D. 59-64; A. 28-32; Proportions - depth ca. 1/10 of TL; anal fin about 1/2 length of dorsal fin; long head and pointed snout.<sup>1</sup>

## Eggs:

Demersal (presumably); not described.<sup>1</sup>

## Larvae:

Developmental stages only briefly described.<sup>2,3</sup> Vent opens at one side, about midway back; yolk-sac is not absorbed until larvae are about 7 mm; beginnings of caudal rays visible at 8 mm and anal and dorsal fin rays appear at 13 mm.<sup>1</sup> Lower jaw protrusible even at early stages of development. Distinctive row of chromatophores along dorsal side of intestine (and not ventral side as in clupeids).<sup>2</sup>

## Spawning:

Commences in November and continues into May;<sup>1</sup> in vicinity of Cape Cod, occurs in November, December, January, and February, and later more northward.<sup>2</sup> On the shelf waters off lower Chesapeake Bay hatching began in late November, 1959, and continued until mid-March, 1960, with a peak in mid-December; spawning here may have occurred in waters 5-12 fathoms.<sup>1</sup> In the Delaware Bay specimens 17-30 mm in length were collected in June, July, and August.

## Distribution:

Atlantic coast of North America from Cape Hatteras to the Gulf of St. Lawrence, perhaps to Hudson Bay.<sup>2</sup>

## References:

1. Norcross, J.J., W.H. Massmann, and E.B. Joseph. 1961: 49-59.
2. Bigelow, H.B. and W.C. Schroeder. 1953: 488-491.
3. Wheatland, S.B. 1956: 279.

## Other pertinent references:

- Colton, J.B. and R.R. Marak. 1969: 27.  
Ford, E. 1920: 241-248.

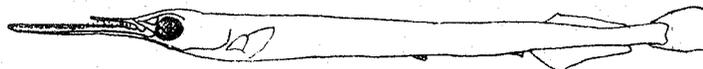
## Illustration credits:

- 5.2 mm, 5.6 mm, 8.1 mm, 13.5 mm, 22.3 mm Norcross, Massmann and Joseph, 1961

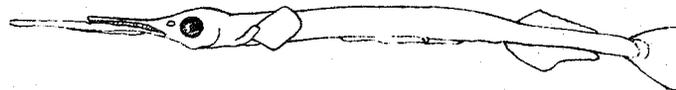
Species No. 12 Strongylura marina



9.5 mm



30.0 mm



37.0 mm

## BELONIDAE

Strongylura marina (Walbaum). Atlantic needlefish.

## Adult characteristics:

D. 13-17; A. 17-21.<sup>1</sup> In SL- head 2.45-3.25; depth 14.3-24; snout 1.47-1.87 in head; eye 9.5-13 in head. Lower jaw longer than upper.<sup>2</sup>

## Eggs:

Average diameter 3.6 mm; demersal; long adhesive threads.<sup>3</sup>

## Larvae:

## Spawning:

Eggs deposited in summer in bays and estuaries;<sup>2</sup> (S. notata was observed to spawn near stands of red mangrove, but this was not the case for S. marina).<sup>3</sup> Specimens 17-30 mm in length collected in Delaware Bay June-August, 1960.

## Distribution:

Maine to Texas; often found in fresh waters above tide water.<sup>1</sup>

## References:

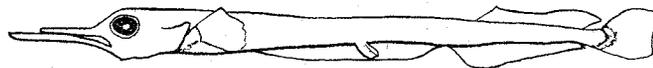
1. Bigelow, H.B. and W.C. Schroeder. 1953: 167-168.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 148.
3. Breder, C.M., Jr. and D.E. Rosen. 1966: 302-303.

## Other pertinent reference:

Breder, C.M., Jr. 1959: 141-148.

## Illustration credits:

9.5 mm, 30.0 mm, 37.0 mm Original illustrations by Nancy Smith

Species No. 13 Ablennes hians

37.0 mm

## BELONIDAE

Ablennes hians (Valenciennes). Flat needlefish.

## Adult characteristics:

(Flat-sided and not cylindrical as is Strongylura marina). D. 24; A. 25-27;<sup>1,2</sup> Laterally compressed - less than 1/2 as thick as deep.<sup>3</sup> In SL- head 3.1-3.8; depth 15.9-16.5; snout 1.4-1.5 in head, eye 9.65-11.6 in head.<sup>1</sup>

## Eggs:

Undescribed but probably with attachment filaments; demersal.<sup>4</sup> Ripe ova measure 3 mm in diameter.<sup>1,2</sup>

## Larvae:

## Spawning:

In spring.<sup>1</sup>

## Distribution:

From Brazil to Chesapeake Bay in the western Atlantic; northward as a stray to Cape Cod.<sup>3</sup>

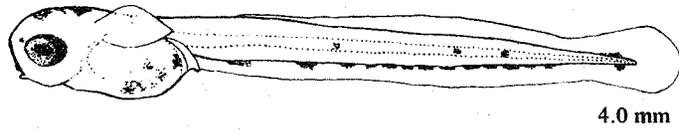
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 150-151.
2. Kobayashi, K. and K. Abe. 1963: 170.
3. Bigelow, H.B. and W.C. Schroeder. 1953: 168-169.
4. Orton, G.L. 1955: 103.

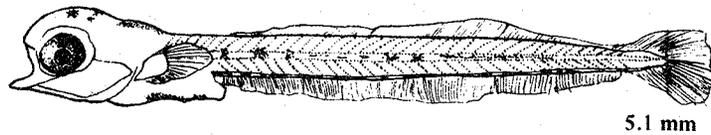
## Illustration credits:

37.0 mm Original illustration by Nancy Smith

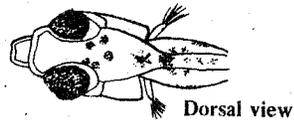
Species No. 14 Menidia menidia



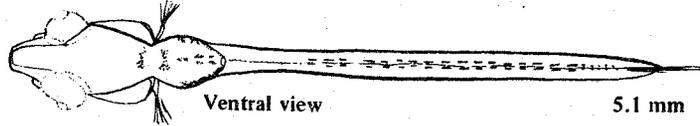
4.0 mm



5.1 mm

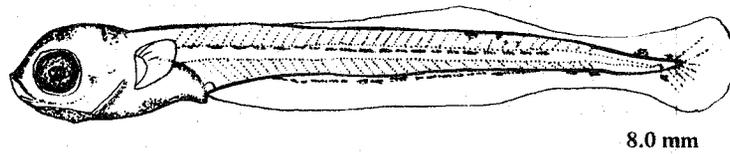


Dorsal view

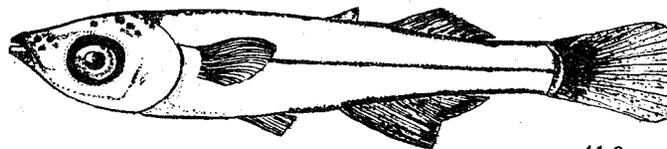


Ventral view

5.1 mm



8.0 mm



41.0 mm

## ATHERINIDAE

Menidia menidia (Linnaeus). Atlantic silverside.

## Adult characteristics:

D. III to VII - I, 7 to 10; A. I, 20-26.<sup>1</sup> Maxillary not extending to front of eye;<sup>2</sup> proportions in SL - head 4.15-4.7; depth 4.3-6.95 snout 2.7-3.75 in head; eye 2.75-3.75;<sup>1</sup> vertebrae 30-41.

## Eggs:

1.1-1.2 mm in diameter; demersal, each with a tuft of sticky filaments causing the eggs to stick together in sheets; 5-12 large oil globules and numerous smaller ones; in a mass the eggs are yellowish green, but singly they are semitransparent.<sup>3</sup>

## Larval stages:

Newly hatched larvae are 3.85<sup>2</sup> to 5 mm<sup>2,4</sup> and the yolk is absorbed before hatching;<sup>3</sup> larvae are very long and slender<sup>4</sup> and the gut is short. Black and yellow chromatophores are aggregated on the dorsal surface of the head and the dorsal region of the gut;<sup>3,4</sup> black chromatophores are found on the ventral surface of the yolk-sac,<sup>3</sup> in a row at the base of the ventral finfold,<sup>3,4</sup> and in small groups at the base of the dorsal finfold toward the caudal region.<sup>3</sup> At 5.5 mm the yellow pigment is reduced and there is more black pigment on the dorsal surface of the head and anterior trunk.<sup>3</sup> At 12-15 mm in length the dorsal, anal, and caudal fins are fully formed,<sup>2</sup> and the fish looks much like the adult.<sup>4</sup> The silvery lateral band is not well formed at this stage.<sup>3</sup>

## Spawning:

In the Chesapeake Bay from early spring to late summer,<sup>1</sup> over grassy beds in shallow tidal water.<sup>5</sup> In the Delaware Bay, specimens of Menidia sp. 3-6 mm (3-mm larvae most likely M. beryllina)<sup>4</sup> were collected from May through August; in Rehoboth and Indian River Bays, Delaware, young larvae 4-9 mm SL were collected from June-August 1968 and May through August 1969.<sup>6</sup> Spawns in May, June, and early July on the southern New England coast.<sup>1</sup>

## Distribution:

Nova Scotia to the east coast of northern Florida; M. menidia notata is found north of Chesapeake Bay and M. menidia menidia predominates south of Chesapeake Bay (has been found as far north as Woods Hole).<sup>1</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 187-189.
2. Bigelow, H.B. and W.C. Schroeder. 1953: 302-303.
3. Kuntz, A. and L. Radcliffe. 1917: 127-130.



Menidia menidia (Cont.)

4. Hildebrand, S.F. 1922: 115-118, 120.
5. Breder, C.M., Jr. and D.E. Rosen. 1966: 361.
6. Scotton, L.N. 1970: 65 pp.

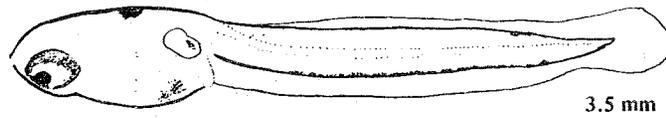
## Other pertinent references:

- Nichols, I.T. 1908: 731.  
Fowler, H.W. 1918: 1-19.

## Illustration credits:

- 4.0 mm Hildebrand, 1922  
5.1 mm Original illustration by Nancy Smith  
8.0 mm Kuntz and Radcliffe, 1917  
41.0 mm Original illustration by Nancy Smith

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Species No. 15 Menidia beryllina

## ATHERINIDAE

Menidia beryllina (Cope). Tidewater silverside.

## Adult characteristics:

D. IV or V - I, 8-11; A.I, 14-20;<sup>1</sup> vertebrae 41-42.<sup>2</sup> Proportions - head 3.9-4.7; depth 5.4-6.6 (M. beryllina is distinguished from M. menidia by the former's short anal fin,<sup>1,3</sup> small size,<sup>1,4</sup> more anterior position of the dorsal fins, and in the pale silvery peritoneum).<sup>4</sup>

## Eggs:

Not quite spherical when first spawned; diameter ca. 0.75 mm; gelatinous threads fewer in number than in M. menidia and 1 is always enlarged; eggs of the 2 species identical in other respects.<sup>4</sup>

## Larval stages:

Newly hatched larvae ca. 3.5 mm in length; identical to M. menidia in all respects (except development of M. beryllina is slower).

## Spawning:

Protracted spawning season in the Chesapeake Bay from April 10 to September 19, 1921;<sup>1</sup> in Delaware Bay specimens of Menidia sp. 3-6 mm<sup>4</sup> taken from May through August (3-mm larvae most likely M. beryllina);<sup>4</sup> at Woods Hole spawns in June and July.<sup>3</sup>

## Distribution:

Cape Cod to South Carolina, entering streams and fresh water.<sup>1</sup>

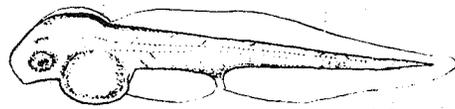
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 187-189.
2. Anon. Unpubl. Teleost meristic table.
3. Bigelow, H.B. and W.C. Schroeder. 1953: 304-305.
4. Hildebrand, S.F. 1922: 118-120.

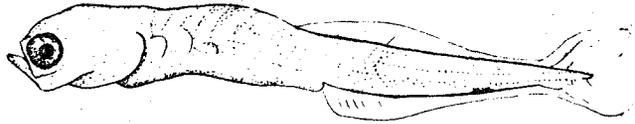
## Illustration credits:

3.5 mm Hildebrand, 1922

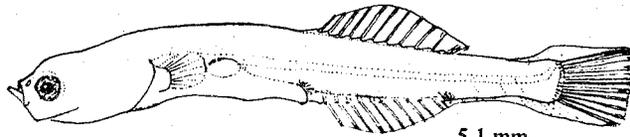
Species No. 16 Gobionellus boleosoma



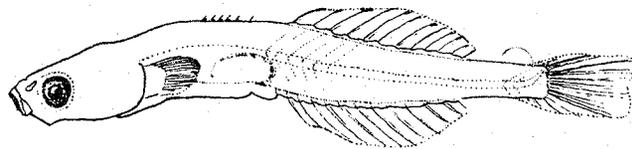
1.2 mm



3.7 mm



5.1 mm



7.5 mm

## GOBIIDAE

Gobionellus boleosoma (Jordan and Gilbert). Darter goby.

## Adult characteristics:

Maximum size about 55 mm.<sup>1</sup> D. VI-II; A. 17.<sup>2</sup> Definite dark shoulder spot,<sup>1,2</sup> V-shaped markings along sides.<sup>1</sup> Center of caudal fin prolonged.<sup>2</sup>

## Eggs:

Yellow, translucent, irregular in shape, 0.3-mm diameter, demersal, with gelatinous threads; slightly adhesive; large amounts of protoplasm and little yolk.<sup>1,3,4</sup>

## Larval stages:

Newly hatched larvae are ca. 1.2 mm in length, highly transparent, with the vent near the middle of the body; dorsal and anal finfolds are continuous, and yolk sac is small; at 2.5 mm the yolk is absorbed, air bladder is visible with black peritoneum becoming visible above it; at 3.5 mm the characteristic black, crescent-shaped peritoneum over the air bladder is present; caudal fin striations and pectoral buds (without rays) are present.

At 5.0 mm the mouth is superior (maxillary does not extend to eye), principal rays of caudal are fully formed, soft dorsal and anal fins contain some well-developed rays; pectoral rays still not differentiated; notochord is bent upward at tip; crescent-shaped dark area over air bladder is prominent and is an important identification feature. At 7.5 mm, depth contained in SL length is about 7.5 to 8.0 times; soft dorsal and anal rays have reached a full complement; spinous dorsal is undeveloped.

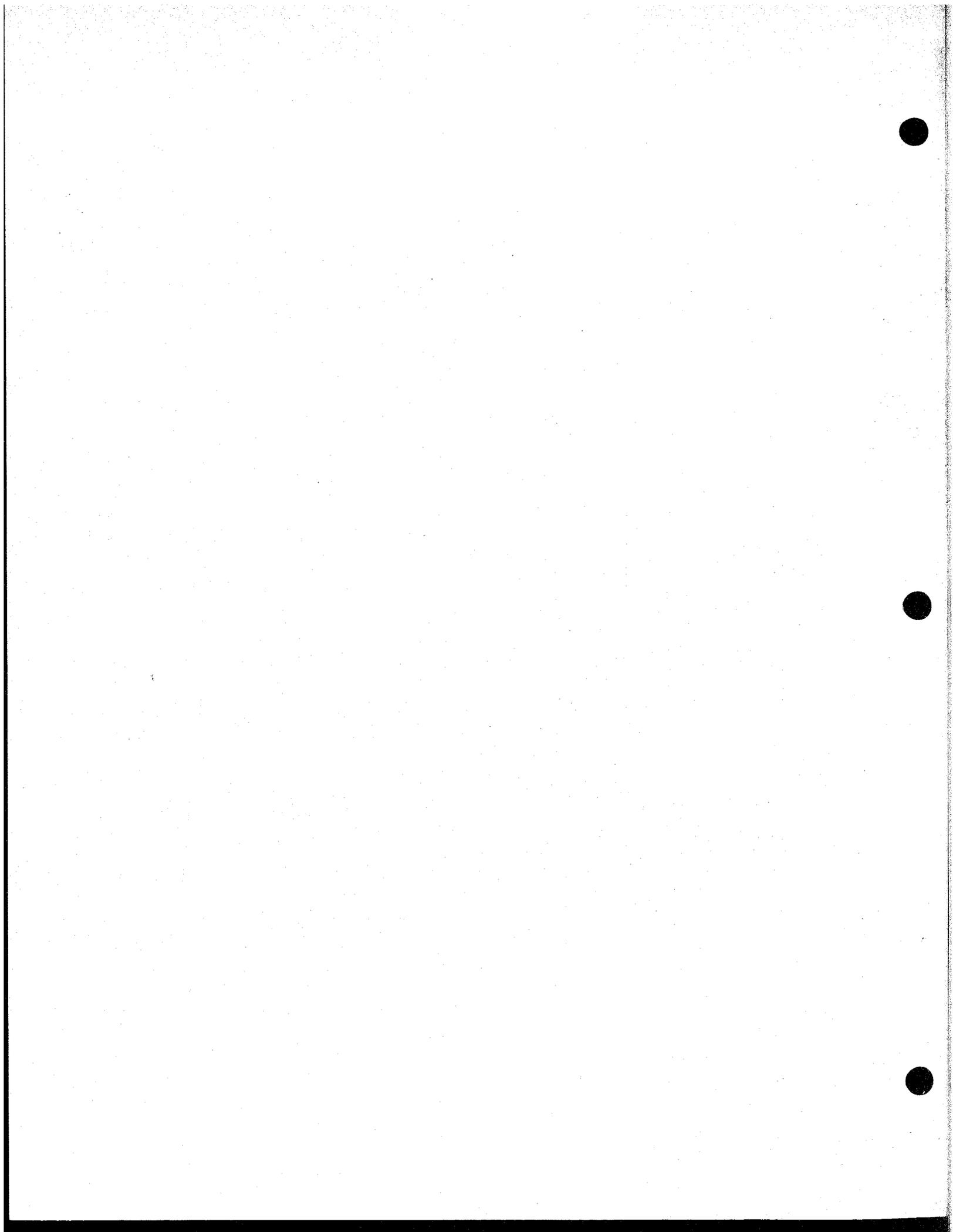
At 10 mm, body is still slender, with depth in length to base of caudal contained about 6.5 to 8.0 times; maxillary reaching opposite anterior margin of eye; fins all developed; crescent-shaped dark area over air bladder is very prominent; differences between fish 10 mm long and those 13 mm long are slight. Specimens of about 10 mm resemble adults, e. g., dorsal and anal fins each have 11 to 13 rays.<sup>1</sup>

## Spawning:

In summer along Carolina coast;<sup>1</sup> in Delaware Bay, 1 specimen 5 mm was taken in August.

## Distribution:

Delaware Bay; North Carolina to Brazil, including Gulf of Mexico and Bahamas; "most abundant in euryhaline continental localities."<sup>2</sup>



Gobionellus boleosoma (Cont.)

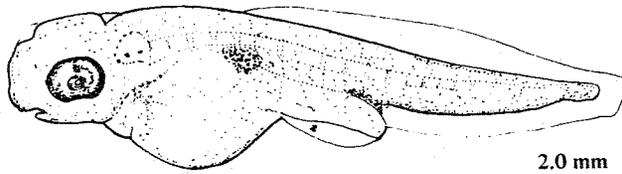
References:

1. Hildebrand, S.F. and L.E. Cable. 1938: 565-571.
2. Böhlke, J.E. and C.C.G. Chaplin. 1968: 585 and 631.
3. Kuntz, A. 1916: 426-428.
4. Breder, C.M., Jr. and D.E. Rosen. 1966: 532-533.

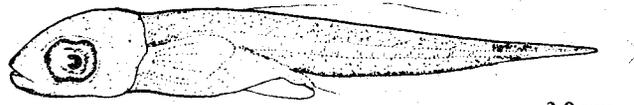
Illustration credits:

1.2 mm, 3.7 mm, 5.1 mm, 7.5 mm Hildebrand and Cable, 1938

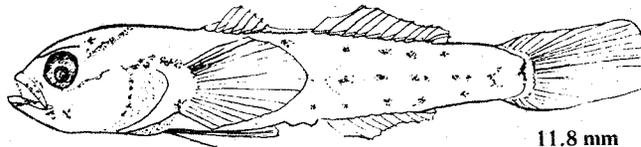
Species No. 17 Gobiosoma bosci



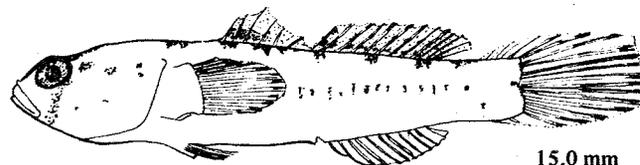
2.0 mm



3.0 mm



11.8 mm



15.0 mm

## GOBIIDAE

Gobiosoma bosci (Lacépède). Naked goby.

## Adult characteristics:

D.VII or VIII-13 (infrequently 12 or 14); eye 3.25 to 4.67 in SL; body robust, depth 3.95 to 4.8 in SL; head 3.15 to 3.5;<sup>1</sup> ventral disk short, reaching less than half the distance from its base to the vent;<sup>1,2</sup> Adult rarely exceeds 2 inches;<sup>2</sup> maxillary reaching middle of eye.<sup>1</sup>

## Eggs:

Demersal; unfertilized eggs slightly elongate, major axis of 5 eggs ranged from 0.637-0.675 mm and the minor axis from 0.52-0.6 mm; fertilized eggs more elongate; major axis in 10 eggs ranged from 1.147-1.369 mm and minor axis from 0.573-0.592 mm.<sup>2</sup> The yolk usually is found near one pole of the major axis, with gelatinous adhesive strands at the opposite pole.<sup>2,3</sup>

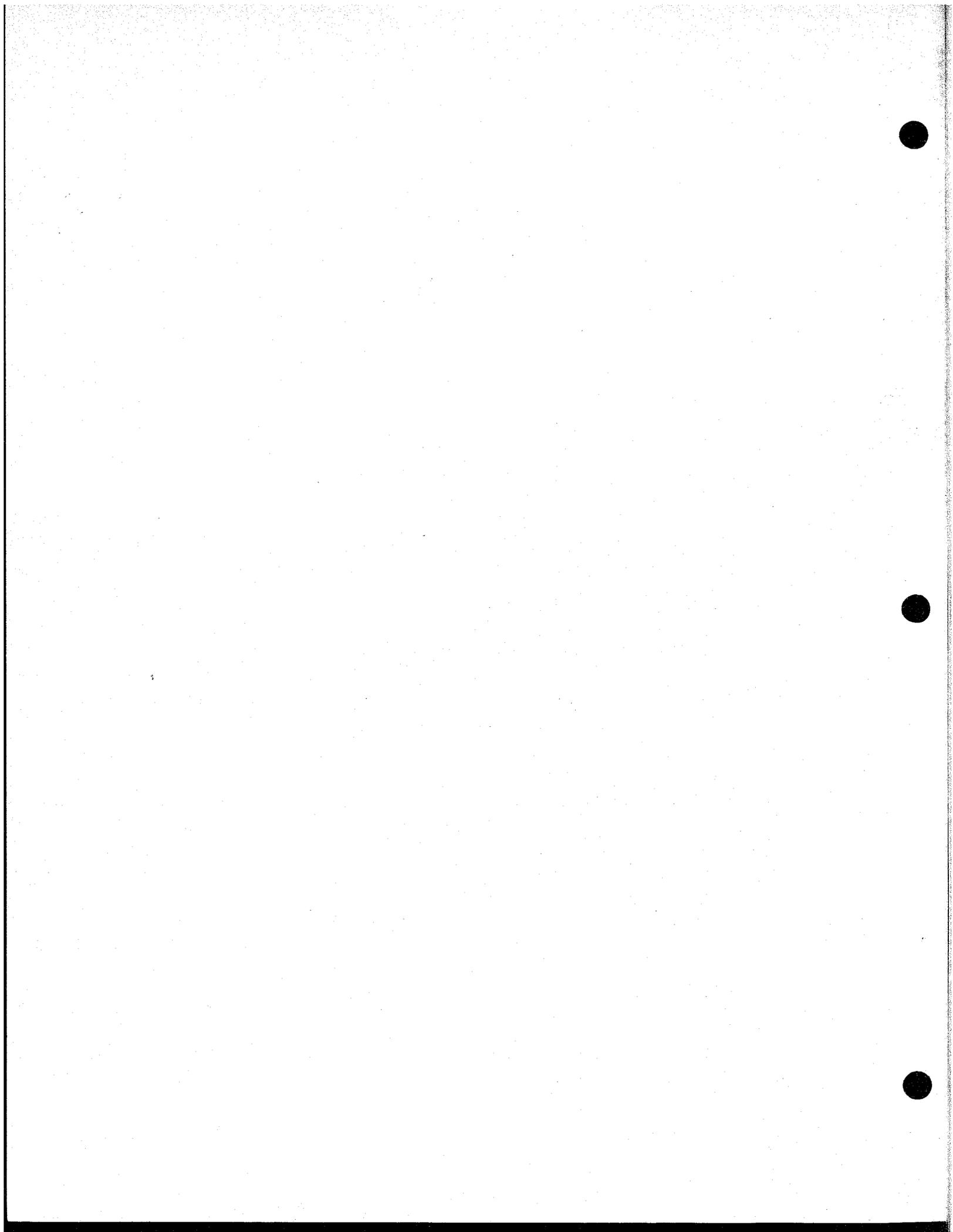
## Larval stages:

Newly hatched larvae about 2 mm in length; pigment spots over vent and at base of ventral finfold; mouth is inferior.<sup>1,2</sup> At 3.0 mm, mouth nearly terminal; pigment spots conspicuous along ventral finfold; vent is closer to tail than to snout; air bladder evident.

Descriptions of specimens greater than 3.0 mm SL are of Gobiosoma sp. as given by Hildebrand and Cable (1938). (Illustrations are not included because of the uncertainty of identification). At about 3.3 mm the mouth becomes terminal and nearly vertical. At about 4 mm the principal rays of the caudal are present and are partially differentiated. At about 7.5 mm, the snout is pointed, soft rays of dorsal and anal fins are differentiated; air bladder still visible. At 10 mm the fish has assumed most all adult characteristics; body robust, depth contained in SL about 5.3 times; ventral fins developed as a sucking disk. Pigmentation consists of dark markings along anal fin and on ventral outline; chromatophores scattered vaguely as bars on sides and back. At 15 mm, depth contained in SL 5.3 times; snout blunt; mouth small, oblique,<sup>2</sup> slightly inferior; fins fully developed and body fully pigmented.<sup>2</sup>

## Spawning:

At Beaufort, N.C., larvae were taken from May to December, being most abundant in July and August; young were found in same places as the adults;<sup>2</sup> in Chesapeake Bay from June to October;<sup>1</sup> in Delaware Bay specimens 4 to 9 mm taken from June to October.



Gobiosoma bosci (Cont.)

## Distribution:

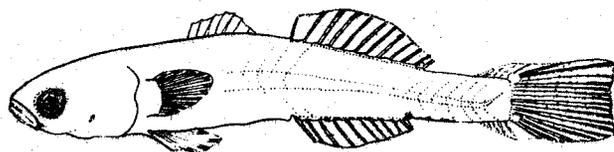
From Long Island to Tampico, Mexico.<sup>4</sup> Taken in shallow water, whereas G. ginsburgi is collected in deeper water; this vertical distribution pattern often is best<sup>2</sup> means of distinguishing between G. bosci and G. ginsburgi.

## References:

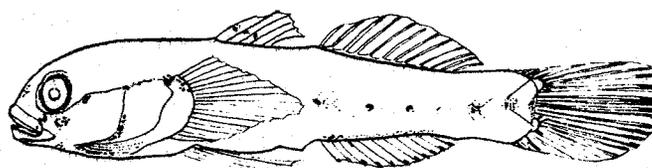
1. Hildebrand, S.F. and W.C. Schroeder. 1928: 323.
2. Hildebrand, S.F. and L.E. Cable. 1938: 548-559.
3. Kuntz, A. 1916: 423-426.
4. Ginsburg, I. 1933: 34.

## Illustration credits:

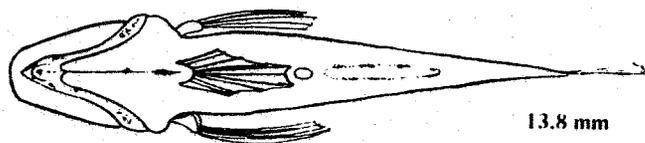
2.0 mm, 3.0 mm Kuntz, 1916  
11.8 mm, 15.0 mm Original illustrations by Nancy Smith

Species No. 18 Gobiosoma ginsburgi

11.0 mm



13.8 mm



13.8 mm

## GOBIIDAE

Gobiosoma ginsburgi Hildebrand and Schroeder. Seaboard goby.

## Adult characteristics:

D. VII-12; A. 11. Head 3.45 to 3.8 in SL; depth 6 to 7.15 in SL; eye 3.8 to 4.6; mouth terminal, oblique; maxillary extends beyond middle of eye; gill membranes joined to isthmus.<sup>1</sup> (Body more slender than in case of G. bosci.) Two large, dark scales at base of caudal, dorsally and ventrally situated, distinguish this species from G. bosci.<sup>2</sup>

## Eggs:

Demersal; believed to be similar to eggs of G. bosci (see description under G. bosci).<sup>2</sup>

## Larval stages:

(Refer to descriptions from G. bosci); up to about 10-11 mm larvae are very similar; at this size scales at base of caudal fin begin to develop, and are well developed by 11-13.8 mm. At 15 mm G. ginsburgi is notably more slender (depth in TL 6.1) than G. bosci.<sup>2</sup>

## Spawning:

Believed to spawn at same times as G. bosci (see description under G. bosci).<sup>2</sup> In Delaware Bay specimens 3-9 mm SL of Gobiosoma sp. were taken from June to September, 1960.

## Distribution:

Larvae and adults collected in deeper water than G. bosci.<sup>2</sup> Occurs from New York to Virginia.<sup>3</sup>

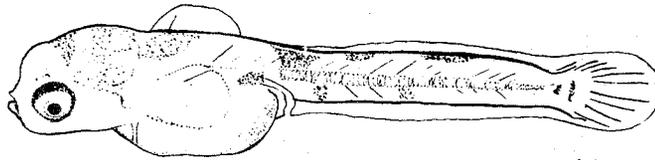
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 324-325.
2. Hildebrand, S.F. and L.E. Cable. 1938: 548-559.
3. Perlmutter, A. 1961: 395.

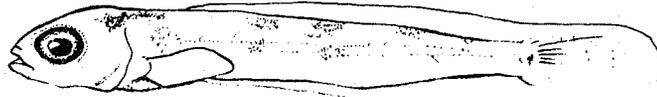
## Illustration credits:

- 11.0 mm Hildebrand and Cable, 1938  
13.8 mm Original illustration by Nancy Smith

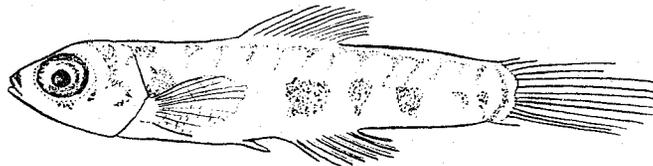
Species No. 19 Cyprinodon variegatus



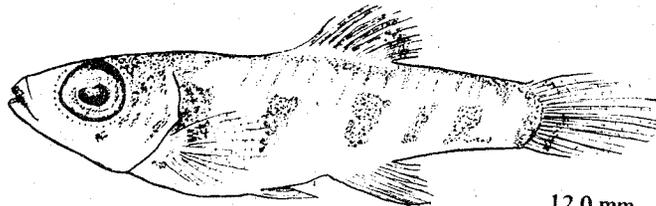
4.0 mm



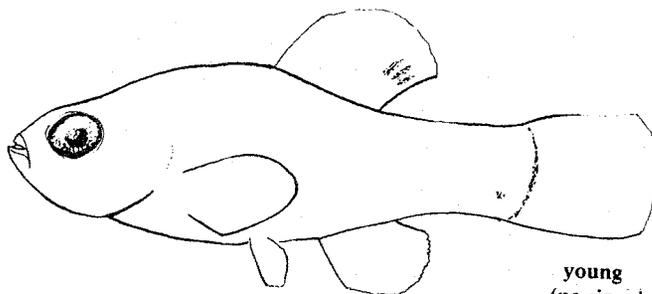
5.0 mm



9.0 mm



12.0 mm



young  
(no size given)

## CYPRINODONTIDAE

Cyprinodon variegatus (Lacépède). Sheepshead minnow.

## Adult characteristics:

D. 11 or 12; A. 10 or 11. Head 2.65 to 3.3 in SL; depth 2 to 2.65 in SL; eye 2.5 to 4 in head;<sup>1</sup> vertebrae 26-27.<sup>2</sup>

## Eggs:

Unfertilized ova 1.2 to 1.4 mm in diameter; slightly heavier than sea water; adhere in clumps, being held together by minute adhesive threads;<sup>1,3</sup> after fertilization the egg membrane expands and egg becomes more transparent.<sup>3</sup>

## Larval stages:

Newly hatched larva is "approximately 4 mm in length and relatively plump";<sup>3</sup> alternate light and dark crossbands;<sup>4</sup> yolk-sac large but head is not deflected. Dorsal and ventral finfolds are continuous. At about 5 mm yolk is absorbed and depth of body has increased. Color is yellowish with dark vertical bands.<sup>3</sup> At 9 mm all fins are formed,<sup>4</sup> but body is still relatively slender and back is not raised. At about 12 mm SL fish has practically all of the adult diagnostic characters.<sup>3</sup>

## Spawning:

In Chesapeake Bay occurs throughout spring and summer; one female lays eggs several times during one season.<sup>1</sup> In the Gulf of Maine spawning takes place in shallow water from April to September.<sup>4</sup> In Delaware Bay spawning occurs from late April to mid-August.

## Distribution:

Atlantic coast of the U.S., Cape Cod to Mexico, in brackish as well as sea water.<sup>4</sup>

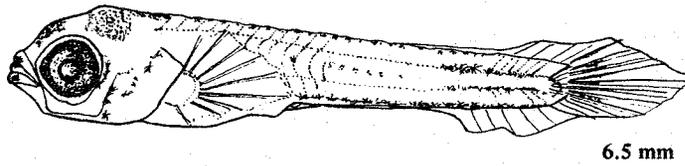
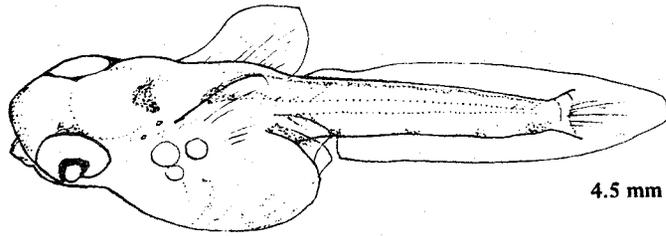
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 135-136.
2. Anon. Unpubl. Teleost meristic table.
3. Kuntz, A. 1916: 409-410 and 414-415.
4. Bigelow, H.B. and W.C. Schroeder. 1953: 166.

## Illustration credits:

4.0 mm, 5.0 mm, 9.0 mm, 12.0 mm, young (no size given)  
Kuntz, 1916

Species No. 20 Lucania parva



## CYPRINODONTIDAE

Lucania parva (Baird). Rainwater killifish.

## Adult characteristics:

D. 11 or 12; A. 10 or 11; Head 3.4 to 3.7 in SL; depth 3 to 3.8 in SL; rays of dorsal and anal proportionally longer in males than in females;<sup>1</sup> females larger than males;<sup>2,3</sup> length 1.5 to 2 inches.<sup>2</sup>

## Eggs:

Unfertilized ova are 1.1 to 1.3 mm in diameter; demersal and held together in clumps by adhesive threads.<sup>4</sup>

## Larval stages:

"Newly hatched larvae are 4.5 to 5 mm in length";<sup>4</sup> yolk-sac large and head is not deflected; both dorsal and ventral finfolds are continuous. Seven days after hatching, larva is 6 mm in length and yolk is absorbed. At about 15 to 20 mm in length, young show many diagnostic characters of the adults.<sup>4</sup>

## Spawning:

In Chesapeake Bay from early in April to end of July.<sup>1</sup> In Beaufort, N.C. this species spawns throughout the summer.<sup>4</sup> In Delaware Bay a 6 mm SL specimen was taken early in June.

## Distribution:

Atlantic Coast from Cape Cod to Key West; in brackish waters of Chesapeake Bay, but not in fresh water.<sup>1</sup>

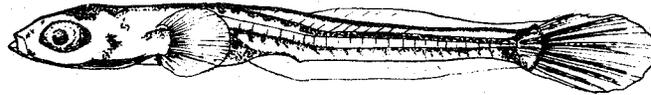
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 136-137.
2. Jordan, D.S. and B.W. Evermann. 1896:666
3. Breder, C.M., Jr. and D.E. Rosen. 1966: 318.
4. Kuntz, A. 1916: 415-416 and 420.

## Illustration credits:

- 4.5 mm Kuntz, 1916  
6.5 mm Original illustration by Nancy Smith

Species No. 21 Fundulus diaphanus



7.0 mm



longer than  
7.0



11.0 mm

## CYPRINODONTIDAE

Fundulus diaphanus (Lesueur). Banded killifish.

## Adult characteristics:

D. 13 or 14; A. 10 to 12; head 3.3 to 4 in SL; depth 4.1 to 5.7 in SL; eye 2.8 to 4 in head; head depressed<sup>1</sup> and flat above.<sup>2</sup> Distinguished from related species by elongate body, long depressed snout, small scales, and by many narrow vertical bars on sides (bars dark on female and silvery on male).<sup>1</sup>

## Eggs:

Fertilized eggs spherical and about 2 mm in diameter.<sup>1</sup>

## Larval stages:

## Spawning:

In Chesapeake Bay gravid females were taken from April until September.<sup>1</sup> Spawning season occurs in the late spring and early summer; spawning grounds are grassy bottoms.<sup>3</sup>

## Distribution:

From Quebec to North Carolina;<sup>1</sup> found in fresh water and slightly brackish water of bays, rivers, and coves.<sup>1,4</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 143-144.
2. Jordan, D.S. and B.W. Evermann. 1896: 645.
3. Breder, C.M., Jr. and D.E. Rosen. 1966: 315.
4. Perlmutter, A. 1961: 308.

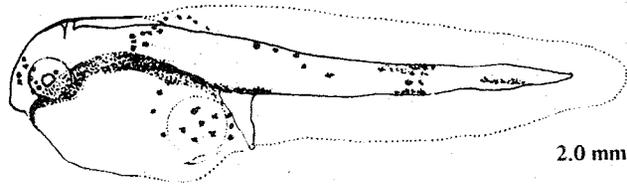
## Other pertinent references:

- Eigenmann, C.H. 1896: 203-296.  
 Fowler, H.W. 1916: 743-750.  
 Wright, A.H. and A.A. Allen. 1913: 4-6.

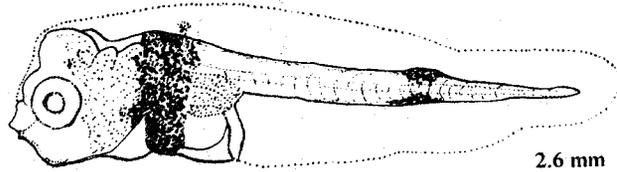
## Illustration credits:

7.0 - 11.0 mm Agassiz, 1882

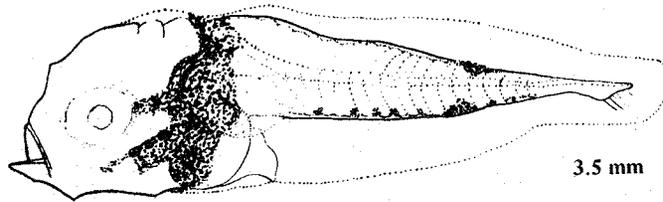
Species No. 22 Bairdiella chrysur



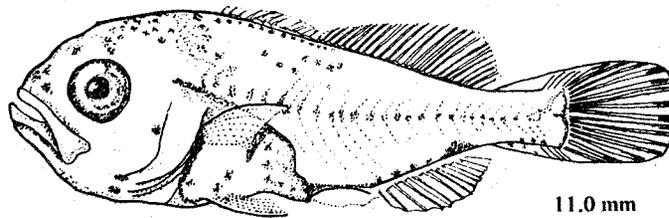
2.0 mm



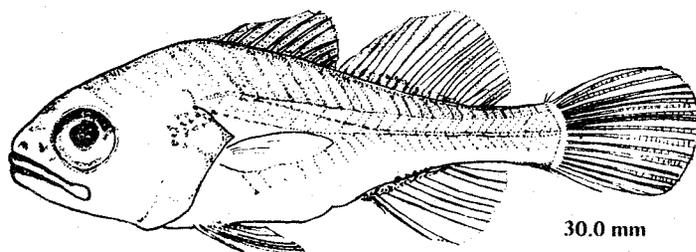
2.6 mm



3.5 mm



11.0 mm



30.0 mm

## SCIAENIDAE

Bairdiella chrysura (Lacépède). Silver perch.

## Adult characteristics:

D. XI or XII, 19 to 21; A. II, 9 or 10; head 2.85 to 3.4 in SL; <sup>2</sup> depth 2.8 to 3.15 in SL; eye 2.85 to 4.15 in head; <sup>1</sup> vertebrae 25.

## Eggs:

Pelagic; <sup>3</sup> spherical 0.7 to 0.8 mm in diameter; <sup>3,4</sup> 1 oil globule. <sup>4</sup>

## Larval stages:

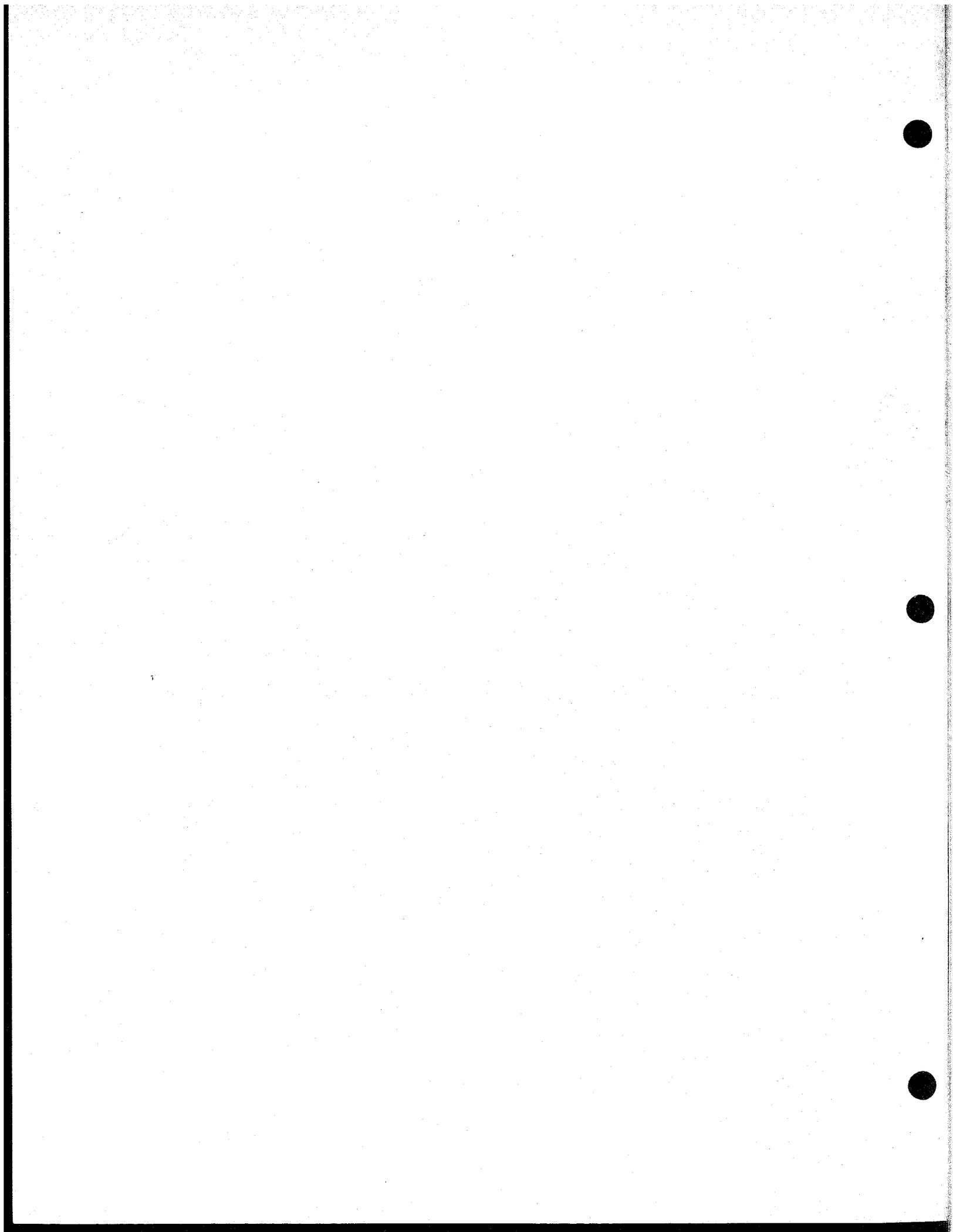
At time of hatching, the larvae are 1.5 to 1.8 mm in length; <sup>1,4</sup> oil globule is in posterior region of yolk-sac; head is deflected; chromatophores are aggregated, forming vertical bands; 5 hours after hatching vertical bands, for the most part, break up. One day after hatching the larva is 2.4 to 2.6 mm in length; head is no longer deflected; small amount of yolk remains. Two days after hatching, body is 2.5 to 2.8 mm in length; yolk is absorbed; 2 vertical bands are present -- one behind head and one is 2/3 distance from the vent to the posterior end of the body. At 3.5 mm the larva is feeding actively. Depth of head greater than depth of body; vertical bands blackish. At 5 mm in length, body form same as in 3.5 mm larvae; notochord curved upward. At about 7 to 8 mm, the larva begins to assume adult characteristics. At 10 to 12 mm in length, full complement of fin rays is present; appearance similar to that of adults, except depth in thoracic region is greater and head is more blunt than in adults. At 30 mm the larvae are miniature adults. <sup>4</sup> (See additional illustrations and descriptions of larvae). <sup>5</sup>

## Spawning:

In Chesapeake Bay occurs in late spring and early summer. <sup>1</sup> At Beaufort, N.C., from near end of April to the middle of July; most <sup>6</sup> prolific spawning occurs during the last half of May and early June. (This contradicts the statement that "the height of the spawning season of Bairdiella chrysura occurs during the last week of June and the first week of July.") <sup>4</sup> In New Jersey, B. chrysura spawns from June-August, and time of greatest spawning is June. <sup>5</sup> In northern Florida, spawning may occur from June to September. <sup>7</sup> Spawning in Everglades National Park occurs intermittently from late January to June. <sup>8</sup> In the Delaware Bay, eight larvae 4 to 8 mm in length were collected from July 20 to August 25, 1960.

## Distribution:

South Atlantic and Gulf coasts of the United States, north to New York. <sup>9</sup>



Bairdiella chrysur (Cont.)

## References:

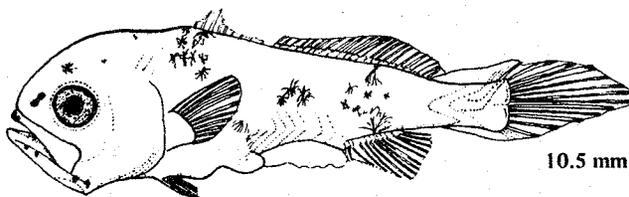
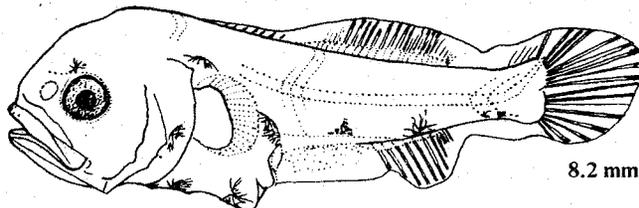
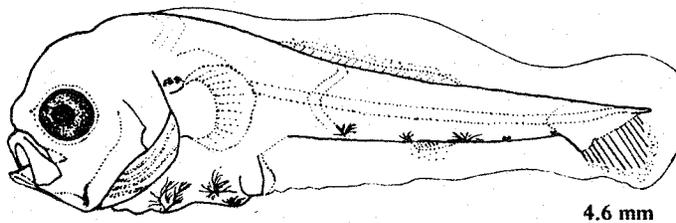
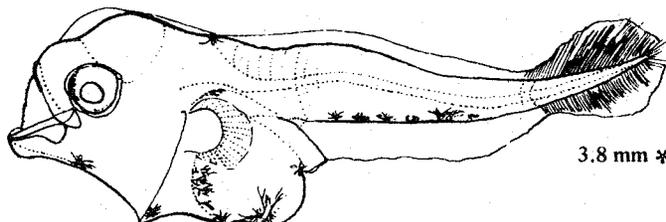
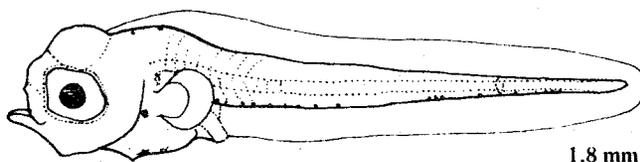
1. Hildebrand, S.F. and W.C. Schroeder. 1928: 279-282.
2. Anon. Unpubl. Teleost meristic table.
3. Breder, C.M., Jr. and D.E. Rosen. 1966: 459-460.
4. Kuntz, A. 1914: 3.
5. Welsh, W.W. and C.M. Breder, Jr. 1923: 171.
6. Hildebrand, S.F. and L.E. Cable. 1930: 411-412.
7. Reid, G.K., Jr. 1954: 49.
8. Jannke, T.E. 1971: 29-30.
9. Jordan, D.S. and B.W. Evermann. 1896: 1433.

## Other pertinent reference:

Gunter, G. 1938: 313-346.

## Illustration credits:

2.0 mm, 2.6 mm, 3.5 mm, 11.0 mm, 30.0 mm Kuntz, 1914

Species No. 23 Cynoscion regalis

\* The jaw of this specimen appears to be broken.

## SCIAENIDAE

Cynoscion regalis (Bloch and Schneider). Weakfish.

## Adult characteristics:

D. X-I, 25 to 28; A. II, 11 or 12;<sup>1</sup> vertebrae 25;<sup>2</sup> head 2.9 to 3.3 in SL; depth 3.5 to 4.25 in SL; eye 3.1<sub>1</sub> to 5.6 in head; gill rakers (lower-limb 1st arch) 11 to 13;<sup>1</sup> branchiostegals, for family Sciaenidae, 7 (rarely 8).<sup>3</sup>

## Eggs:

Pelagic; spherical; 1 mm in diameter; transparent.<sup>1</sup>

## Larval stages:

Newly hatched larvae are about 1.75 mm in length;<sup>4</sup> larvae 1.8 mm TL have an elongated slender body and "a large eye covering most of the side"; greatest depth of body is 4.0 to 4.5 in NL or SL; ventral series of melanophores present; yolk-sac absorbed at 1.8 mm<sup>5</sup> (the yolk-sac was present on specimen 2.2 mm from Chesapeake Bay).<sup>4</sup> At 3 mm TL body depth has increased; ventral series of melanophores more pronounced. Minute teeth (perhaps larval teeth) help to distinguish C. regalis from other young sciaenids such as Bairdiella chrysura and Micropogon undulatus. At 4.6 mm TL caudal rays present and dorsal and anal fin rays are slightly differentiated; most melanophores have disappeared except for pigment spots at the base of the anal and on gut (distinguishes C. regalis from both C. nebulosus and C. nothus). At 8.2 mm TL anal fin rays and soft dorsal rays are present. By 10.5 mm TL nearly the full complement of dorsal fin elements is present; some lateral pigment; the young assume a demersal existence. By 17 mm TL, there are four vertical band or saddles of chromatophores; anal pigment spot is gone. Body depth increases in proportion to length from hatching until about 17 mm TL, then body becomes more slender.<sup>5</sup>

## Spawning:

Occurs in larger bays and possibly in the ocean; from May to September, majority spawn between mid-May and mid-June.<sup>1,4,5</sup> The principal spawning ground in Delaware Bay is on the eastern<sup>4</sup> side in 3 to 5 fathoms of water over a bottom of mud and sand. In Delaware Bay 12 larvae 3-5 mm SL collected from June 18 to July 19, 1960.

## Distribution:

Eastern coast of the U. S. from the east coast of Florida to Massachusetts Bay, straying northward to Nova Scotia.<sup>6,7</sup>



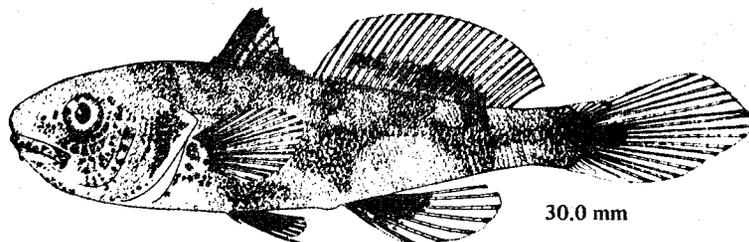
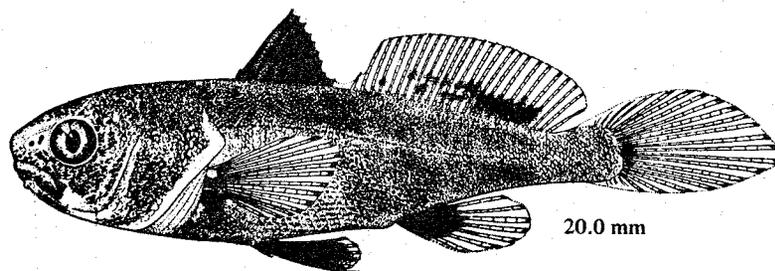
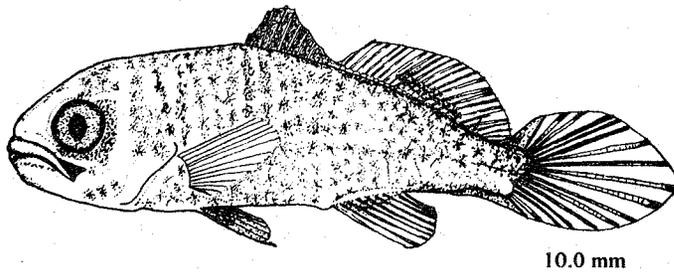
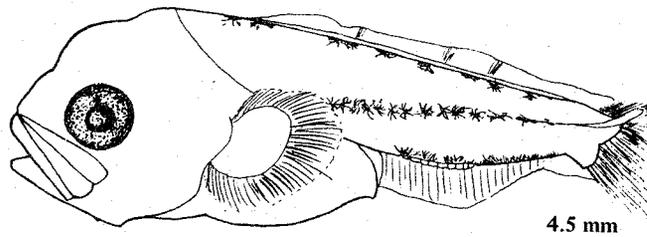
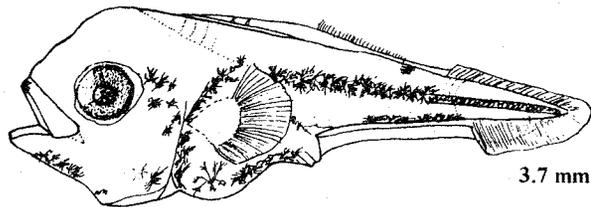
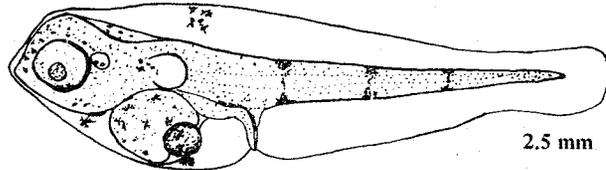
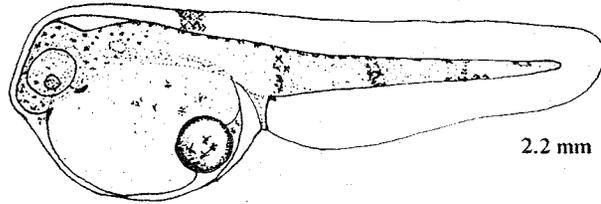
Cynoscion regalis (Cont.)

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 300 and 301.
2. Anon. Unpubl. Teleost meristic table.
3. McAllister, D.E. 1968: 139.
4. Welsh, W.W. and C.M. Breder, Jr. 1923: 150-164.
5. Pearson, J.C. 1941: 92-97.
6. Bigelow, H.B. and W.C. Schroeder. 1953: 420.
7. Leim, A.H. and W.B. Scott, 1966: 260.

## Illustration credits:

- 1.8 mm, 8.2 mm Pearson, 1941  
3.8 mm, 4.6 mm, 10.5 mm Original illustrations by Nancy Smith

Species No. 24 Menticirrhus saxatilis

## SCIAENIDAE

Menticirrhus saxatilis (Bloch and Schneider). Northern kingfish.

## Adult characteristics:

D. X-I, 24 to 26; A. I, 8; head 3.05 to 4.1 in SL; depth 3.65 to 4.3 in SL; eye 2.8 to 4.6 in head;<sup>1</sup> branchiostegals, in family, 7 (rarely 8);<sup>2</sup> vertebrae 25.<sup>3</sup>

## Eggs:

Pelagic; spherical, 0.76 to 0.92 mm diameter; variable number of oil globules.<sup>4</sup>

## Larval stages:

Length at hatching is 2 to 2.5 mm; head deflected. Four days after hatching (length about 2.7 mm) yolk almost completely absorbed.<sup>4,5</sup> Our larvae 3.7 mm in length show large, deep heads; line of melanophores extending from ventral surface of gut dorsally, around cleithrum and then mid-laterally towards tail; at 4.5 mm most pigmentation lost from gut; mid-lateral and ventral series still present; depth of head greater in proportion to SL than at 10 mm and larger. Nearly all soft dorsal and anal rays present at 5.0 mm SL.<sup>6</sup> At 10 mm full complement of fin rays present; body covered by melanophores as is spinous dorsal.<sup>5</sup>

## Spawning:

Off New Jersey, spawning from June-August;<sup>1,4</sup> in region of Beaufort, N.C., spawning occurs from April-May.<sup>5</sup> In Delaware Bay larvae 4-9 mm SL were collected from June 8 to August 23, 1960.

## Distribution:

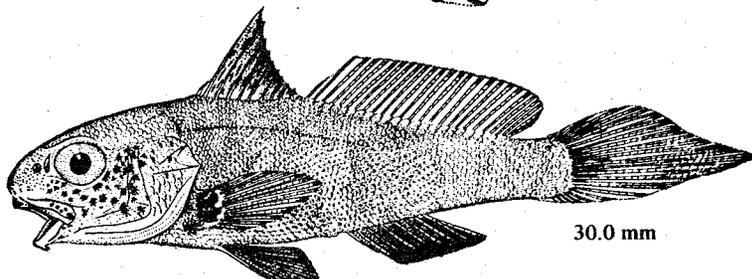
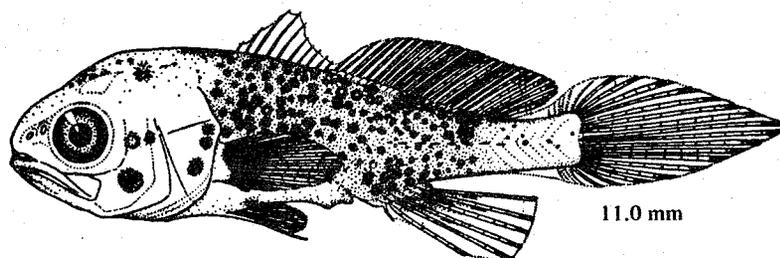
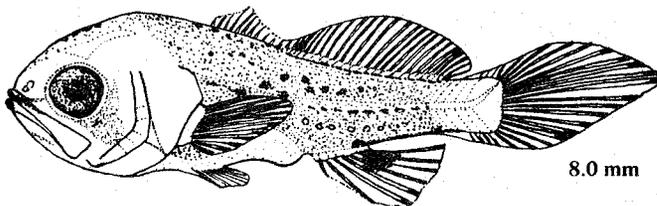
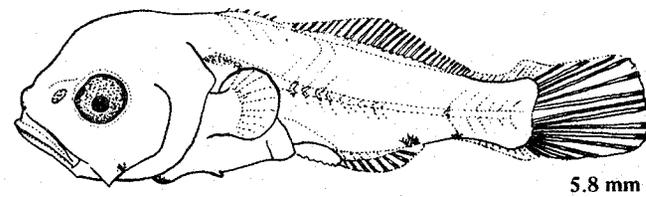
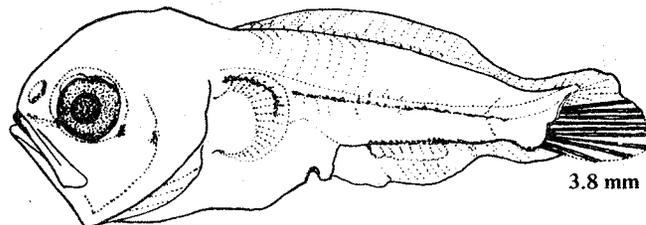
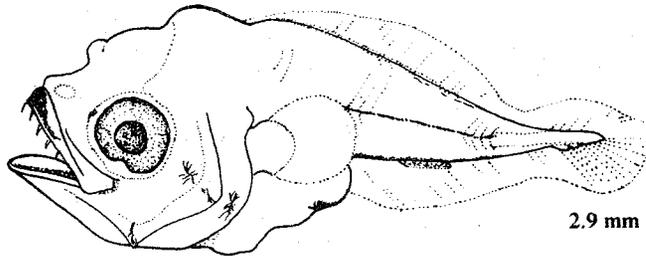
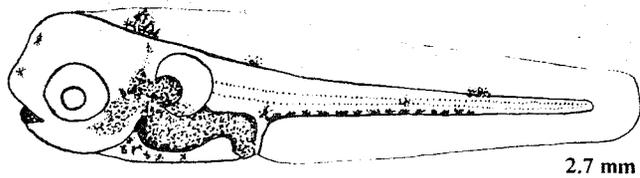
From Cape Cod<sub>7</sub> to Florida;<sup>1,7</sup> greatest abundance from Chesapeake Bay to New York,<sup>7</sup> i.e., mainly a northern distribution.

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 290 and 291.
2. McAllister, D.E. 1968: 139.
3. Anon. Unpubl. Teleost meristic table.
4. Welsh, W.W. and C.M. Breder, Jr. 1923: 190-195.
5. Hildebrand, S.F. and L.E. Cable. 1934: 64-70.
6. Jannke, T.E. 1971: 113.
7. Bigelow, H.B. and W.C. Schroeder. 1953: 425.

## Illustration credits:

2.2 mm, 2.5 mm Source unknown  
 3.7 mm, 4.5 mm Original illustrations by Nancy Smith  
 10.0 mm, 20.0 mm, 30.0 mm Hildebrand and Cable, 1934

Species No. 25 Menticirrhus americanus

## SCIAENIDAE

Menticirrhus americanus (Linnaeus). Southern kingfish.

## Adult characteristics:

D. X-I, 24 to 27; A. I, 7 (rarely I,8); head 3.1 to 3.9 in SL; depth 3.56 to 4.1 in SL; eye 2.8 to 6.5 in head;<sup>1</sup> branchiostegals, for sciaenids, 7 (rarely 8);<sup>2</sup> vertebrae 25.<sup>3</sup>

## Eggs:

## Larval stages:

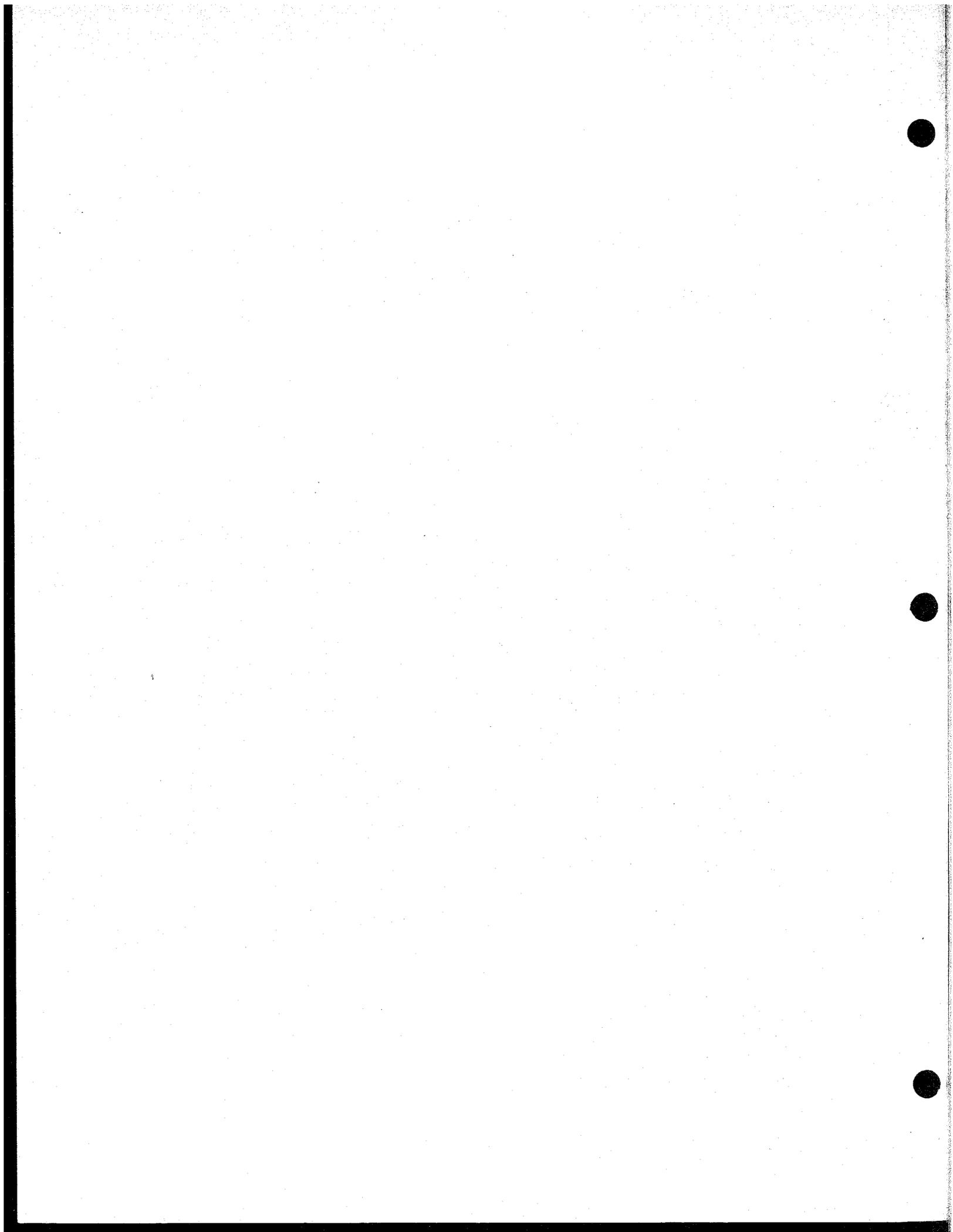
Newly hatched larvae about 1.7 mm long, head robust, larval teeth present, pigment lines ventrally and mid-laterally. At 2.9 mm, the chief recognition marks are the deep anterior half of the body, slender tail, and 2 black pigment lines on caudal portion of body. By 3.8 mm, tail deeper than before; dark pigment on premaxilla. At 5.8 mm, body more rotund; about 25 myomeres; caudal fin well developed and rounded; soft rays of 2nd dorsal and anal mostly differentiated. By 8 mm SL, body proportionately more slender; head broader; spinous dorsal evident; caudal fin pointed (rays nearly as long as head length); middle portion body with scattered chromatophores. By 10 mm, greatest body depth about 3.6 to 3.8 in SL; full complement of fin rays; caudal fin symmetrical and very pointed; dark pigment nearly everywhere. M. americanus is distinguished from M. saxatilis by its long, pointed and nearly symmetrical caudal fin, by nearly colorless ventral fins and partly black spinous dorsal, whereas M. saxatilis has a rounded, asymmetrical caudal with longest rays in lower half; spinous dorsal and ventral fins are wholly black. In specimens longer than 10 mm, appearance is similar to 10-mm specimens except that body becomes less tapered, there are fewer chromatophores, and caudal fin is longer and more pointed; at about 18-20 mm SL a slight knob appears on lower jaw, this becoming the characteristic mandibular barbel of adults.<sup>5</sup>

## Spawning:

Spawns in summer and fall.<sup>1,4,5,6</sup>

## Distribution:

New York to Texas; common from Chesapeake Bay southward;<sup>1</sup> this more southern distribution helps to separate this species from M. saxatilis.



Menticirrhus americanus (Cont.)

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 291-294.
2. McAllister, D.E. 1968: 139.
3. Anon. Unpubl. Teleost meristic table.
4. Welsh, W.W. and C.M. Breder, Jr. 1923: 191.
5. Hildebrand, S.F. and L.E. Cable. 1934: 54-64.
6. Breder, C.M., Jr. and D.E. Rosen. 1966: 460.

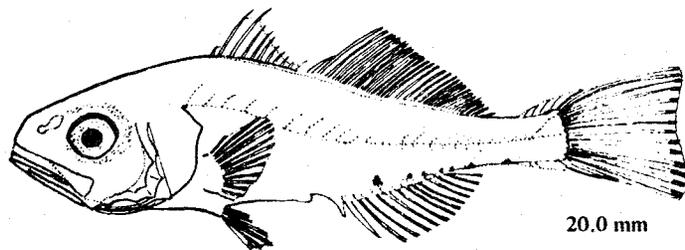
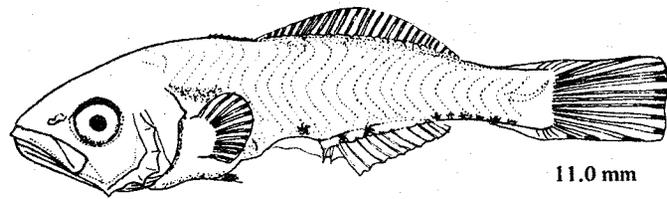
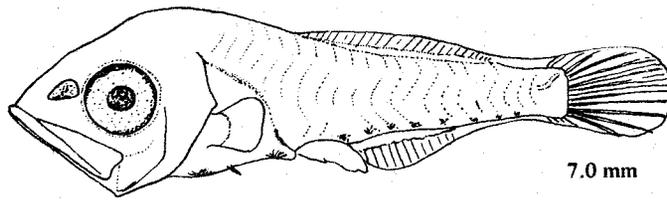
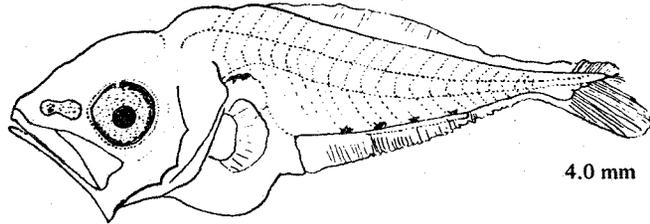
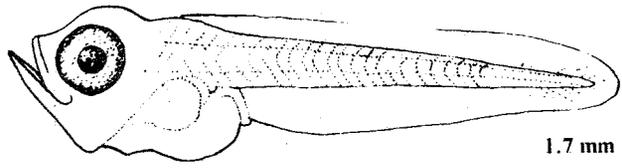
## Other pertinent reference:

Dovel, W.L. 1971: 12.

## Illustration credits:

2.7 mm Welsh and Breder, 1924  
2.9 mm, 3.8 mm, 5.8 mm, 8.0 mm, 11.0 mm, 30.0 mm Hildebrand  
and Cable, 1934

Species No. 26 Leiostomus xanthurus



## SCIAENIDAE

Leiostomus xanthurus Lacépède. Spot.

## Adult characteristics:

D. X-I, 30 to 34; A. II, 12 or 13; head 2.95 to 3.6 in S.L.; depth 2.55 to 3.6 in S.L.; eye 3 to 3.95 in head; gill rakers, 1st arch lower limb 22 to 23;<sup>1</sup> vertebrae 25;<sup>2</sup> branchiostegals, in family, 7 (rarely 8);<sup>3</sup> snout blunt; large black spot behind upper corner of operculum.<sup>4</sup>

## Eggs:

## Larval stages:

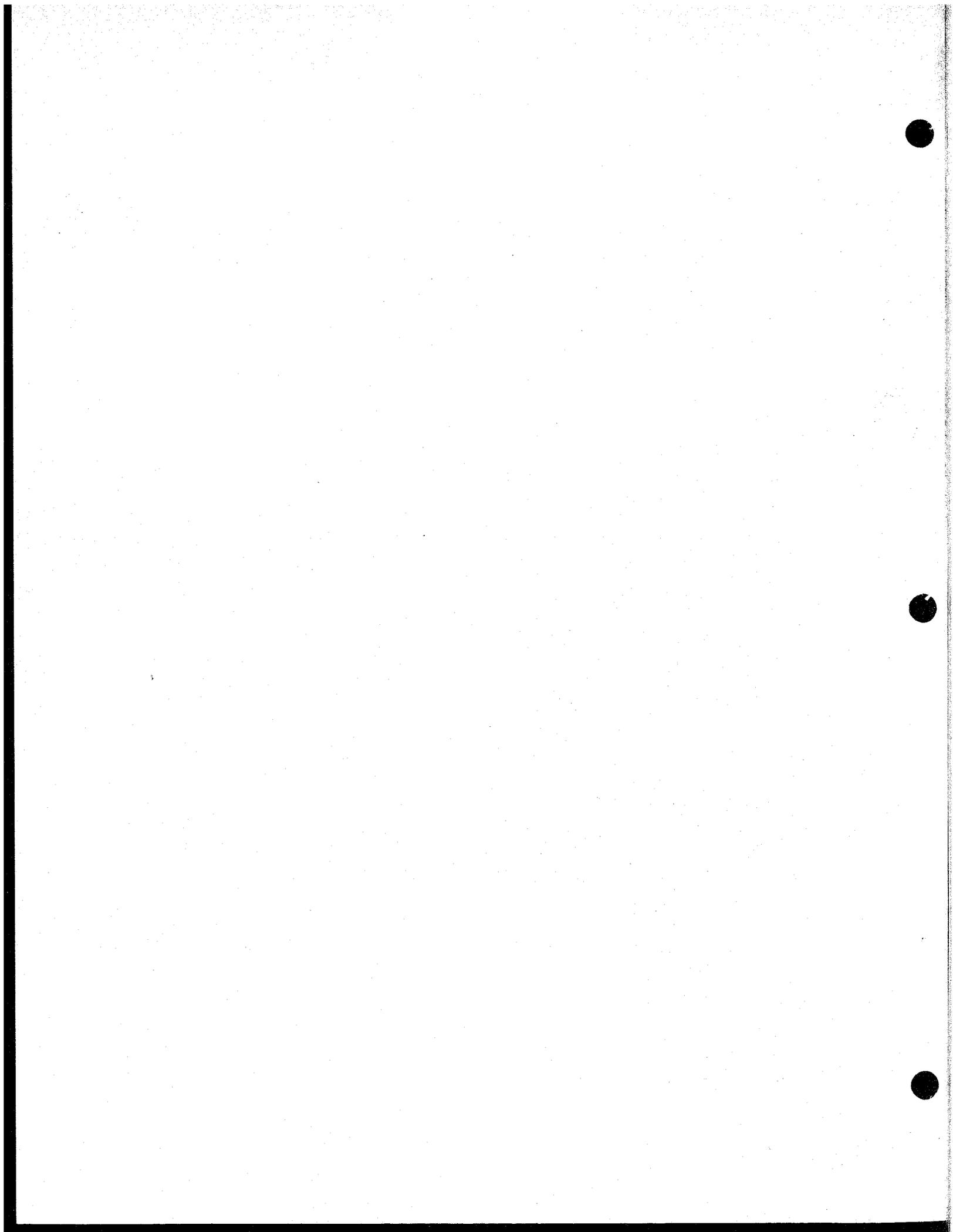
At 1.5 mm, yolk-sac completely absorbed; body depth tapers toward tail; dark covering (peritoneum) above air bladder; by 2.8 mm, mouth oblique to vertical; anterior portion of body deep; prominent hump over eyes and another at nape; at 3.6 mm, principal caudal ray rudiments appear on ventral side of tail; humps on head are mostly gone. Caudal fin well formed at 6 mm; gut protrudes ventrally; by 7 mm, anal rays beginning to appear; dorsal fin rays less developed; gut no longer projects; by 10 mm, soft dorsal and anal fins show full complements of rays, spinous dorsal just beginning to appear; posterior margin of caudal fin is straight. By 15 mm, most spines of 1st dorsal are developed; black peritoneum no longer visible; young fish still more slender than adult.<sup>5</sup> Characteristics useful in separating L. xanthurus from other young sciaenids are: presence of 12 anal rays, truncate caudal fin, relative lack of pigmentation.<sup>6</sup>

## Spawning:

In the Gulf of Mexico from December to March,<sup>6,7</sup> and at about the same time in the Atlantic off the coast of North Carolina.<sup>5,6</sup> In Florida from December until late March.<sup>8,9</sup> In the Delaware Bay a 3-mm specimen was collected on August 18, 1960.

## Distribution:

Massachusetts to Texas.<sup>1</sup>



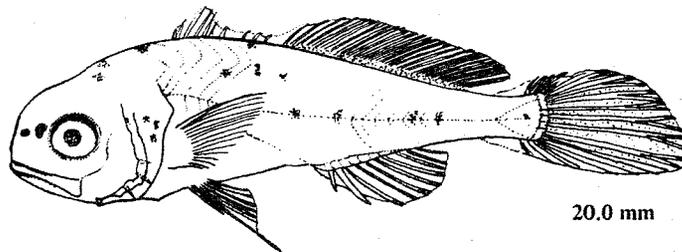
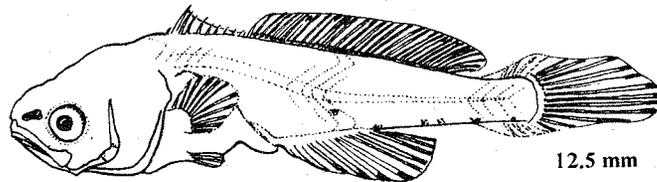
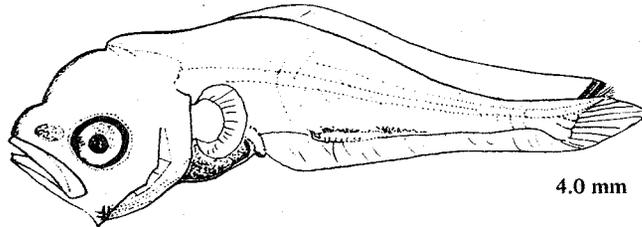
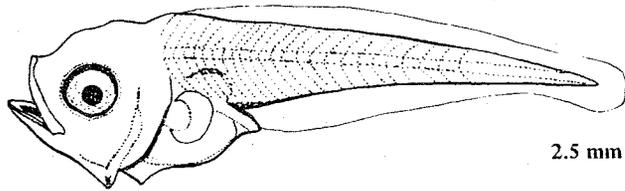
Leiostomus xanthurus (Cont.)

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 271-276.
2. Anon. Unpubl. Teleost meristic table.
3. McAllister, D.E. 1968: 139.
4. Bigelow, H.B. and W.C. Schroeder. 1953: 423.
5. Hildebrand, S.F. and L.E. Cable. 1930: 416-430.
6. Pearson, J.C. 1929: 204-210.
7. Breder, C.M., Jr. and D.E. Rosen. 1966: 460.
8. Jannke, T.E. 1971: 47-50.
9. Reid, G.K., Jr. 1954: 50.

## Illustration credits:

1.7 mm, 4.0 mm, 7.0 mm, 11.0 mm, 20.0 mm Hildebrand and Cable, 1930

Species No. 27 Micropogon undulatus

## SCIAENIDAE

Micropogon undulatus (Linnaeus). Atlantic croaker.

## Adult characteristics:

D. X-I, 28 or 29; A. II, 8; head 2.95 to 3.4 in S.L.; depth 2.9 to 3.65 in S.L.; gill rakers 14 to 16 on lower limb of 1st arch;<sup>1</sup> vertebrae 25;<sup>2</sup> branchiostegals, in family, 7 (rarely 8);<sup>3</sup> mouth inferior and horizontal; row of short barbels on each side of dentary.<sup>4</sup>

## Eggs:

## Larval stages:

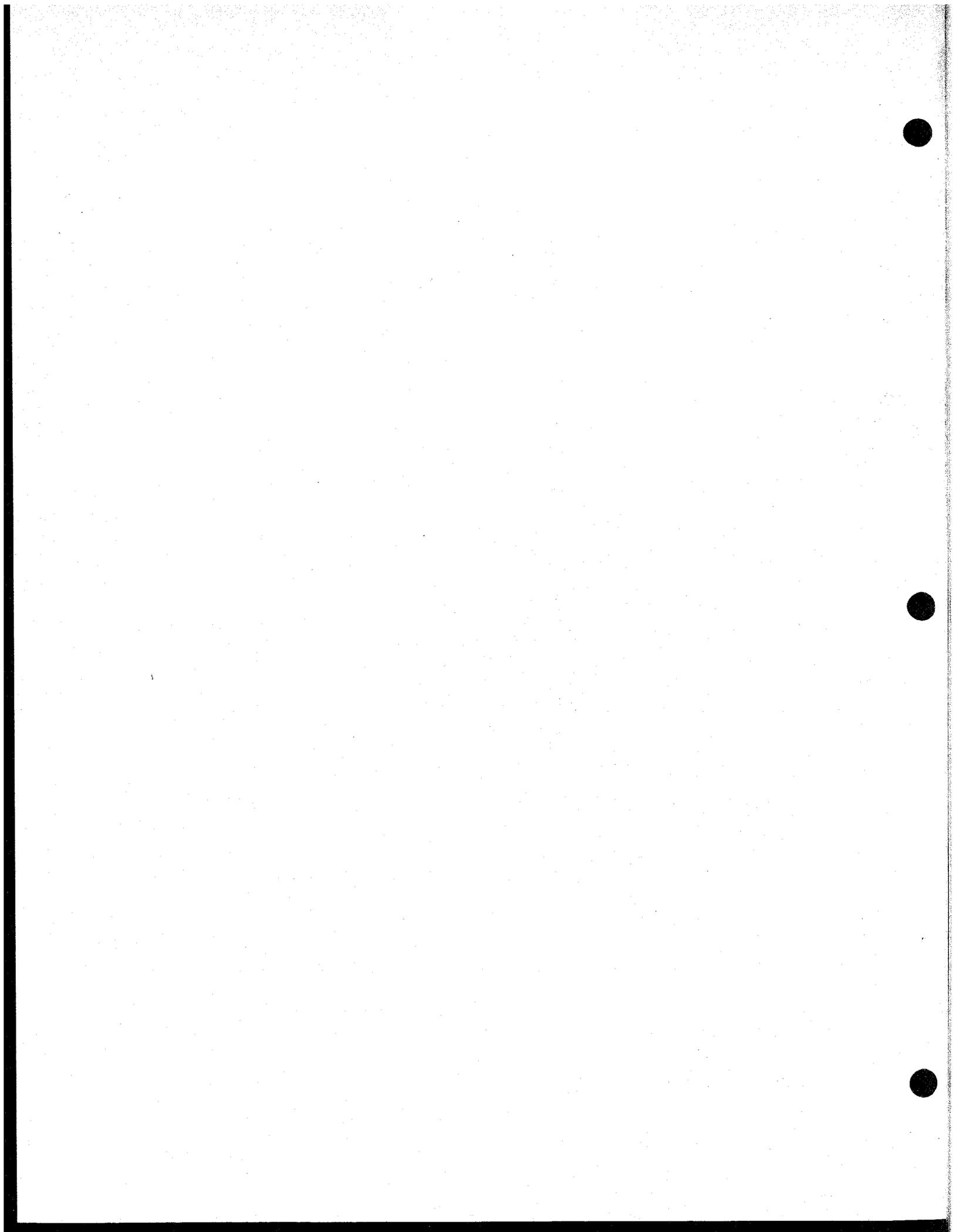
At 2.8 mm, mouth large and nearly vertical; dark crescent-shaped peritoneum above visceral mass; by 3.6 mm, rudimentary rays of caudal fin point ventrally from slightly upturned notochord; by 4.0 mm, caudal rays more horizontal.<sup>5</sup> At 6 mm, anal fin rays differentiated, usually being II, 8; soft dorsal rays somewhat differentiated; distinctive pigmentation consists of 2 small chromatophores at base of anal fin; 3 to 5 chromatophores lie posterior to anal fin along the caudal peduncle.<sup>4</sup> (Hildebrand and Cable, 1930, Fig. 53, p. 436, appears to be Pogonias chromis and not M. undulatus).<sup>5</sup> At 11 mm, full complement of dorsal and anal rays present, caudal fin asymmetrical and somewhat pointed, thus separating this species from Leiostomus xanthurus.<sup>4,5</sup> (See list of characters distinguishing young of these two species, Hildebrand and Cable, 1930: 439).<sup>5</sup>

## Spawning:

From August to December, depending on latitude and local conditions.<sup>1,4,5,6,7</sup> Spawning season includes nearly entire year in Chesapeake Bay region;<sup>7,8</sup> offshore of Beaufort, N.C. and in estuaries there, from September to May.<sup>5</sup> In Delaware Bay, two 4-mm specimens taken on July 1, 1960. (2 juveniles 14 and 19 mm, respectively were collected in November, 1968, in the Rehoboth and Indian River bays, Delaware.<sup>9</sup>

## Distribution:

Massachusetts to Texas; not common north of New Jersey.<sup>4</sup>



Micropogon undulatus (Cont.)

## References:

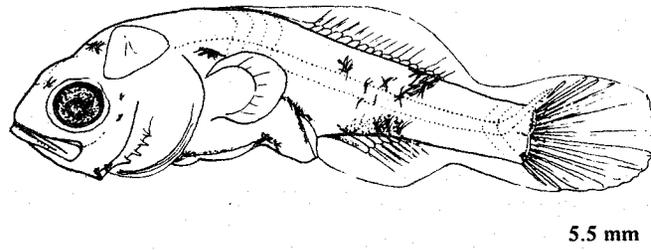
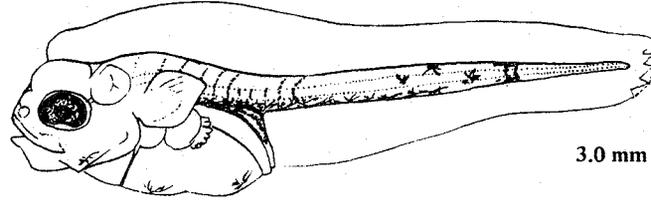
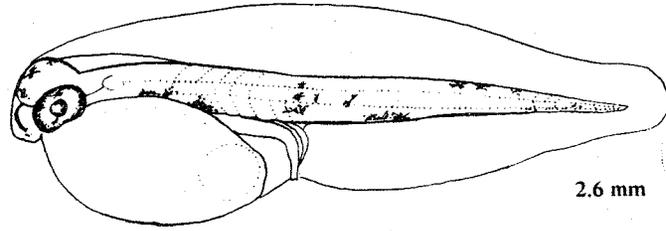
1. Hildebrand, S.F. and W.C. Schroeder. 1928: 283-287.
2. Anon. Unpubl. Teleost meristic table.
3. McAllister, D.E. 1968: 139.
4. Pearson, J.C. 1929: 195.
5. Hildebrand, S.F. and L.E. Cable. 1930: 430-445.
6. Welsh, W.W. and C.M. Breder, Jr. 1923: 180-184.
7. Breder, C.M., Jr. and D.E. Rosen. 1966: 460.
8. Haven, D.S. 1957: 88-97.
9. Scotton, L.N. 1970: 14.

## Other pertinent references:

- Dovel, W.L. 1968: 313-319.  
Dovel, W.L. 1971: 12.

## Illustration credits:

2.5 mm, 4.0 mm, 12.5 mm, 20.0 mm Hildebrand and Cable, 1930

Species No. 28 Pogonias cromis

## SCIAENIDAE

Pogonias cromis (Linnaeus). Black drum.

## Adult characteristics:

D. X-I, 20 to 22; A. II, 6 or 7; <sup>1</sup> primary rays caudal fin, 17; <sup>2</sup> head 2.9 to 3.45 in SL; depth 2.65 to 2.8 in SL; eye 2.85 to 3.95 in head. Gill rakers, 14 to 16 on lower limb of first arch; <sup>1</sup> barbels on chin; <sup>3</sup> branchiostegals, in family, 7 (rarely 8). <sup>4</sup>

## Eggs:

## Larval stages:

Yolk-sac present until about 5-6 mm SL; 2 prominent chromatophores lie ventrally, behind vent. 3-4 small preopercular spines present at about 5 mm. Soft D., A., and caudal fins generally differentiated at about 5 mm, full complement of rays present at about 8mm; dark chromatophores appear dorsally and on sides and begin to form the 6 black vertical bars that remain until the adult size is reached. When a size of 15 mm is reached, the young drum is the adult shape and the 6 black bars are pronounced. <sup>5</sup>

## Spawning:

Along Texas coast in Gulf of Mexico, from February to May. <sup>5</sup>

## Distribution:

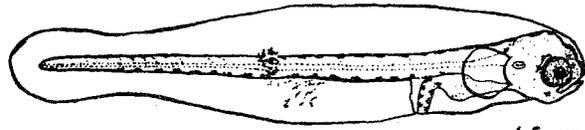
Atlantic and Gulf coasts from southern New England to Argentina. <sup>1,3</sup>

## References:

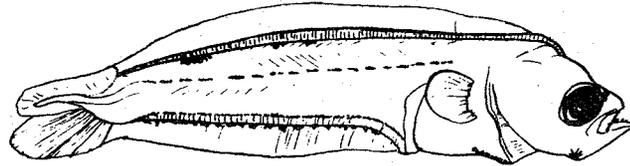
1. Hildebrand, S.F. and W.C. Schroeder. 1928: 287-289.
2. Anon. Unpubl. Teleost meristic table.
3. Bigelow, H.B. and W.C. Schroeder. 1953: 425-426.
4. McAllister, D.E. 1968: 139.
5. Pearson, J.C. 1929: 157-161.

## Illustration credits:

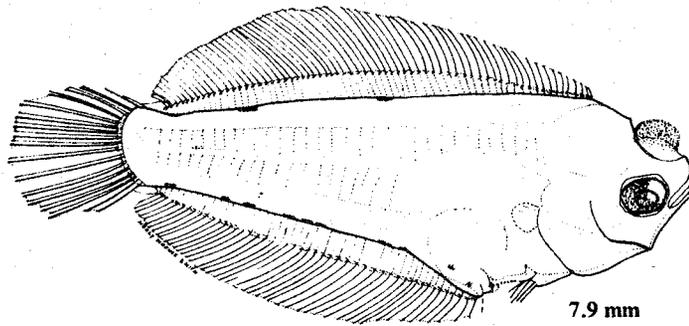
2.6 mm, 3.0 mm Loaned by E. B. Joseph  
5.5 mm Jannke, 1971

Species No. 29 Pseudopleuronectes americanus

4.5 mm



5.0 mm



7.9 mm

## PLEURONECTIDAE

Pseudopleuronectes americanus (Walbaum). Winter flounder.

## Adult characteristics:

D. 62 to 69; A. 46 to 53; head 3.4 to 4.4 in SL; depth 1.75 to 2.55 in SL; eye 3.05 to 4.9 in head; eyes<sub>2</sub> and color on right side;<sup>1</sup> branchiostegals, in family, 7 (rarely 8).<sup>2</sup> Mouth is small, not gaping to eye, and lateral line nearly straight.<sup>3</sup>

## Eggs:

Demersal, adhere in clusters; each egg 0.74 to 0.85 mm diameter;<sup>1,3</sup> newly shed eggs lack an oil globule.<sup>3</sup>

## Larval stages:

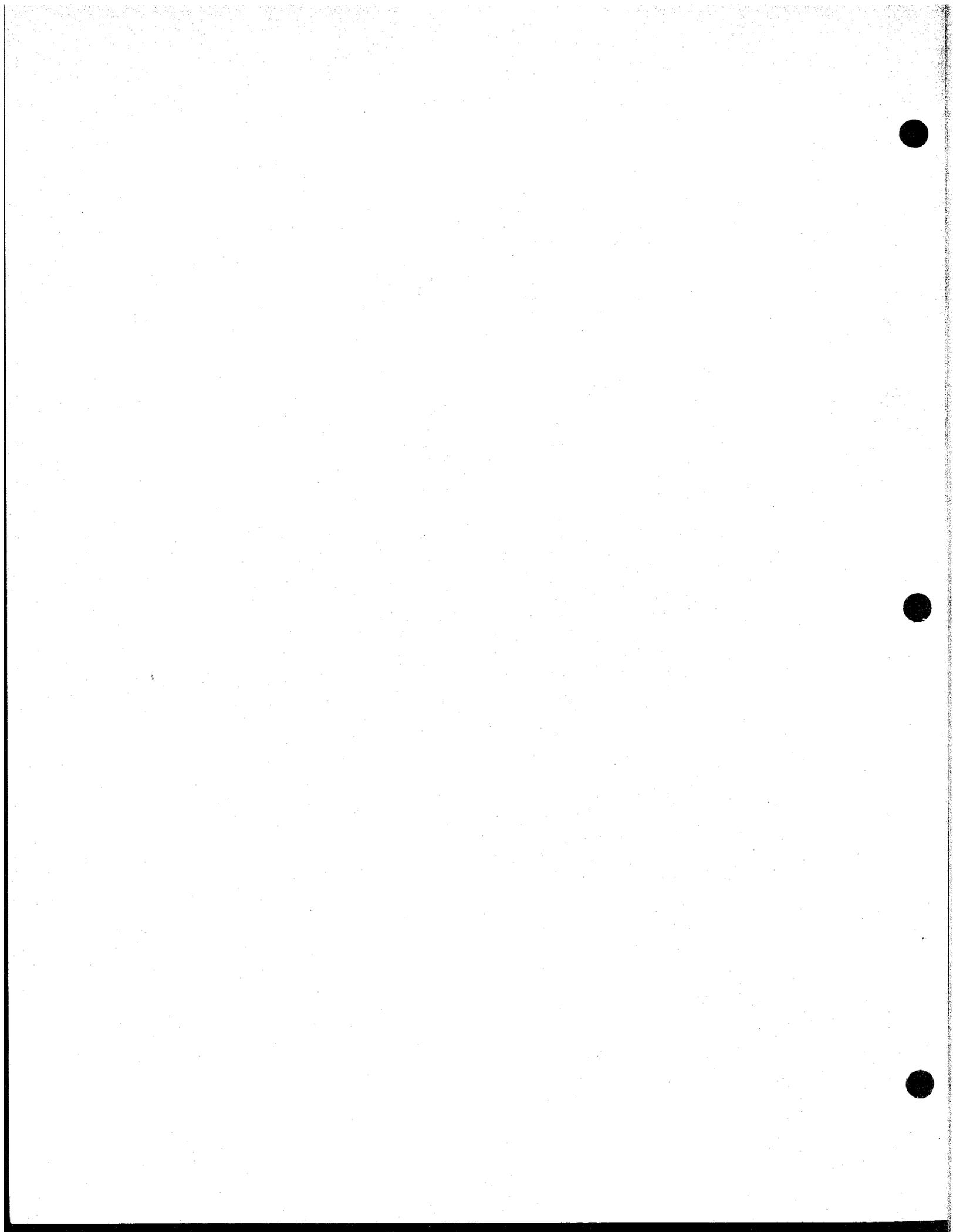
Newly hatched larvae 3 to 3.5 mm in length;<sup>1,3</sup> marked by broad vertical band of pigment cells midway back from head, and gut heavily pigmented. At about 6 mm vertical fin rays begin to appear and left eye has moved so that it is visible above dorsal outline of head. When larva is 8 mm, fins fully formed and left eye has migrated more; then at about 9 mm, the left eye moves to final position on right side, pigment fades from left (blind) side, fish swims and lies with blind side down and metamorphosis is complete at about 9 mm in length<sup>3</sup> (not complete in yellowtail flounder, Limanda ferruginea, until about 14 mm).<sup>4</sup>

## Spawning:

In Chesapeake Bay along sandy shores in winter and early spring;<sup>1</sup> from January through May in New England.<sup>3</sup> Spawning is at its height when water temperature is coldest.<sup>3</sup> In Delaware Bay larvae 6-10 mm collected from April 28-June 24, 1960. (In Delaware area, adults spend winter in shallow areas of estuaries and bays and move offshore in late winter).<sup>5</sup> There is a general tendency for fry produced in bays and estuaries to move offshore as they grow.<sup>6</sup>

## Distribution:

Northern Labrador to Georgia; not taken in commercial numbers south of Chesapeake Bay.<sup>1</sup>



Pseudopleuronectes americanus (Cont.)

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 168-170.
2. McAllister, D.E. 1968: 132.
3. Bigelow, H.B. and W.W. Welsh. 1925: 505-507.
4. Colton, J.B., Jr., and R.R. Marak. 1969: 37.
5. de Sylva, D.P., F.A. Kalber, Jr., and C.N. Shuster, Jr. 1962: 43.
6. Bigelow, H.B. and W.C. Schroeder. 1953: 276-283.

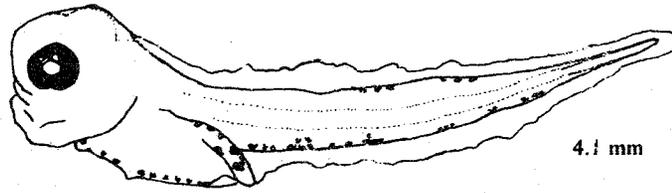
## Other pertinent references:

- Breder, C.M., Jr. 1923: 311-316.  
Wheatland, S.B. 1956: 234-314.

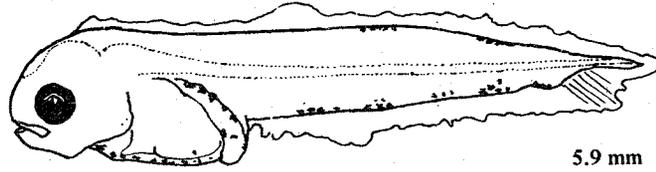
## Illustration credits:

- 4.5 mm, 5.0 mm Bigelow and Welsh, 1925  
7.9 mm Original illustration by Nancy Smith

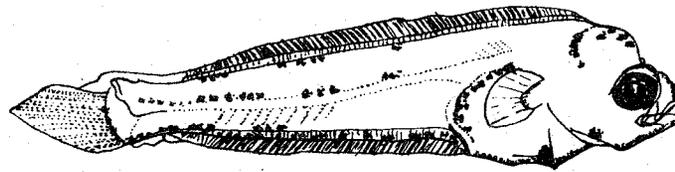
Species No. 30 Limanda ferruginea



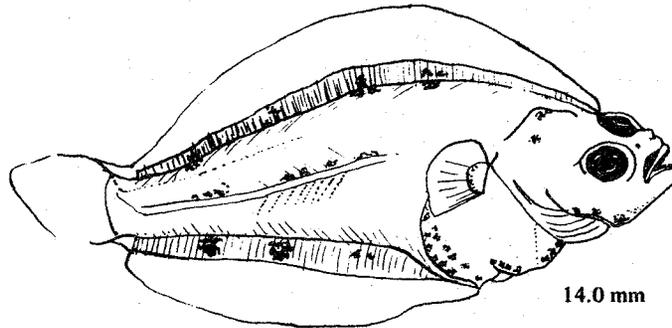
4.1 mm



5.9 mm



10.3 mm



14.0 mm

## PLEURONECTIDAE

Limanda ferruginea (Storer). Yellowtail flounder.

## Adult characteristics:

D. 75-85; A. 56-63;<sup>1</sup> head 4 in SL; depth 2.2 in SL; eyes and color on right side;<sup>2</sup> mouth small; arched lateral line;<sup>3</sup> branchiostegals, in family, 7 (rarely 8).<sup>4</sup>

## Eggs:

Spherical, pelagic,<sup>2</sup> 0.79-1.01 mm diameter.<sup>1</sup>

## Yolk-sac larvae:

Hatch at 2.00-3.52 mm; vent immediately behind yolk-sac; ventral row of postanal pigment spots.<sup>1</sup>

## Postlarvae:

After yolk-sac absorption there are 4 vertical bars of melanophores located postanally; heavy pigment concentrations on dorsal surface of intestine and ventral edge of gut. Caudal rays present at 10 mm. D. and A. fin ray complements complete at 14 mm and left eye has started to migrate to right side. Metamorphosis complete at ca. 14 mm when young yellowtail moves to bottom.<sup>1</sup> (Postlarval yellowtail distinguished from postlarval winter flounder by yellowtail's greater number of D. and A. fin rays and larger size before completing metamorphosis).<sup>1,3</sup>

## Spawning:

Mid-March to August, Cape Sable to Block Island;<sup>1</sup> all summer in Gulf of Maine.<sup>3</sup>

## Distribution:

From north shore of the Gulf of St. Lawrence to lower part Chesapeake Bay.<sup>3</sup>

## References:

1. Colton, J.B., Jr. and R.R. Marak. 1969: 36.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 168.
3. Bigelow, H.B. and W.C. Schroeder. 1953: 271-275.
4. McAllister, D.E. 1968: 132.

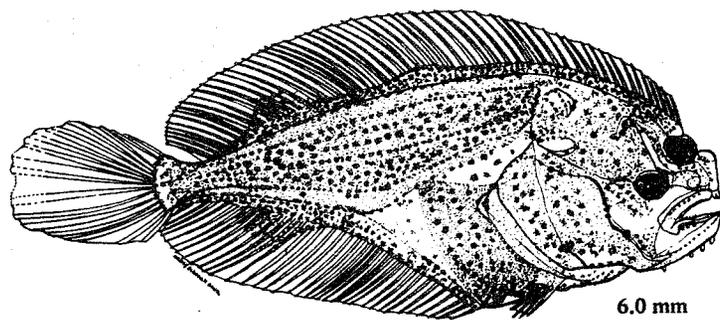
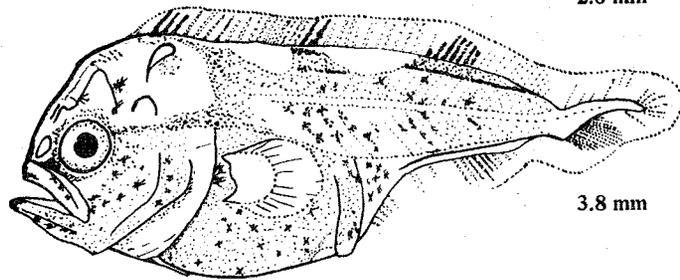
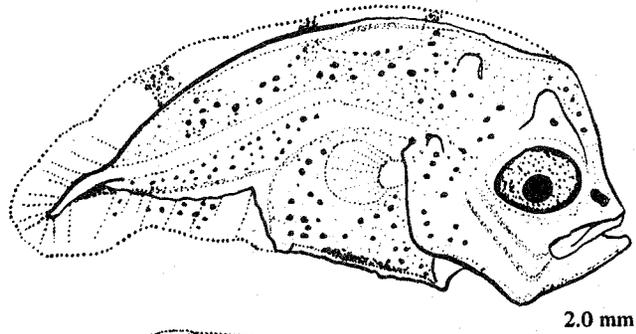
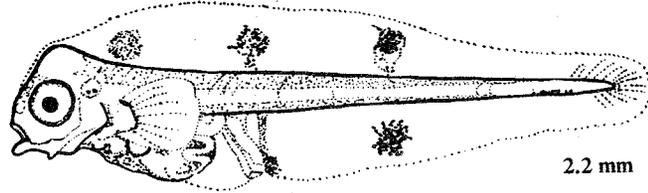
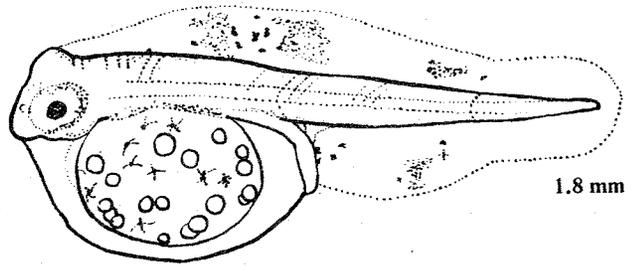
## Other pertinent reference:

Bigelow, H.B. and W.W. Welsh. 1925: 495-500.

## Illustration credits:

4.1 mm, 5.9 mm David Miller, unpublished drawing  
10.3 mm, 14.0 mm Bigelow and Schroeder, 1953

Species No. 31 Trinectes maculatus



## SOLEIDAE

Trinectes maculatus (Bloch and Schneider). Hogchoker.

## Adult characteristics:

D. 50-56; A. 36-42; head 3.45 to 4 in SL; depth 1.6 to 1.95 in SL; eye 5.2 to 7.5 in head; eyes and color on right side.<sup>1</sup>

## Eggs:

Pelagic; range from 0.66 to 0.84 mm in diameter; number of oil globules range from 15-34.<sup>2</sup> In a study on the Patuxent River estuary, Maryland, eggs showed a size-salinity relationship; at 20 ‰ major axis ranged from 0.86 to 0.97 mm and minor axis from 0.86 to 0.90 mm.<sup>3</sup>

## Larval stages:

Newly hatched larvae are 1.7 to 1.9 mm in length; numerous oil globules in yolk sac. By 2.2-2.4 mm, yolk-sac nearly absorbed; pigment concentrations on fin folds; "bump" on head; vent separated from rudimentary stomach. (Pectoral fins are present and remain in larvae until metamorphosis but no traces are found in adults.) After 3 mm the larvae become deep bodied and pigment is scattered about body; at 3.8 mm, rays developed in vertical fins, eyes still symmetrical; depression forms over right eye. In larvae 34 days old (about 5-6 mm SL) left eye beginning to migrate. (No specimens collected between 6 and 18 mm.). By 18 mm, both eyes on right side; pigment on eyed side; pectoral rudiment lost by 25 to 30 mm.<sup>2</sup>

## Spawning:

In late spring and summer in Chesapeake Bay<sup>1</sup> and in Gulf of Maine.<sup>4</sup>  
In Delaware Bay a 6-mm specimen taken on August 25, 1960.

## Distribution:

Off Atlantic and Gulf coasts of North America, from Massachusetts Bay to Atlantic coast of Panama. Rare north of Cape Cod.<sup>4</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 175-177.
2. Hildebrand, S.F. and L.E. Cable. 1938: 632-640.
3. Dovel, W.L., J.A. Mihursky, and A.J. McErlean, 1969: 109-111.
4. Bigelow, H.B. and W.C. Schroeder. 1953: 296-297.

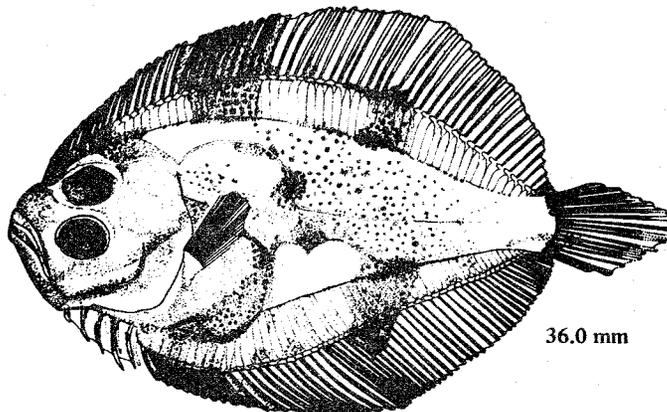
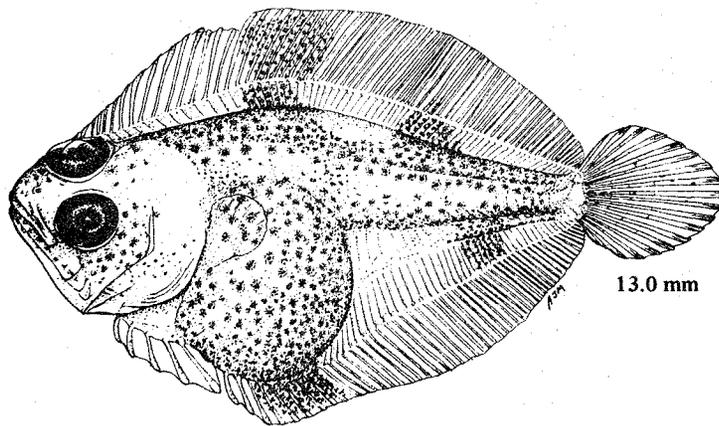
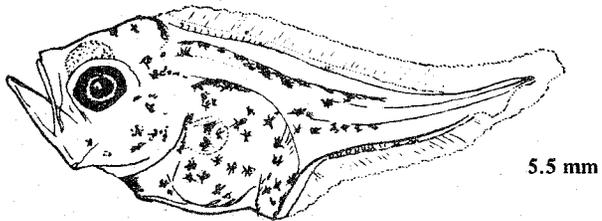
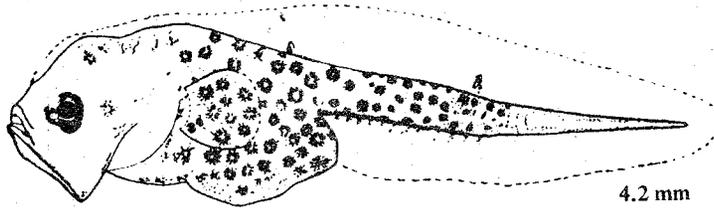
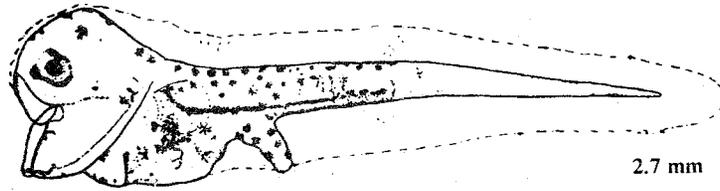
## Other pertinent reference:

Pearson, J.C. 1941: 84.

## Illustration credits:

1.8 mm, 2.2 mm, 2.0 mm, 3.8 mm Hildebrand and Cable, 1938  
6.0 mm Original illustration by Nancy Smith

Species No. 32 Scophthalmus aquosus



## BOTHIDAE

Scophthalmus aquosus (Mitchill). Windowpane.

## Adult characteristics:

D. 63-69; A. 46-52;<sup>1,2</sup> head 2.9<sub>1</sub> to 4.05 in SL; depth 1.45 to 1.8<sub>3</sub> in SL; eye 2.7 to 3.95 in head. Eyes and color on left side.<sup>1,3</sup>

## Eggs:

0.9-1.3 mm in diameter, pelagic, 1 oil globule.<sup>4</sup>

## Yolk-sac larvae:

Hatching length about 2 mm; heavy pigment<sub>4</sub> from behind head to midlength, remainder of tail unpigmented.

## Postlarvae:

Deep bodied; pigmentation similar to that of yolk-sac larvae; eye begins to move to left side at about 6.5 mm; migration of eye nearly complete at about 13 mm. D. and A. fin elements complete and ventral fins formed at about 8.5 mm. Late postlarval and adult windowpane separable from all other Bothidae due to left ventral fin being as wide at the base as it is at the tip.<sup>3,4</sup>

## Spawning:

May-August from Cape Sable to Block Island;<sup>4</sup> late spring and summer in Gulf of Maine;<sup>3</sup> may occur much earlier in Chesapeake Bay.<sup>1</sup> In Delaware Bay, three larvae ranging from 3-8 mm were collected from May 31-August 4, 1960.

## Distribution:

Coastal waters of eastern North America from the Gulf of St. Lawrence to South Carolina.<sup>2</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 171.
2. Bigelow, H.B. and W.C. Schroeder. 1953: 290-293.
3. Bigelow, H.B. and W.W. Welsh. 1925: 516-520.
4. Colton, J.B., Jr., and R.R. Marak. 1969: 33.

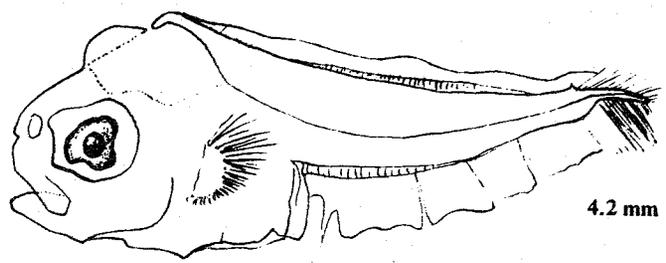
## Other pertinent reference:

Perlmutter, A. 1939.

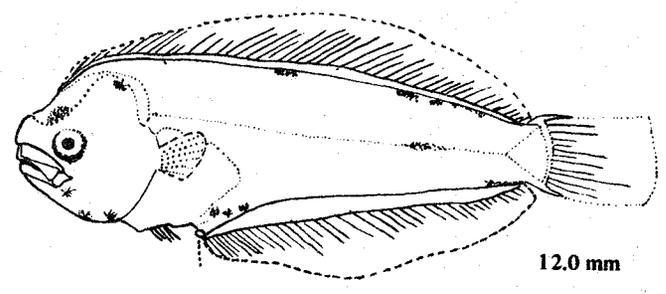
## Illustration credits:

2.7 mm, 4.2 mm, 5.5 mm Unknown  
 13.0 mm Alice J. Mansueti, unpublished drawing  
 36.0 mm Original Illustration by Nancy Smith

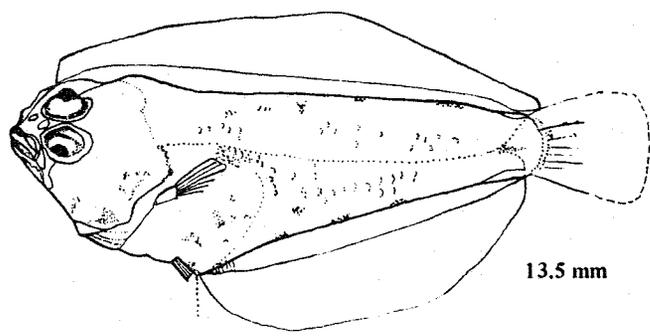
Species No. 33 Etropus microstomus



4.2 mm



12.0 mm



13.5 mm

## BOTHIDAE

Etropus microstomus (Gill). Smallmouth flounder.

## Adult characteristics:

D. 67-82; A. 50-63; depth 43-51 percent SL; head 21 to 27 percent SL; eye about 6 in head;<sup>1</sup> eyes and color on left side;<sup>2</sup> vertebrae 10+24 or 25.<sup>1</sup>

## Eggs:

## Larval stages:

Specimens identified as Etropus sp. and ranging in length from 2.5 to 13 mm were collected in July, 1929, in lower Chesapeake Bay.<sup>3</sup>

## Spawning:

Delaware Bay, larvae 4 mm - 8 mm collected August 2 to September 7, 1960.

## Distribution:

From Long Island, N.Y., to Virginia<sup>2</sup> or from N.C. to Mississippi<sup>1</sup>.

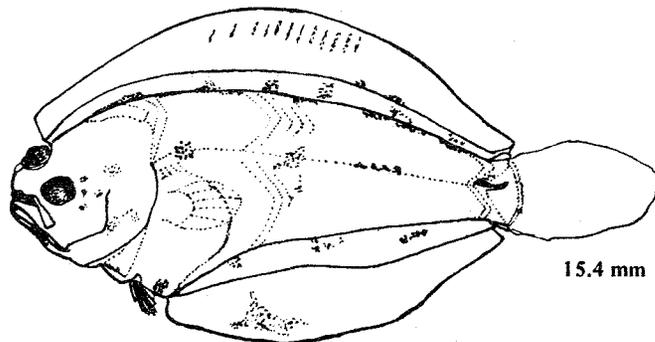
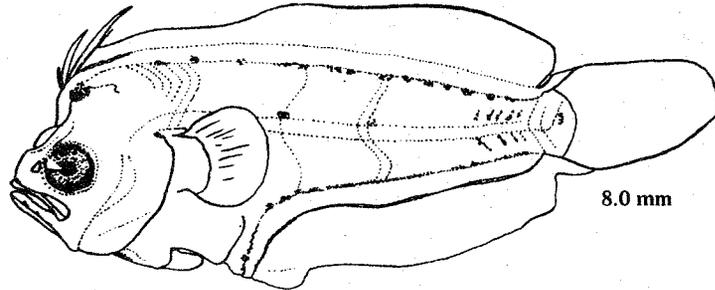
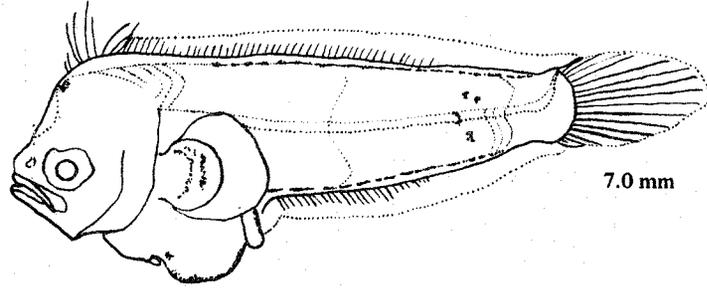
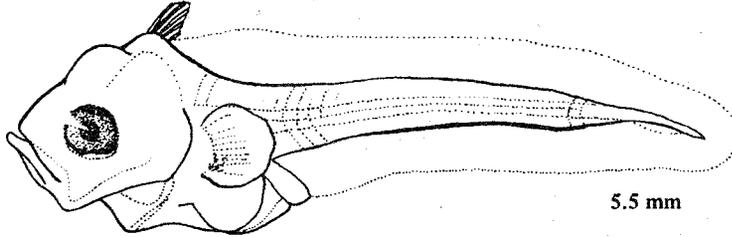
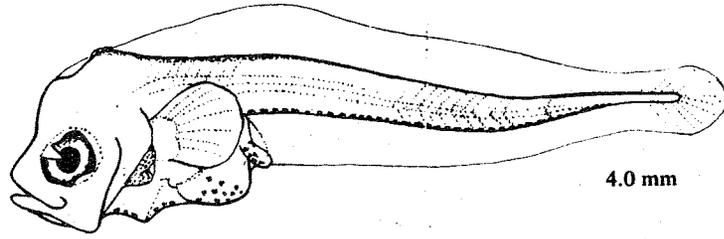
## References:

1. Gutherz, E.J. 1967: 28.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 172-173.
3. Pearson, J.C. 1941: 83.

## Illustration credits:

4.2 mm, 12.0 mm, 13.5 mm Original illustrations by Nancy Smith

Species No. 34 Paralichthys (?) dentatus



## BOTHIDAE

Paralichthys (?)dentatus (Linnaeus). Summer flounder.

## Adult characteristics:

D. 80-96; A. 61-73; vertebrae, 11+30 or 31; depth 41-47 percent SL; head 24-33 percent SL; eye 15-20 percent head.<sup>1</sup> Eyes and color on left side.<sup>2</sup>

## Eggs:

Pelagic, 1 oil globule; 0.93-1.13 mm diameter; egg capsule thick (1/40 total egg diameter).<sup>3</sup>

## Larval stages:

Note--the illustrations used for specimens 4.0-8.0 mm are taken from Hildebrand and Cable, 1930, where they are identified as Paralichthys sp.;<sup>4</sup> recent research indicates these larvae are probably P. lethostigma or P. albigutta.<sup>5</sup>

## Yolk-sac larvae:

Average hatching length, 3.1 mm; vent is located about halfway between snout and tip of tail;<sup>3,5</sup> at about 3 mm pigment is scattered and faint,<sup>3</sup> caudal finfold unpigmented except for melanophores at its base;<sup>5</sup> at slightly larger size pigment spots more numerous and larger.<sup>3</sup>

## Postlarvae:

At the time of yolk-sac absorption, i.e., 3.4 mm to about 8 mm, there are pigment spots on the dorsal and ventral finfolds and along the dorsal and ventral edge of the trunk and tail. In larvae 8 mm to 9.5 mm, there is a row of 7 to 9 melanophores along the lateral line and small spots along the ventral edge of the head and gut.<sup>3,5</sup> Right eye begins to move to the left side about 9.5 mm SL and can be seen over the dorsal edge of the skull at about 12 mm SL.<sup>5</sup> By 12.1 mm<sup>5</sup> to 14mm<sup>3</sup> the full complement of fin rays are present; from this size on, the dorsal fin ray number serves to separate P. dentatus from P. oblongus, the fourspot (D. 71-86).<sup>3</sup> Postlarval pigmentation along the D. and A. fins does not appear to be a consistent characteristic: the "well-defined" band of black pigment along the border of the anterior 4/5 of the D. and anterior 2/3 of the A. in specimens 9-15 mm SL<sup>6</sup> was not present in postlarvae from Cape Sable to Block Island,<sup>3</sup> and was not evident presumably until the D. and A. rays were formed, i.e., at about 12 mm, in another study.<sup>5</sup>



Paralichthys (?)dentatus (Cont.)

## Spawning:

Mid-October to mid-April from Cape Sable to Block Island,<sup>3</sup>  
 spawns in the winter in Chesapeake Bay, perhaps in deep water.<sup>2</sup>  
 In Delaware Bay a 16-mm specimen was collected on Feb. 10, 1960.  
 "The larvae, during winter and early spring, drift into Delaware  
 (Bay) waters."<sup>7</sup>

## Distribution:

From Maine to South Carolina, possibly to Florida<sup>8</sup> (P.  
lethostigma and P. albigutta do not range beyond North Carolina).<sup>5</sup>

## References:

1. Guthertz, E. 1967: 9.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 165.
3. Colton, J.B., Jr. and R.R. Marak. 1969: 31.
4. Hildebrand, S.F. and L.E. Cable. 1930: 471-474.
5. Smith, W.G. and M.P. Fahay. 1970: 21 pp.
6. Deubler, E.E., Jr. 1958: 112-116.
7. de Sylva, D.P., F.A. Kalber, Jr., and C.N. Shuster, Jr.  
1962: 42.
8. Bigelow, H.B. and W.C. Schroeder. 1953: 269.

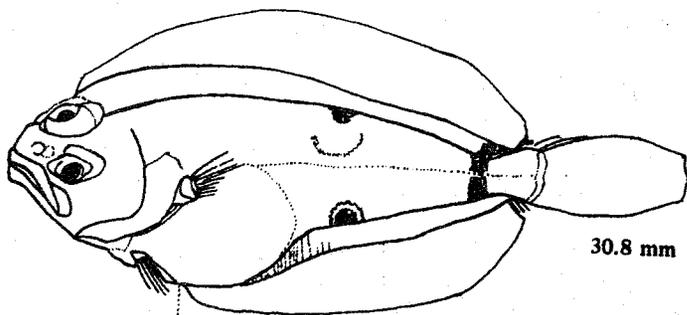
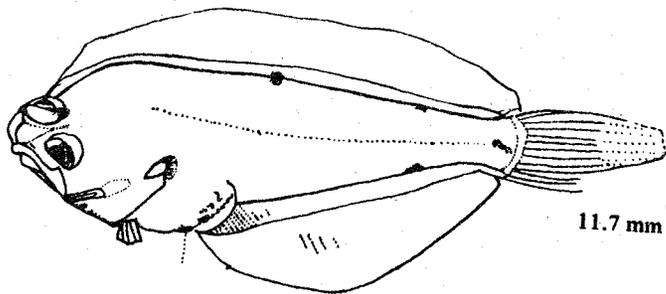
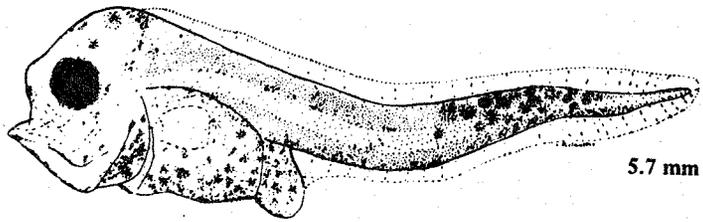
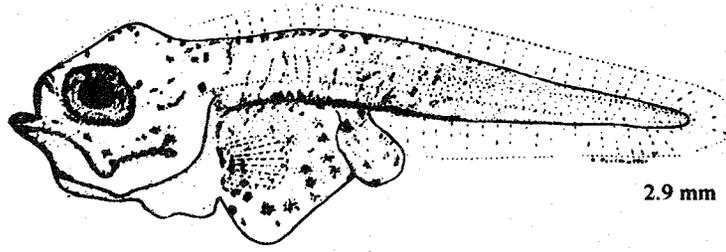
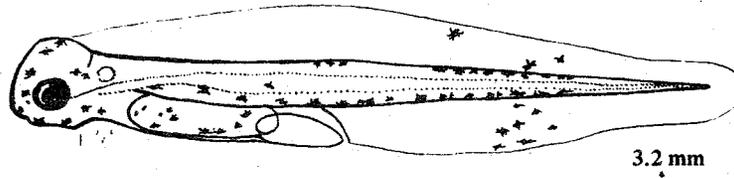
## Other pertinent references:

Woolcott, W.S., C. Beirne, and W.M. Hall, Jr. 1968: 109-120.  
 Smith, R.W. 1969: 72 pp.

## Illustration credits:

4.0 mm, 5.5 mm, 7.0 mm, 8.0 mm Hildebrand and Cable, 1930  
 15.4 mm Original illustration by Nancy Smith

Species No. 35 Paralichthys oblongus



## BOTHIDAE

Paralichthys oblongus (Mitchill). Fourspot flounder.  
(Also referred to as Hippoglossina oblonga)<sup>1,2</sup>

## Adult characteristics:

D. 71-86; A. 58-72; vertebrae 11+30 or 31; depth, 38-44 percent SL; head, 25-29 percent SL; eye, 25-30 percent in head. Eyes and color on left side.<sup>1</sup>

## Eggs:

Pelagic; 1 oil globule; 0.91-1.12 mm diameter.<sup>3</sup>

## Larval stages:

(For detailed descriptions and illustrations, see Leonard, 1971).<sup>2</sup>

## Yolk-sac larvae:

Hatching length 2.7-3.2 mm; vent is halfway between the snout and the tail tip; halfway between the vent and the tip of tail is a diffuse band of melanophores extending onto the dorsal and ventral finfolds.<sup>3,4</sup>

## Postlarvae:

By time of yolk-sac absorption, the postanal pigment band is conspicuous<sup>3</sup> and spreads anteriorly and posteriorly.<sup>2</sup> C. fin ray evident by 6 mm; D. and A. fin rays begin to differentiate at about 7 mm, adult complement attained at 9-10 mm and vertebral counts possible.<sup>2</sup> From this size on, the D. fin ray number permits separation of P. oblongus from P. dentatus, (D. 80-96).<sup>2,3</sup> Migration of right eye begins at about 10 mm<sup>2</sup> and at about 25 mm the eye is on the dorsal edge of the snout.<sup>3</sup>

## Spawning:

From May to mid-July off Maine;<sup>5</sup> from May-July at Cape Sable to Block Island.<sup>3</sup>

## Distribution:

From Georges Bank to Tortugas, Florida.<sup>1</sup>

## References:

1. Gutherz, E. 1967: 18.
2. Leonard, S.B. 1971: 676-681.
3. Colton, J.B., Jr., and R.R. Marak. 1969: 32.
4. Miller, D. and R.R. Marak. 1962: 454-455.
5. Bigelow, H.B., and W.C. Schroeder. 1953: 271.

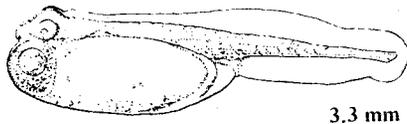
## Other pertinent reference:

Perlmutter, A. 1939: 11-71.

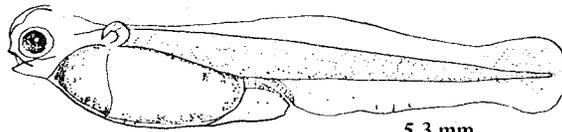
## Illustration credits:

- 3.2 mm Miller and Marak, 1962  
2.9 mm, 5.7 mm Perlmutter, 1939  
11.7 mm, 30.8 mm Original illustrations by Nancy Smith

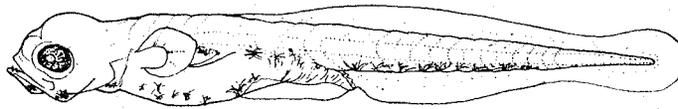
Species No. 36 Morone saxatilis



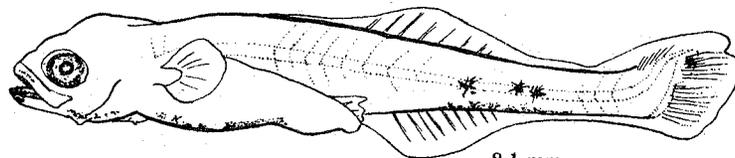
3.3 mm



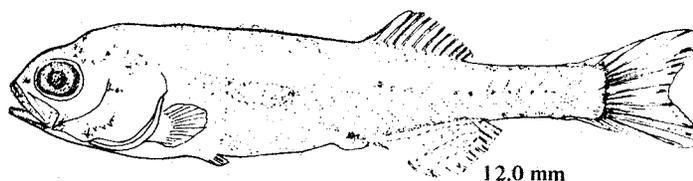
5.3 mm



6.3 mm



8.1 mm



12.0 mm

## PERCICHTHYIDAE

Morone saxatilis (Walbaum). Striped bass.  
(formerly Roccus saxatilis, family Serranidae)

## Adult characteristics:

D. IX or X-I, 11 or 12; A. III, 10 or 11; head 3.1 to 3.25 mm SL; depth 3.45 to 4.2 in SL;<sup>1</sup> side striped.<sup>2</sup>

## Eggs:

Large, pelagic, buoyant, single large oil globule; diameter (fertilized egg) 2.4-3.9 mm.<sup>3</sup>

## Larval stages:

Note--much literature exists on this species; detailed developmental descriptions and illustrations are available.<sup>3,4,5</sup>

Size at hatching, 2.0-3.7 mm; large yolk-sac extends in front of head. At about 5 mm part of yolk absorbed; melanophores along ventral surface. By 7.5 mm, body slender, yolk-sac absorbed; pigmentation on ventral part of body, upper surface of air bladder and visceral mass; teeth visible. At about 10 mm, D. (soft only) and A. fins somewhat differentiated; caudal rays well developed. By 15 mm, fins well formed, except for spinous D. and pelvics. Fish between 9-15 mm possess 2 anal spines; fish greater than 20 mm have 3 anal spines.<sup>3</sup>

## Spawning:

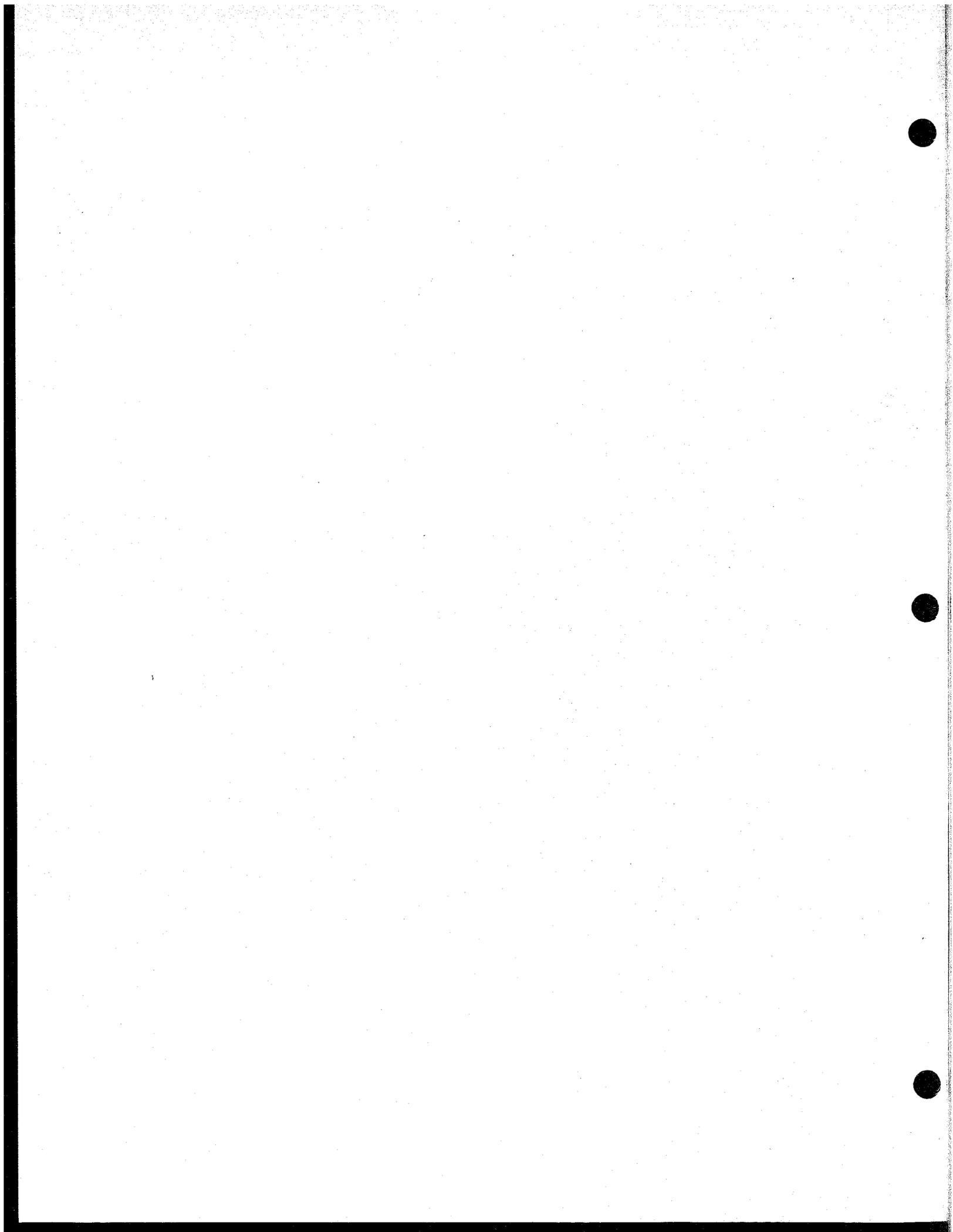
Anadromous; lives in the sea, not far from shore, generally near estuaries; moves into fresh or brackish water to reproduce.<sup>6</sup> In North Carolina from late April-early May; Chesapeake Bay, in May; Gulf of Maine in June.<sup>2</sup> In Delaware Bay, 4-10-mm larvae collected from April 22-May 5, 1960.

## Distribution:

St. Lawrence River to northern Florida<sup>6</sup> and the northern Gulf of Mexico; introduced into California and the U.S.S.R.

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 247.
2. Bigelow, H.B. and W.C. Schroeder. 1953: 389-404.
3. Mansueti, R. 1958: 1-36.



Morone saxatilis (Cont.)

4. Pearson, J.C. 1938: 825-851.
5. Raney, E.C. 1952: 5-97.
6. Breder, C.M., Jr., and D.E. Rosen. 1966: 397.

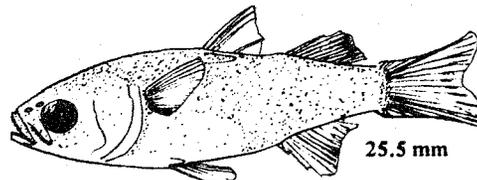
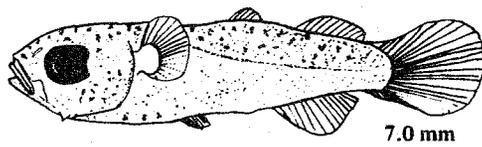
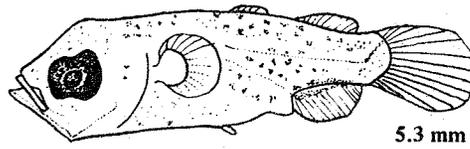
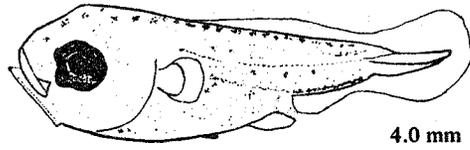
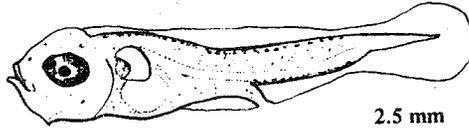
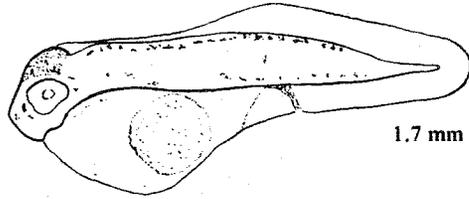
Other pertinent reference:

Dovel, W.L. 1971: 5-6.

Illustration credits:

3.3 mm, 5.3 mm, 6.3 mm, 8.1 mm, 12.0 mm Mansueti, 1958

Species No. 37 Mugil curema



## MUGILIDAE

Mugil curema Valenciennes. White mullet.

## Adult characteristics:

D. IV-I, 8; A. III, 9;<sup>1</sup> (young less than 30-40 mm SL have A. II, 10)<sup>2</sup>; head 3.6-4.1 in SL; depth 3.1-4.75 in SL; eye 3.15-4.35 in head.<sup>1</sup>

## Eggs:

Pelagic, spherical, single oil globule; fertilized eggs 0.86-0.92 mm diameter.<sup>2</sup>

## Yolk-sac larvae:

Newly hatched larvae about 1.7 mm long; ventral and dorsal rows of pigment spots; vent just over halfway back from snout; yolk-sac absorbed at about 2.5-3.5 mm.<sup>2</sup>

## Postlarvae:

Dorsal pigment rows; caudal fin elements present at 4.7 mm TL; spines of 1st D. and soft rays of 2nd D. evident at 5.3 mm. A. rays complete at 5.3 mm, 2 anal spines present at about 14.5 mm (3rd spine develops from first ray at about 30-40 mm -- considered end of larval period). Pigmentation becomes somewhat dense by 7.0 mm SL and by 14.5 mm specimens appear almost black).<sup>2</sup>

## Spawning:

Associated with the outer Continental Shelf and probably occurs from late March until September, with the peak during April, May, and June.<sup>2</sup> In Delaware Bay, 41 specimens 20-30 mm long collected in December, 1959;<sup>3</sup> 1 specimen 33 mm long collected on June 18, 1960.

## Distribution:

On the Atlantic coast from Cape Cod to South America; on Pacific coast from Chile to Gulf of California.<sup>2</sup>

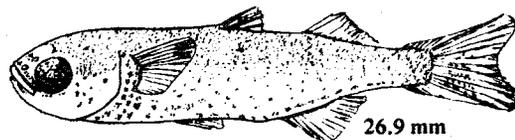
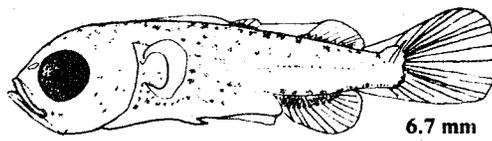
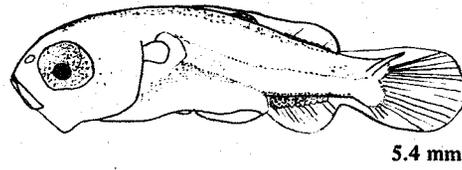
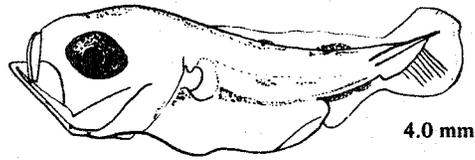
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 196-197.
2. Anderson, W.W. 1957: 397-414.
3. de Sylva, D.P., F.A. Kalber, Jr., and C.N. Shuster, Jr. 1962: 41.

## Illustration credits:

1.7 mm, 2.5 mm, 4.0 mm, 5.3 mm, 7.0 mm, 25.5 mm Anderson, 1957

Species No. 38 Mugil cephalus



## MUGILIDAE

Mugil cephalus Linnaeus. Striped mullet.

## Adult characteristics:

D. IV-I, 8; A. III, 8 (young less than 35-45 mm SL have II, 9); head 3.3-4.5 in SL; depth 3.3-3.75 in SL; eye 3.3-4.2 in head. Dark longitudinal lines along rows of scales.<sup>1</sup>

## Eggs:

Average 0.72 mm diameter; eggs collected in the Mediterranean "floated for a short time and then sank."<sup>2</sup>

## Larval stages:

(Smallest specimen described is 4.0 mm;<sup>3</sup> however, larvae as small as 2.4 mm have been identified from southern Biscayne Bay, Florida.)<sup>4</sup> At 4.0 mm, 7 caudal rays present; full complement principal caudal rays present at 5.4 mm and secondary caudal rays by 9.7 mm; D. rays evident at 4.0 mm; by 6.7 mm, spines of 1st D. and rays of second D. easily counted. By 5.4 mm full complement of anal rays present. End of larval period recognized as time of formation of 3rd anal spine; occurs between 35-45 mm SL.<sup>3</sup>

## Spawning:

From North Carolina to lower Florida from October to February, with the peak in December.<sup>3</sup> In Delaware Bay, specimens 20-30 mm taken during summer.<sup>5</sup>

## Distribution:

Warm waters of both hemispheres; on Atlantic coast from Cape Cod to Brazil.<sup>1,3</sup>

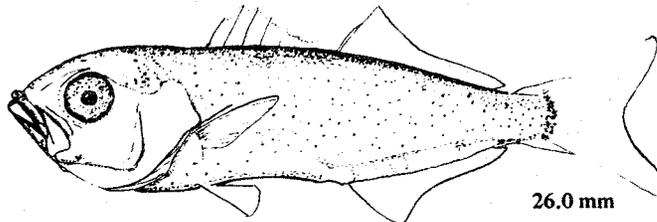
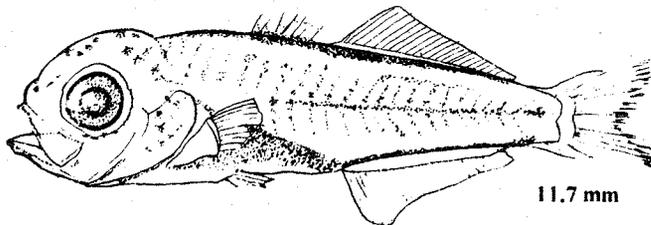
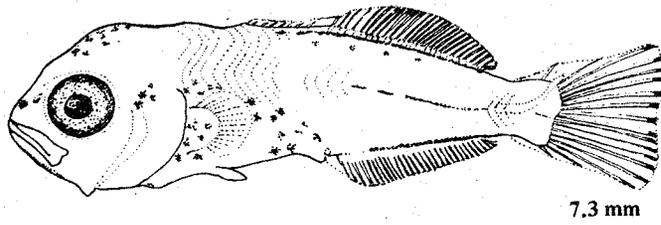
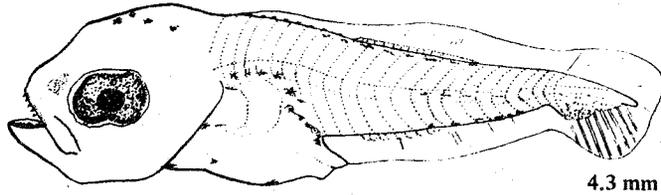
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 193-196.
2. Breder, C.M., Jr., and D.E. Rosen. 1966: 367.
3. Anderson, W.W. 1958: 501-519.
4. de Sylva, D.P. 1970: 198 pp.
5. de Sylva, D.P., F.A. Kalber, Jr., and C.N. Shuster, Jr. 1962: 40.

## Illustration credits:

4.0 mm, 5.4 mm, 6.7 mm, 26.9 mm Anderson, 1958

Species No. 39 Pomatomus saltatrix



## POMATOMIDAE

Pomatomus saltatrix (Linnaeus). Bluefish.

## Adult characteristics:

D. VIII-I, 23 to 26; A. II-I, 25 to 27; head, 3.1-3.4 in SL; depth, 3.1-3.55 in SL; eye 4.4-5.6 in head.<sup>1</sup>

## Eggs:

Believed to have been identified from Newport, R.I., as pelagic, large oil globule.<sup>2</sup> Early stages of the fertilized eggs illustrated.<sup>3,4</sup>

## Larval stages:

At 4.3 mm, the caudal, D., and A. slightly differentiated; yolk-sac absent; 3 series of black pigment dashes occur on body -- dorsal, median and ventral; pigment on top of head and gut; teeth present and diagnostic. By 7.3 mm, the fin rays are differentiated. At 26 mm, spinous dorsal further developed; fine dots on entire body; caudal forked.<sup>5</sup>

## Spawning:

Spawns in the spring and early summer off New York<sup>4</sup> and near Chesapeake Bay.<sup>6</sup> Spawning may occur in southern portion of Chesapeake Bay with larvae being carried northward by currents.<sup>3</sup> In Delaware Bay, 3 larvae 5-11.7 mm taken from July-August, 1960. Off Indian River Inlet, Delaware, ripe females were obtained during August, 1958; 4-mm larva were collected off Ocean City, Maryland.<sup>7</sup>

## Distribution:

From Nova Scotia to Brazil and Argentina.<sup>6</sup>

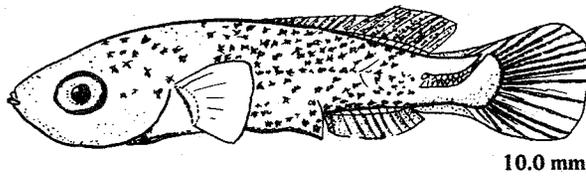
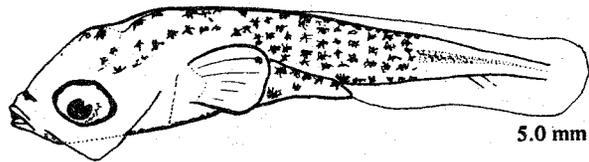
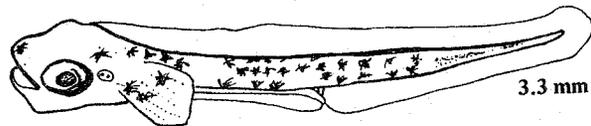
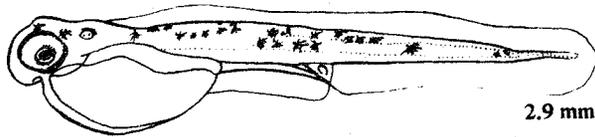
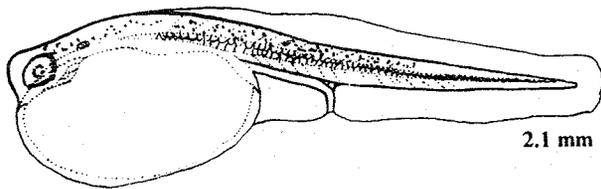
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 231-234.
2. Agassiz, A. and C.O. Whitman. 1885: 56 pp.
3. Perlmutter, A. 1939: 23-24.
4. Breder, C.M., Jr., and D.E. Rosen. 1966: 455-456.
5. Pearson, J.C. 1941: 89-90.
6. Bigelow, H.B. and W.C. Schroeder. 1953: 383-389.
7. de Sylva, D.P., F.A. Kalber, Jr., and C.N. Shuster, Jr. 1962: 31.

## Illustration credits:

4.3 mm, 7.3 mm, 11.7 mm, 26.0 mm Pearson, 1941

Species No. 40 Tautoga onitis



## LABRIDAE

Tautoga onitis (Linnaeus). Tautog.

## Adult characteristics:

D. XVI or XVII, 10; A. III, 7 or 8; head, 3.25-3.56 in SL; depth, 2.55-2.95 in SL; eye, 3.05-6 in head.<sup>1</sup>

## Eggs:

Pelagic; no oil globule; spherical;<sup>2</sup> 0.89-1.15 mm diameter.<sup>3</sup>

## Yolk-sac larvae:

Newly hatched larvae approximately 2.2 mm;<sup>2</sup> melanophores confined to dorsal and dorso-lateral portions of body; caudal region unpigmented (in cunner larvae pigment extends to tail); vent halfway between snout and tip of tail; in the first day number of melanophores greatly increases.<sup>3</sup>

## Postlarvae:

Most of body covered with pigment;<sup>3</sup> caudal fin begins to appear at 5 mm;<sup>4</sup> D. and A. and caudal differentiated at 10 mm.<sup>3,4</sup> Adult morphology obtained at about 30 mm. (Larvae of T. onitis distinguished from cunner larvae by the uniformly scattered black pigment on the body of T. onitis, whereas pigment on the cunner is concentrated in three definite patches).<sup>4</sup>

## Spawning:

Mid-May to mid-July from Cape Sable to Block Island;<sup>3</sup> in June and July near Woods Hole.<sup>2</sup> In Delaware Bay, 3 specimens 6-10 mm were taken in June, 1960.

## Distribution:

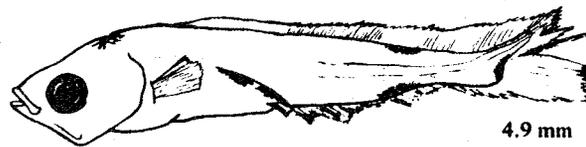
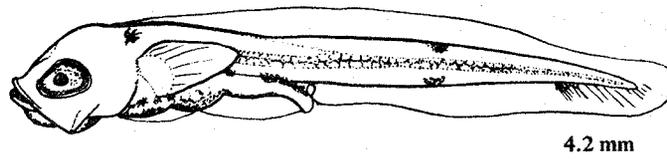
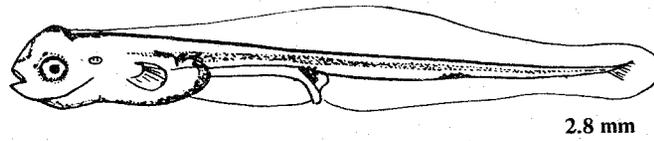
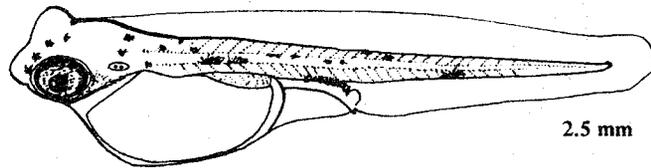
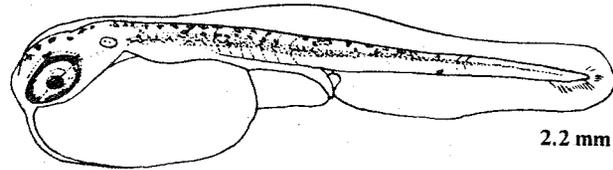
Nova Scotia to South Carolina.<sup>4</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 318-320.
2. Kuntz, A. and L. Radcliffe. 1917: 92-99.
3. Colton, J.B., Jr., and R.R. Marak. 1969: 22.
4. Bigelow, H.B. and W.C. Schroeder. 1953: 478-484.

## Illustration credits:

2.1 mm, 3.3 mm Kuntz and Radcliffe, 1917  
2.9 mm, 5.0 mm, 10.0 mm Bigelow and Schroeder, 1953

Species No. 41 Tautogolabrus adspersus

## LABRIDAE

Tautogolabrus adpersus (Walbaum). Cunner.

## Adult characteristics:

D. XVIII, 9<sup>1</sup> or 10;<sup>2</sup> A. III, 18<sup>1</sup> or 9;<sup>2</sup> head 3.45 in SL; depth 3.45 in SL; eye 2.8 in head.<sup>1</sup> Cunner distinguished from similar appearing Tautoga onitis by more pointed head and snout of the cunner.<sup>2</sup>

## Eggs:

Pelagic, spherical, no oil globule;<sup>3,4</sup> 0.78-0.97 mm diameter<sup>3</sup> (also reported as 0.75-0.85 mm).<sup>5</sup>

## Yolk-sac larvae

Newly hatched larvae 2-2.2 mm;<sup>4</sup> melanophores confined to dorsal and dorso-lateral regions of body and extend to the tail (in the tautog, caudal region is unpigmented; vent halfway between snout and tip of tail. Pigment soon aggregates into three patches -- one at vent, one midway between vent and tip of tail and one near tail tip.<sup>3</sup> Yolk-sac absorbed at about 2.8 to 3 mm.<sup>4</sup>

## Postlarvae:

Pigmentation consists of a band over the gut, single spot on back of head, dorso-ventral pair of melanophores half-way between vent and tip of tail, and spot on ventral side of tip of tail; this pattern continues to about 8 mm; at this size D., A., and caudal fin rays well differentiated.<sup>3,4</sup> At 15 mm young cunner displays practically adult form.<sup>5</sup>

## Spawning:

May-August from Cape Sable to Block Island,<sup>3</sup> June-August in Gulf of Maine,<sup>5</sup> and Chesapeake Bay.<sup>1</sup> Delaware Bay 1 specimen 6-mm collected on July 26, 1960.

## Distribution:

Labrador to Virginia, rare south of New Jersey.<sup>1</sup>

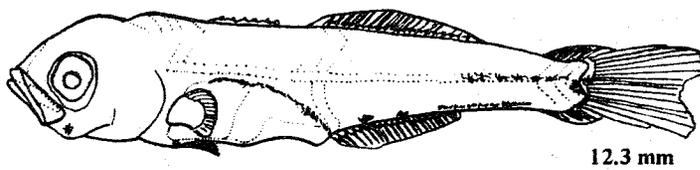
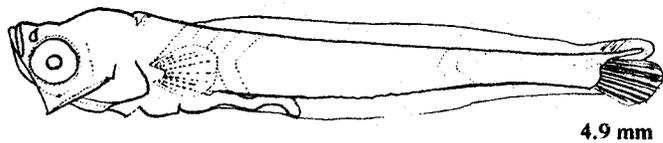
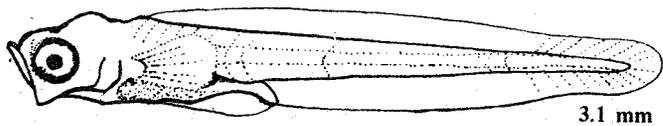
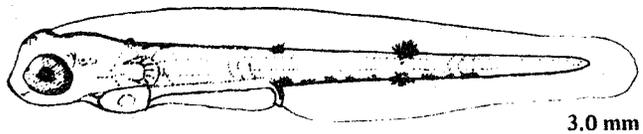
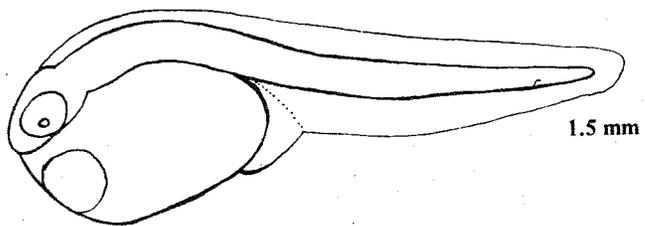
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 320-321.
2. Bigelow, H.B. and W.C. Schroeder. 1953: 473-478.
3. Colton, J.B., Jr., and R.R. Marak. 1969: 23.
4. Kuntz, A. and L. Radcliffe. 1917: 99-102.
5. Bigelow, H.B. and W.W. Welsh. 1925: 281-286.

## Illustration credits:

2.2 mm, 2.5 mm, 2.8 mm, 4.2 mm Bigelow and Welsh, 1925  
4.9 mm Original illustration by Nancy Smith

Species No. 42 Orthopristis chrysoptera



## POMADASYIDAE

Orthopristis chryoptera (Linnaeus). Pigfish.

## Adult characteristics:

D. XIII, 15 to 17; A. III, 12 or 13; head<sup>1</sup> 2.7-3.05 in SL; depth 2.3-2.65 in SL; eye 3.65-5 in head.<sup>1</sup>

## Eggs:

Pelagic, spherical, 1 oil globule; 0.7-0.8 mm diameter.<sup>2</sup>

## Larval stages:

Newly hatched larvae are about 1.5 mm; oil globule lies in the anterior part of the yolk-sac; no prominent pigmentation. At about 2.5-3 mm some specimens have pigment spots dorso-ventrally above the vent and at mid-caudal length; preserved specimens greater than 3 mm show no pigment and no yolk; vent located in advance of midbody length. At about 5 mm the caudal fin becomes evident. D. and A. fins begin to differentiate at 6.7 mm; by 10 mm the soft D., A., and caudal are fairly complete. Spinous D. begins to appear at 11 mm and has 10 well-developed spines at 17 mm. At 15 mm, a lateral band of dark pigment forms; also pigment on head and dorsal portion of body.<sup>2</sup>

## Spawning:

Off Beaufort, N. C., from mid-March to late June, peak in May;<sup>2</sup> in the spring in Chesapeake Bay.<sup>1</sup> In Delaware Bay five specimens 12 mm taken in July, 1960.

## Distribution:

From New York to Mexico.<sup>2</sup>

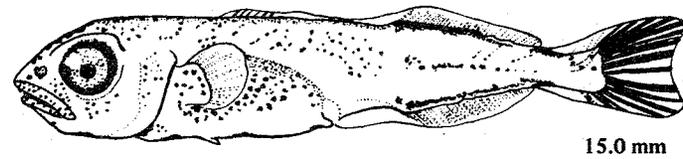
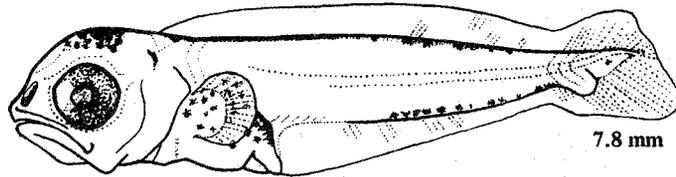
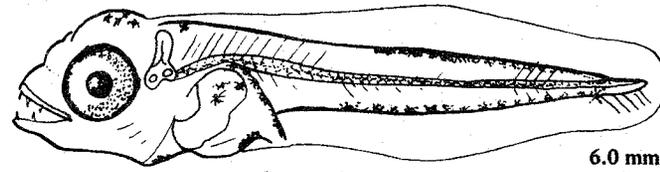
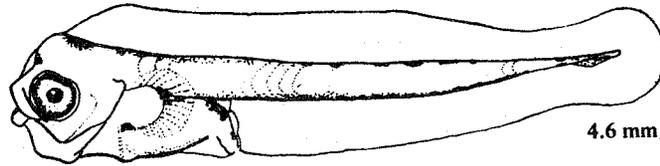
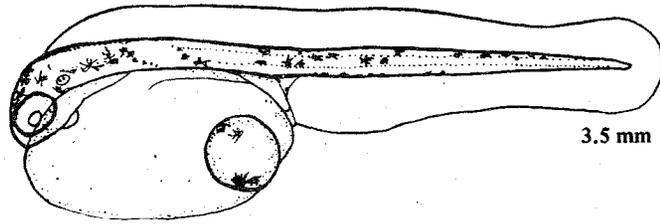
## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 258-260.
2. Hildebrand, S.F. and L.E. Cable. 1930: 395-411.

## Illustration credits:

1.5 mm, 3.0 mm, 3.1 mm, 4.9 mm Hildebrand and Cable, 1930  
12.3 mm Original illustration by Nancy Smith

Species No. 43 Scomber scombrus



## SCOMBRIDAE

Scomber scombrus Linnaeus. Atlantic mackerel.

## Adult characteristics:

D. X to XIV (usually XI, XII or XIII) - 9 to 15 (usually 12)  
- V (sometimes IV or VI finlets);<sup>1</sup> A. I, 11 or 12 - V (finlets);  
head 3.6-3.8 in SL; depth 5.65-6 in SL; eye 4.75-5.55 in head.

## Eggs:

Pelagic, spherical, 1 oil globule (pigmented pale yellow);  
0.98-1.37 mm.<sup>3</sup>

## Yolk-sac larvae:

Newly hatched larvae 2.46-3.83 mm;<sup>3</sup> large yolk-sac with a  
conspicuous pigmented oil globule;<sup>1,3</sup> vent opens at the  
margin of the finfold;<sup>3</sup> black pigment cells scattered  
over head and trunk.<sup>1,3</sup>

## Postlarvae:

By 6 mm, yolk-sac is absorbed, teeth are visible, and caudal rays,<sup>1</sup>  
are beginning to form; at 9 mm second D., and A. rays are formed;<sup>1</sup>  
first D. present at about 12 mm<sup>3</sup> or 14-15 mm. By 15 mm pigment is  
scattered over body; D. and A. finlets present at about 22 mm.<sup>1</sup>

## Spawning:

May-July from Cape Sable to Block Island;<sup>3</sup> in spring and early  
summer off the American coast.<sup>4</sup> In Delaware Bay, two larvae 4-5  
mm collected June-July, 1960.

## Distribution:

Both sides of the North Atlantic; in western North Atlantic from  
Gulf St. Lawrence to North Carolina.<sup>1</sup>

## References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 317-333.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 201-202.
3. Colton, J.B., Jr., and R.R. Marak. 1969: 24.
4. Sette, O.E. 1943: 149-237.

## Other pertinent reference:

Bigelow, H.B. and W.W. Welsh. 1925: 188-208.

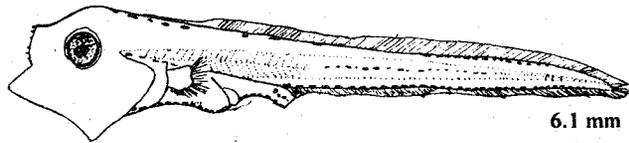
## Illustration credits:

6.0 mm Bigelow and Welsh, 1925  
3.5 mm, 4.6 mm, 7.8 mm, 15.0 mm Bigelow and Schroeder. 1953

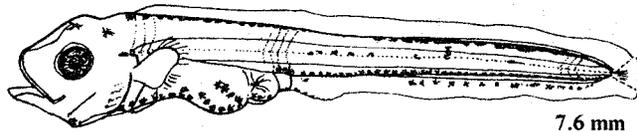
Species No. 44 Rissola marginata



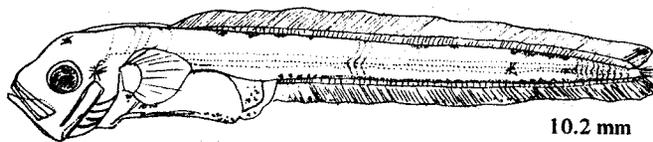
3.8 mm



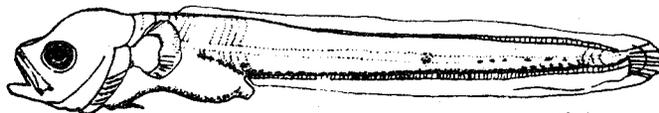
6.1 mm



7.6 mm



10.2 mm



13.5 mm

## OPHIDIIDAE

Rissola marginata (DeKay). Striped cusk-eel.

## Adult characteristics:

D. and A. fins long, low, continuous with round caudal; origin of dorsal about over middle of pectorals; origin of anal posterior to beginning of second 1/3 of body. Ventral fins inserted below vertical from middle of eye; consisting of 2 filaments. Head 5.95-6.15 in SL; depth 7.3-8.2 in SL.<sup>1</sup>

## Eggs:

## Larval stages:

## Spawning:

In Delaware Bay, five young, 5.8 mm-13.5 mm collected from August 20-September 7, 1960.

## Distribution:

New York to Texas.<sup>1</sup>

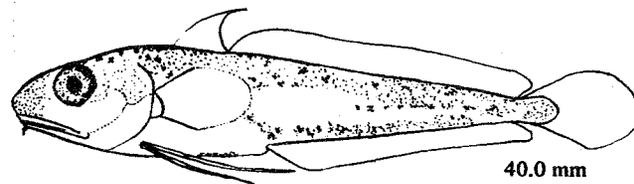
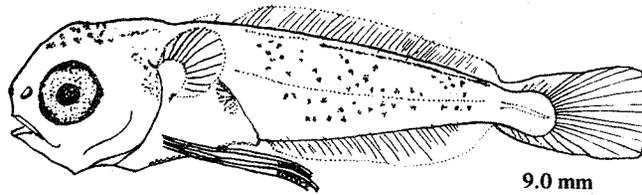
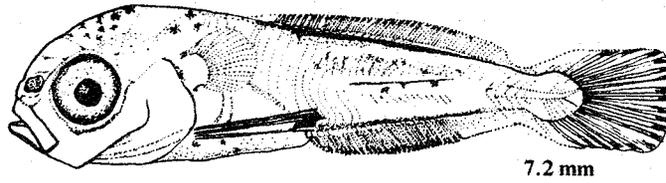
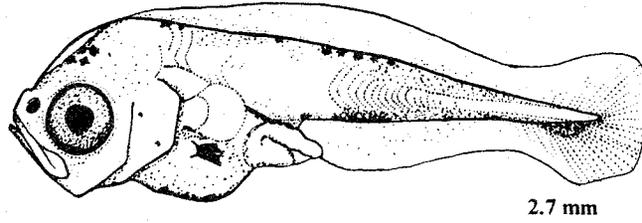
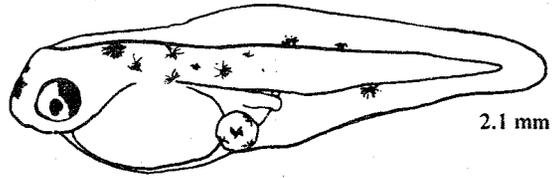
## References:

1. Hildebrand, S. F. and W. C. Schroeder. 1928: 336-337.

## Illustration credits:

3.8 mm, 6.1 mm, 7.6 mm, 10.2 mm, 13.5 mm Original illustrations  
by Nancy Smith

Species No. 45 Urophycis chuss



## GADIDAE

Urophycis chuss (Walbaum). Red hake (previously squirrel hake).

## Adult characteristics:

D. 9 to 11-56 to 61; A. 52-56; head 4.25-4.5 in SL; depth 4.8-5.05 in SL; eye 2.55-3.54 in head. Third ray of 1st D.<sup>2</sup> long, filamentous.<sup>1</sup> Maxillary extends to rear edge of pupil.<sup>2</sup>

## Eggs:

Pelagic, spherical, numerous oil globules;<sup>3,4</sup> eggs 0.15-0.22 mm diameter.<sup>3</sup>

## Larval stages:

Newly hatched larvae 1.76-2.29 mm; vent opens laterally at the base of the finfold;<sup>3</sup> large pigment spots present mainly along dorsal and ventral outline, and on top of head; oil globule conspicuously pigmented.<sup>3,4</sup> Yolk-sac absorbed at about 2.2 mm; a single melanophore on the nape, dorso-ventral pair midway back on body, and the dorsal surface of gut is pigmented; this pattern persists until about 6 mm; then pigment becomes scattered.<sup>3</sup> Second D. and A. rays evident by about 7 mm; pelvic fins begin to develop at about 2.75 mm and the distal parts are colored black.<sup>4</sup>

## Spawning:

May-August from Cape Sable to Block Island.<sup>3</sup>

## Distribution:

Gulf of St. Lawrence to Chesapeake Bay.<sup>2</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 159-160.
2. Bigelow, H.B. and W.C. Schroeder. 1953: 223-230.
3. Colton, J.B., Jr., and R.R. Marak. 1969: 20.
4. Hildebrand, S.F. and L.E. Cable. 1938: 612-627.

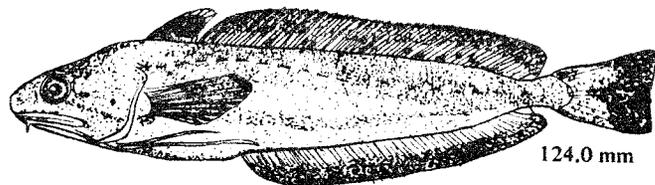
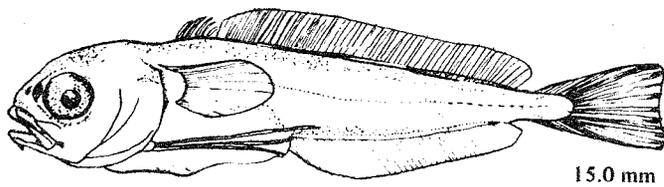
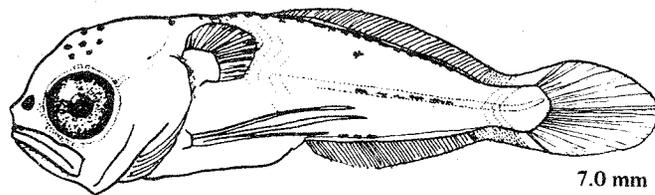
## Other pertinent reference:

Miller, D. and R.R. Marak. 1959: 248-250.

## Illustration credits:

2.1 mm Miller and Marak, 1959  
 2.7 mm, 7.2 mm Hildebrand and Cable, 1938  
 9.0 mm, 40.0 mm Bigelow and Schroeder, 1953

Species No. 46 Urophycis regius



## GADIDAE

Urophycis regius (Walbaum). Spotted hake.

## Adult characteristics:

D. 8 or 9 - 46-51; A. 43-49; head 3.85-4.4 in SL; depth 3.9-5.05 in SL; eye 2.9-4.6 in head. 1st dorsal fin has no extended rays.<sup>1</sup>

## Eggs:

## Larval stages:

Believed to be similar in development to U. chuss (see comparison by Hildebrand and Cable).<sup>2</sup> 4-mm larvae lack pigment on the pelvic fins and have no chromatophores at the base of the anal. At about 5 mm the body is deep and compressed; mouth oblique; pelvic rays<sub>2</sub> reach beyond vent. By 7 mm the 2nd D. and A. rays are differentiated.

## Spawning:

Off Beaufort, North Carolina, from November-December.<sup>2</sup> Spawns in the winter.

## Distribution:

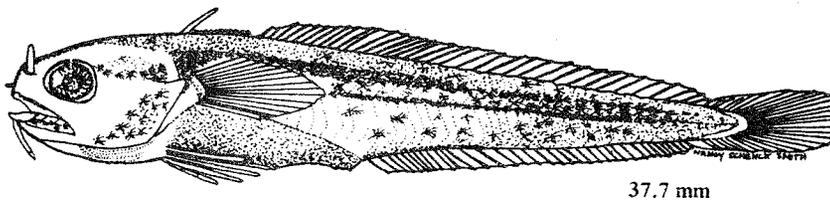
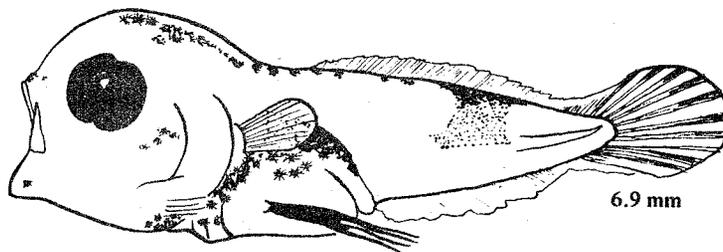
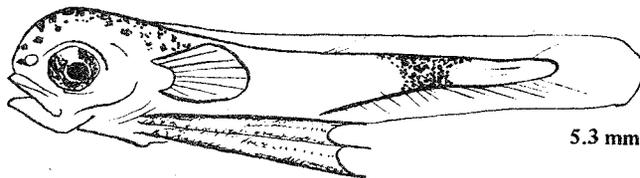
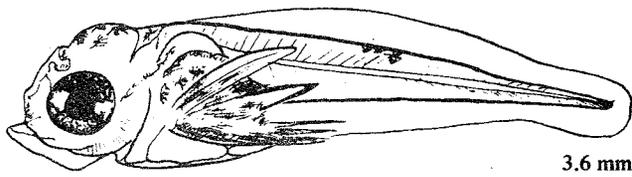
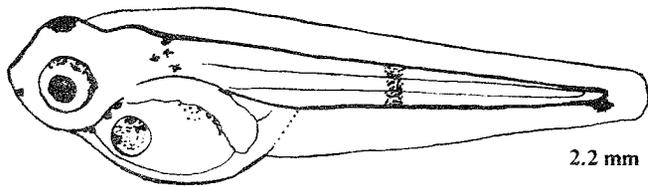
Nova Scotia to South Carolina.<sup>1</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 160-162.
2. Hildebrand, S.F. and L.E. Cable. 1938: 612-629.
3. Breder, C.M., Jr., and D.E. Rosen. 1966: 382.

## Illustration credits:

7.0 mm, 15.0 mm, 124.0 mm Hildebrand and Cable, 1938

Species No. 47 Enchelyopus cimbricus

## GADIDAE

Enchelyopus cimbrius (Linnaeus). Fourbeard rockling.

## Adult characteristics:

D. 1 - 45 to 53; A. 39 to 43; a pair of barbels in front of nostrils; barbel on tip of snout; barbel on chin.<sup>1</sup>

## Eggs:

Pelagic; 0.66-0.98 mm diameter.<sup>1</sup>

## Larval stages:

Newly hatched larvae 1.63-2.42 mm;<sup>2</sup> pigment on tip of snout, dorsal portion of head, along the intestine and A., vertical band midway back on tail. Yolk is absorbed at 3.6 mm; from this size to about 10 mm larvae characterized by large black pelvics,<sup>1</sup> with individual rays connected by fin membrane,<sup>2</sup> one post anal band of pigment and by short stocky body. By 17-20 mm the structure of the 1st D. enables identification.<sup>1</sup>

## Spawning:

April-August from Cape Sable to Block Island;<sup>2</sup> in summer and fall.<sup>3,4</sup>

## Distribution:

Both sides North Atlantic; American coast from Gulf of St. Lawrence to North Carolina.<sup>1</sup>

## References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 234-238.
2. Colton, J.B., Jr., and R.R. Marak. 1969: 14.
3. Bigelow, H.B. and W.W. Welsh. 1925: 458-462.
4. Breder, C.M., Jr., and D.E. Rosen. 1966: 382.

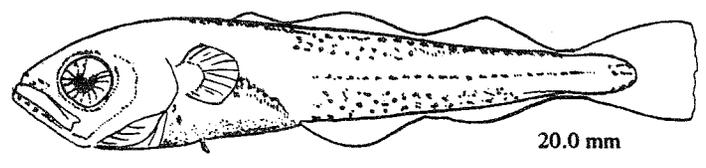
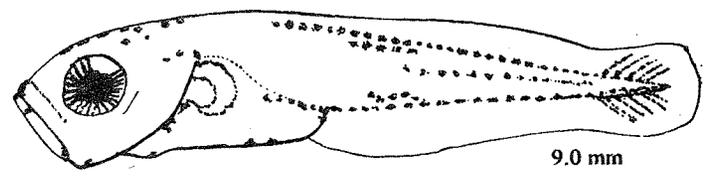
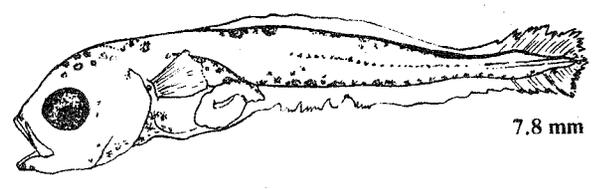
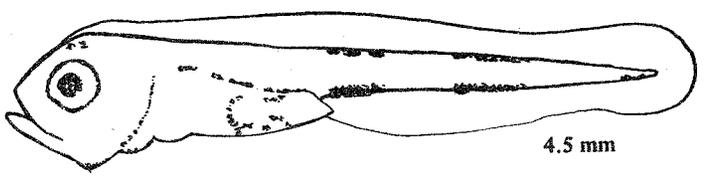
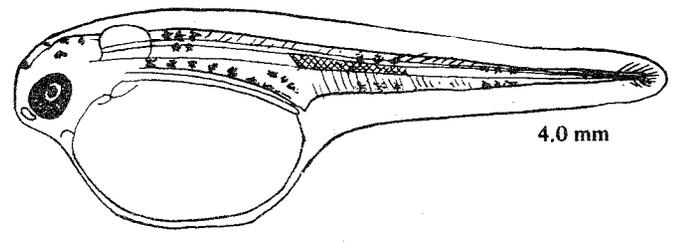
## Other pertinent reference:

Dannevig, A. 1919: 1-49.

## Illustration credits:

2.2 mm, 6.9 mm David Miller, unpublished drawing  
 3.6 mm, 5.3 mm Bigelow and Welsh, 1925  
 37.7 mm Original illustration by Nancy Smith

Species No. 48 Gadus morhua



## GADIDAE

Gadus morhua Linnaeus. Atlantic cod.

## Adult characteristics:

D. 13 to 16-19 to 24-18 to 21; A. 20 to 24-17 to 22; (3 dorsal and 2 anal fins);<sup>1</sup> head 3.53-3.76 in SL; depth 4.74-5.14 in SL; eye 5-5.76 in head. Chin barbel about equal to eye diameter.<sup>2</sup>

## Eggs:

Pelagic, spherical, no oil globule; 1.32 to 1.72 mm diameter.<sup>3</sup>

## Yolk-sac larvae:

Newly hatched larvae are 3.30 to 5.71 mm;<sup>3</sup> vent opens laterally at the base of the finfold; postanal pigmentation consists of 2 dorsal segments and 3 ventral segments (the dorsal bars shorter than opposing ventral bars), 3rd ventral bar near tip of notochord.<sup>1,3</sup>

## Postlarvae:

Yolk-sac absorbed at about 4.5 mm;<sup>1</sup> yolk-sac larval pigmentation continues until about 7 to 10 mm, at which time pigment bars fuse,<sup>3</sup> and a median band forms. Cod 10 to 20 mm have pigment extending to tail; young 15 to 30 mm recognizable by vent under 2nd D. fin and dense pigmentation. At 20 mm D. and A. fins have full complement of rays.<sup>1</sup>

## Spawning:

Roughly December-April, with peak in February in Gulf of Maine;<sup>3</sup> spawning begins and ends earlier in the southern part of the range.<sup>2</sup>

## Range:

Both sides of North Atlantic; on the American coast from Hudson Strait nearly to Cape Hatteras.<sup>1</sup>

## References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 182-196.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 156-158.
3. Colton, J.B., Jr., and R.R. Marak. 1969: 15.

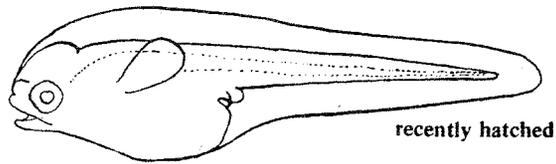
## Other pertinent reference:

Schmidt, J. 1905: 1-77.

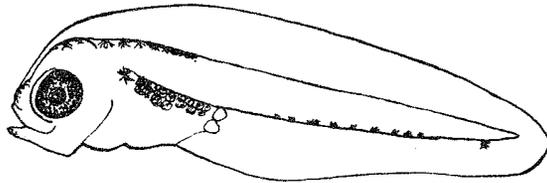
## Illustration credits:

4.0 mm, 4.5 mm, 4.8 mm, 7.8 mm, 9.0 mm, 20.0 mm Bigelow and Schroeder, 1953

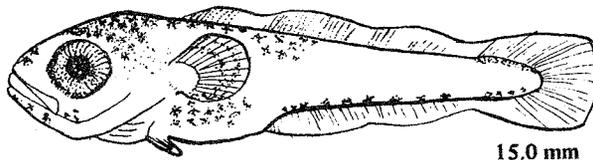
Species No. 49 Melanogrammus aeglefinus



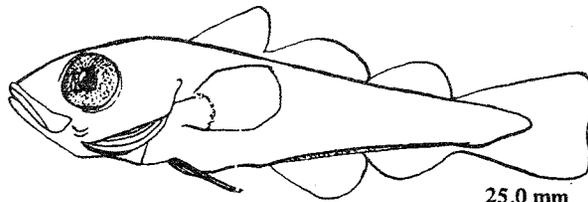
recently hatched



4.2 mm



15.0 mm



25.0 mm

## GADIDAE

Melanogrammus aeglefinus (Linnaeus). Haddock.

## Adult characteristics:

D. 14 to 17-20 to 24-19<sub>1</sub> to 22 (3 dorsal fins); A. 21 to 25-20 to 24 (2 anal fins).<sup>1</sup>

## Eggs:

Spherical, no oil globule; 1.10-1.67 mm diameter.<sup>2</sup>

## Yolk-sac larvae:

Newly hatched larvae 3.08-4.99 mm; vent opens laterally at the base of the finfold; pigmentation on back of head,<sup>2</sup> over gut, and ventral row of melanophores from vent to tip of tail.<sup>2</sup>

## Postlarvae:

Yolk-sac is absorbed at about 5.5 mm;<sup>1</sup> prolarval pigmentation persists until about 8-10 mm, when pigmentation becomes more diffuse and relatively pale.<sup>2</sup> D. and A. fins complete at 16-20 mm; young begin to assume adult shape by about 30-40 mm.<sup>1</sup>

## Spawning:

February-May from Cape Sable to Block Island;<sup>2</sup> in the spring,<sup>3</sup> on the American coast, with the peak over by the middle of May.<sup>3</sup>

## Distribution:

Both sides of North Atlantic; on American coast from Grand Bank to Cape Cod, in the winter occurring southward to New Jersey and occasionally to Cape Hatteras.<sup>1</sup>

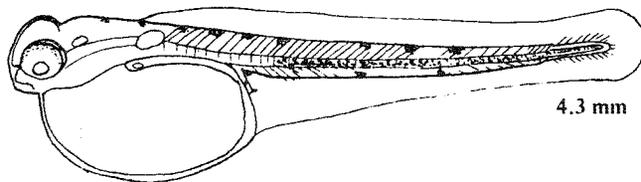
## References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 199-213.
2. Colton, J.B., Jr., and R.R. Marak. 1969: 16.
3. Breder, C.M., Jr., and D.E. Rosen. 1966: 381.

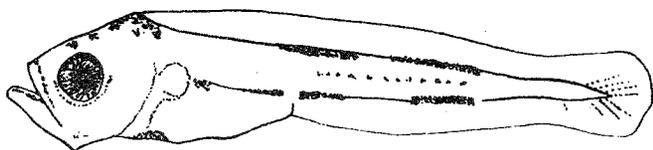
## Illustration credits:

Recently hatched, 4.2 mm, 15.0 mm, 25.0 mm Bigelow and Schroeder, 1953

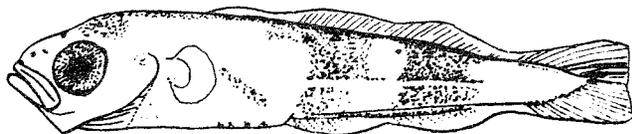
Species No. 50 Pollachius virens



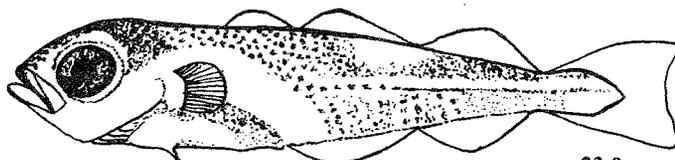
4.3 mm



6.7 mm



12.5 mm



23.0 mm

## GADIDAE

Pollachius virens (Linnaeus). Pollock.

## Adult characteristics:

D. 13 or 14-21 or 22-19 or 20; A. 24 to 28-20 or 21,<sup>1</sup>  
head 3.68-3.88 in SL; depth 4.53 in SL; eye 5.73-6.35 in head.<sup>2</sup>

## Eggs:

Pelagic: spherical, no oil globule; 1.0-1.2 mm diameter.<sup>3</sup>

## Yolk-sac larvae:

Newly hatched larvae 3.4-4.2 mm; vent opens laterally at base of ventral finfold; pigmentation sparse and scattered over anterior portion of body; unlike the cod, characteristic bars of pigmentation do not form until time of yolk-sac absorption.<sup>3</sup>

## Postlarvae:

Yolk-sac is absorbed at about 4.5 mm; postanal pigmentation consists of 2 dorsal and 2 ventral bars of melanophores, the dorsal bars being longer than the ventral bars (opposite to the arrangement in the cod).<sup>1,3</sup> This pigmentation persists until about 8-9 mm<sup>3</sup> (given as 15 mm);<sup>1</sup> then pigment becomes scattered.<sup>1,3</sup> Caudal fin rays appear at 9 mm; D. and A. fin rays by about 15 mm; young 25-30 mm begin to resemble adults.<sup>1</sup> Most reliable character for separating late postlarvae of pollock, haddock and cod is by number of abdominal vertebrae as follows:<sup>3</sup>

	<u>Range</u>	<u>Average</u>
Pollock	23-25	23.6
Haddock	19-22	20.3
Cod	17-20	18.4

## Spawning:

November to mid-February from Cape Sable to Block Island;<sup>3</sup> spawns most actively from November to January in Gulf of Maine.<sup>4</sup>

## Distribution:

Both sides North Atlantic; in western North Atlantic from Gulf of St. Lawrence to New Jersey, occasionally south to Chesapeake Bay and North Carolina.<sup>1</sup>



Pollachius virens (Cont.)

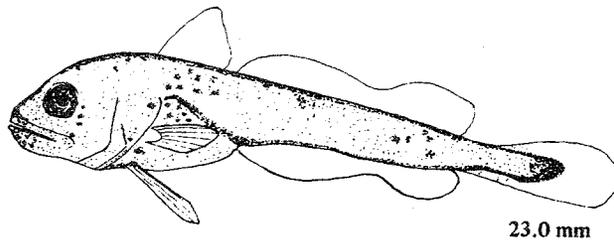
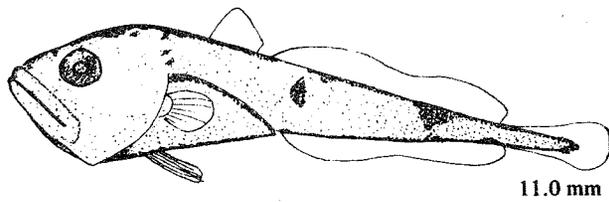
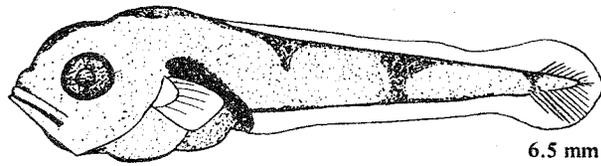
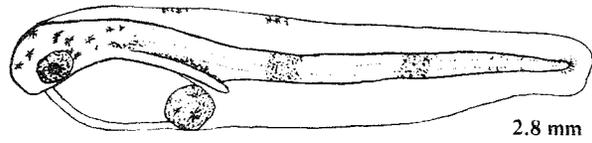
References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 213-221.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 155-156.
3. Colton, J.B., Jr., and R.R. Marak. 1969: 19.
4. Breder, C.M., Jr., and D.E. Rosen. 1966: 376-377.

Illustration credits:

4.3 mm, 6.7 mm, 12.5 mm, 23.0 mm Bigelow and Schroeder, 1953

Species No. 51 Merluccius bilinearis



## GADIDAE

Merluccius bilinearis (Mitchill). Silver hake.

## Adult characteristics:

D. 11 to 14-38 to 41; A. 38 to 41; depth 5-6 in SL; lacks chin barbels.<sup>1</sup>

## Eggs:

Pelagic; with oil globule; spherical; 0.84-1.02 mm diameter.<sup>2</sup>

## Yolk-sac larvae:

Newly hatched larvae 2.64-3.52 mm; vent opens laterally near base of finfold; pigmentation consists of scattered melanophores on the head, gut, oil globule and 2 vertical bands on the tail, one just posterior<sup>2</sup> to vent and the other about midway between vent and tip of tail.

## Postlarvae:

Yolk-sac is absorbed at about 4 mm; large melanophores on head and over gut, and 3 vertical bands evenly spaced on the post-anal portion of body; bands remain to about 11 mm. Teeth visible at 7.5 mm; D., A., and caudal fins formed by 10-11 mm; young assume adult appearance at 20-25 mm.<sup>1</sup>

## Spawning:

May to mid-October from Cape Sable to Block Island.<sup>2</sup>

## Distribution:

Newfoundland to South Carolina.<sup>1</sup>

## References:

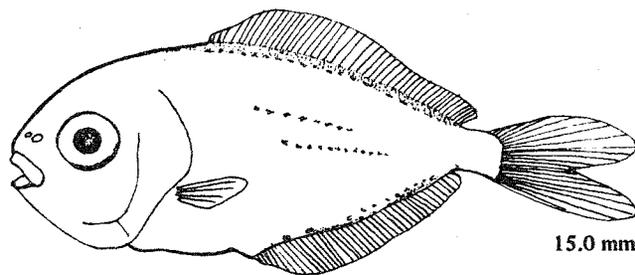
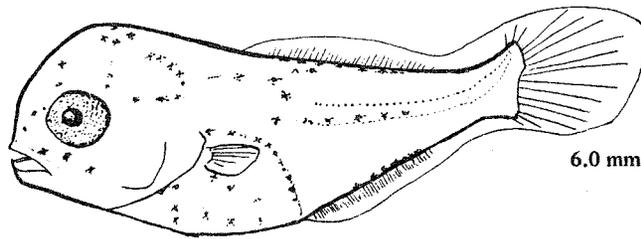
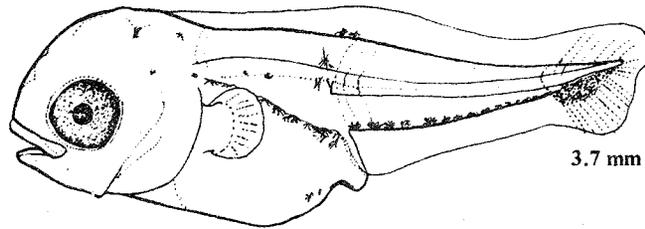
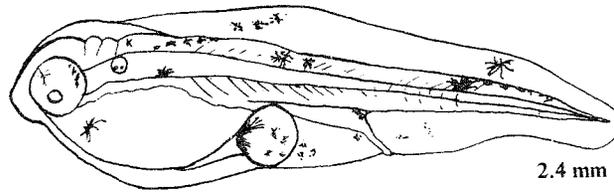
1. Bigelow, H.B. and W.C. Schroeder. 1953: 173-182.
2. Colton, J.B., Jr. and R.R. Marak. 1969: 18.

## Other pertinent reference:

Kuntz, A. and L. Radcliffe. 1917: 109-112.

## Illustration credits:

2.8 mm Kuntz and Radcliffe, 1918  
6.5 mm, 11.0 mm, 23.0 mm Bigelow and Schroeder, 1953

Species No. 52 Peprilus triacanthus

## STROMATEIDAE

Peprilus triacanthus (Peck). Butterfish.  
(formerly Poronotus triacanthus)

## Adult characteristics:

D. III, 44 to 46; A. III, 40 to 42; depth 1.7 to 2.1 in SL; head 3.35 to 4.3 in SL; no pelvic fins.<sup>1</sup>

## Eggs:

Pelagic, spherical, with oil globule; 0.75-0.79 mm diameter.<sup>2</sup>

## Yolk-sac larvae:

Newly hatched larvae 1.68-1.75 mm; vent opens at margin of finfold; pigmentation sparse. Near<sup>2</sup> time of yolk-sac absorption ventral row of melanophores prominent.

## Postlarvae:

Yolk-sac absorbed at about 2.5 mm;<sup>2</sup> (Pearson notes yolk-sac gone at 1.8 mm);<sup>3</sup> ventral row of postanal pigment and pigment on top of head. D., A., and caudal rays evident at 5-6 mm; body assuming deep, thin form.<sup>2,4</sup> Fins fully formed at 15 mm.

## Spawning:

June-August, Cape Sable to Block Island.<sup>2</sup>

## Distribution:

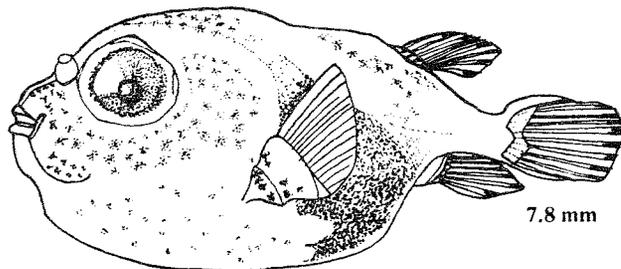
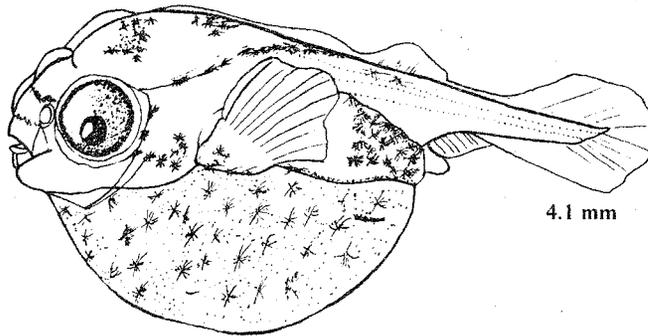
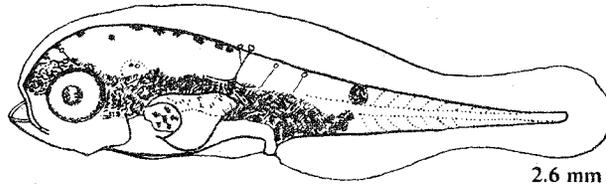
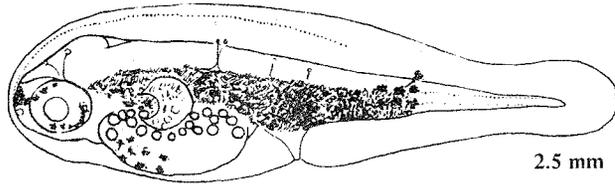
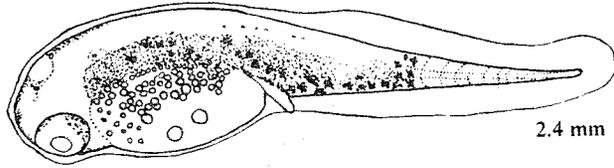
Nova Scotia to South Carolina.<sup>4</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 213-216.
2. Colton, J.B. Jr., and R.R. Marak. 1969: 30.
3. Pearson, J.C. 1941: 87-89.
4. Bigelow, H.B. and W.C. Schroeder. 1953: 363-367.

## Illustration credits:

2.4 mm, 3.7 mm, 6.0 mm, 15.0 mm Pearson, 1941

Species No. 53 Sphaeroides maculatus

## TETRAODONTIDAE

Sphaeroides maculatus (Bloch and Schneider). Northern puffer.

## Adult characteristics:

D. 8; A. 7; head 2.05-2.85 in SL; depth about 2 to 3 in SL; eye 3.6-7.75 in head.<sup>1</sup>

## Eggs:

Demersal;<sup>2</sup> adhesive; spherical, transparent, 0.85 mm-0.91 mm diameter.

## Larval stages:

Newly hatched larvae average about 2.4 mm; yolk-sac small with oil globules; coloration consists of red, orange, yellow, and black chromatophores distributed over the body. On the 5th day after hatching tubercles observed on the ventral surface. Postlarvae at 7.35 mm.<sup>2</sup> Resemble adults at even less than 7 mm.

## Spawning:

Through the warmer months;<sup>2</sup> in shoal water close to shore, from mid-May, in Chesapeake Bay, and through summer off Massachusetts.<sup>3</sup>

## Distribution:

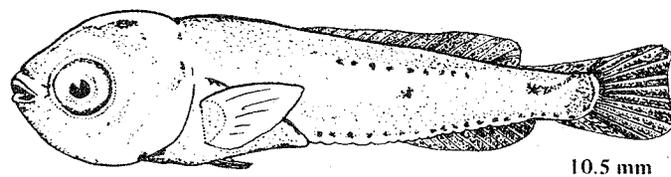
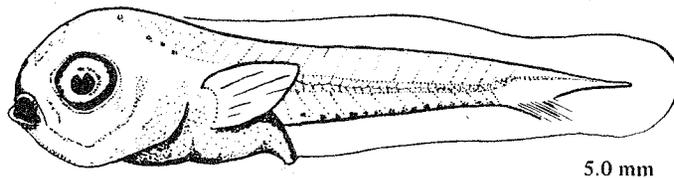
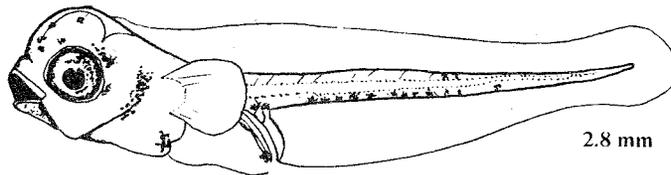
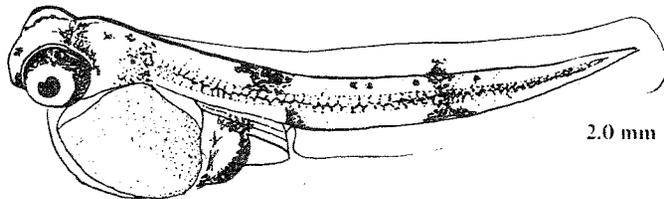
From Cape Cod to Florida (abundant).<sup>3</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 348-349.
2. Welsh, W.W. and C.M. Breder, Jr. 1922: 261-276.
3. Bigelow, H.B. and W.C. Schroeder. 1953: 526-527.

## Illustration credits:

2.4 mm, 2.5 mm, 2.6 mm Welsh and Breder, 1922  
4.1 mm, 7.8 mm Original illustrations by Nancy Smith

Species No. 54 Stenotomus chrysops

## SPARIDAE

Stenotomus chrysops (Linnaeus). Scup.

## Adult characteristics:

D. XII, 12; A. III, 11 or 12;<sup>1,2</sup> head 2.95-3.45 in SL; depth 1.95-2.25 in SL; eye 2.5-3.9 in head.<sup>2</sup>

## Eggs:

Pelagic, spherical, single oil globule; 0.85-0.90 mm diameter.<sup>3</sup>

## Larval stages:

Newly hatched larvae approximately 2 mm; vent opens less than half length of body from snout; black pigment scattered about dorsal and dorso-lateral portions of the body; yellow pigment present. By 5 mm, there is a characteristic ventral row of pigment spots postanally. At about 10 mm D., A., and caudal fins nearly differentiated.<sup>3</sup>

## Spawning:

Largely in June from North Carolina<sup>3</sup> up to southern New England.<sup>1</sup>  
In Delaware Bay five specimens 5 mm in length collected on June 15, 1960.

## Distribution:

Cape Cod to North Carolina.<sup>1</sup>

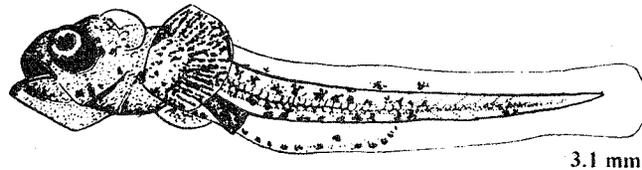
## References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 411-416.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 261-264.
3. Kuntz, A. and L. Radcliffe. 1917: 102-105.

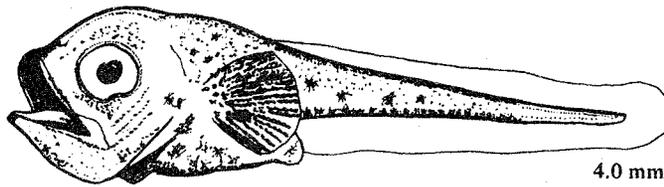
## Illustration credits:

2.0 mm, 2.8 mm, 5.0 mm, 10.5 mm Kuntz and Radcliffe, 1917

Species No. 55 Prionotus carolinus



3.1 mm



4.0 mm

## TRIGLIDAE

Prionotus carolinus (Linnaeus). Northern searobin.

## Adult characteristics:

D. X-13; A. I, 11;<sup>1,2</sup> head 2.8-3.1 in SL; depth 4.15-5.15 in SL; eye 3-5 in head.<sup>2</sup>

## Eggs:

Pelagic, spherical, transparent;<sup>3</sup> 0.94-1.15 mm in diameter;<sup>1</sup> 10-25 oil globules.<sup>1,3</sup>

## Larval stages:

Newly hatched larvae are approximately 2.8 mm; pectoral fins are prominent; vent just posterior to yolk-sac; black and yellow pigment scattered about head and trunk; two transverse yellow cross-bands, one close behind pectoral fins, the other midway between vent and tip of tail.<sup>1,3</sup> Yolk-sac is absorbed and yellow markings no longer prominent at 3-3.4 mm.<sup>1</sup> By 8-10 mm D., A. and caudal fin rays are becoming well differentiated.<sup>3</sup> Young 25-30 mm are darker, with transverse bands, and show most of the distinctive characters of the adult.<sup>1</sup>

## Spawning:

June-early August<sup>3</sup> or September<sup>1</sup> off Woods Hole.<sup>1,3</sup>

## Distribution:

Bay of Fundy to South Carolina.<sup>1</sup>

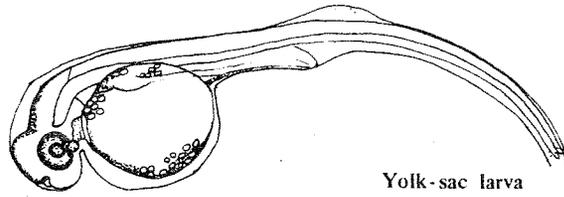
## References:

1. Bigelow, H.B. and W.C. Schroeder. 1953: 467-471.
2. Hildebrand, S.F. and W.C. Schroeder. 1928: 314-315.
3. Kuntz, A. and L. Radcliffe. 1917: 105-109.

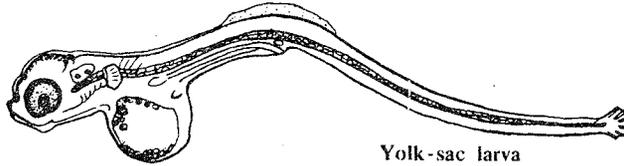
## Illustration credits:

3.1 mm, 4.0 mm Kuntz and Radcliffe, 1917

Species No. 56 Syngnathus fuscus



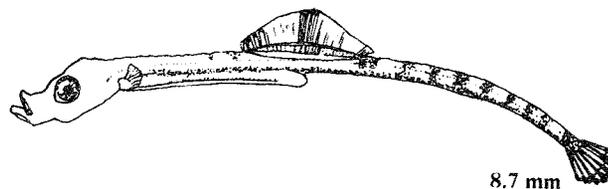
Yolk-sac larva



Yolk-sac larva



8.5 mm



8.7 mm

## SYNGNATHIDAE

Syngnathus fuscus Storer. Northern pipefish.

## Adult characteristics:

D. 35 to 41; A. (very small; behind vent);<sup>1,2</sup> body composed of bony plates connected in rings, 18-20 rings in front of vent<sub>2</sub> and 36-42 behind vent. Male has "marsupial" or brood pouch.<sup>2</sup>

## Eggs:

About 0.75 mm diameter.<sup>3</sup>

## Larval stages:

D. fin just becoming evident at 3 mm; by 3.5 mm D. fin better developed and caudal rays forming.<sup>3</sup>

## Spawning:

On southern shores of New England from March to August.<sup>2</sup>

## Distribution:

Southern side Gulf of St. Lawrence to South Carolina; in salt and brackish water.<sup>2</sup>

## References:

1. Hildebrand, S.F. and W.C. Schroeder. 1928: 182-183.
2. Bigelow, H.B. and W.C. Schroeder. 1953: 312-314.
3. Ryder, J.A. 1887: 508-511.

## Illustration credits:

Yolk-sac larvae     Ryder, 1887  
8.5 mm, 8.7 mm     Original illustrations by Nancy Smith



## III. METHODS SECTIONS

## A. Identification of Fish Larvae

The identification of ichthyoplankton is a challenging endeavor, and much remains to be done. Of the roughly 20,000 known species of fish, less than 10 percent have had their larval stages described.

Literature on larval fishes is widely scattered, and often difficult and expensive to obtain. Although older publications on fish larvae can be of great assistance to a worker, e.g., Hildebrand and Cable, 1930; LoBianco, 1931-1933; Regan, 1916; Roule and Angel, 1930; and Ryder, 1887 (these references cited in bibliography on general references), some do contain errors.

There are few guidelines available to the beginning worker on the taxonomy and development of larval fishes. The worker must be familiar with such things as meristics (serial body features), morphometrics (body proportions), the distribution of the families of fishes being studied, and the pertinent literature on both adults and larvae. Among problems encountered in studying larval fish development are allometric growth (differential growth rates), which usually means that the use of adult proportions is not applicable to larvae. At times, totally unrelated families of fishes may be similar in appearance as larvae, e.g., myctophids (lanternfishes) and scombrids (mackerels and tunas) (Berry and Richards, in press).

### 1. Techniques for Identification

Two standard techniques are used to identify the developmental stages of fishes: 1) selecting a size series from a cultured stock of a known species; and 2) systematic analysis. The first method has a decided advantage; however, until recently only certain freshwater and hardy estuarine species have been artificially reared (see section on rearing). Recent advances in rearing tropical marine species (Shelbourne, 1964) have expanded the field.

Rearing results in a complete series of developmental stages, with all of the specimens reared usually being in excellent condition. However, fish culturing is still in its infancy, and most coastal and pelagic fishes have yet to be successfully reared.

Systematic analysis is therefore the technique most used for ichthyoplankton identification. This method involves working backward from a recognizable developmental stage of a fish species to the smallest larval specimen collected. The preferred technique for the description of larvae is the dynamic method -- describing in detail the smallest larva, and then adding developmental sequences of significant structures and features (e.g., head, fins, pigmentation, etc.) -- as opposed to the static method of repeating complete morphological descriptions for each developmental stage (e.g., 2 mm, 4 mm, 6 mm, etc.). Excellent examples of the dynamic method are given by Ahlstrom and Counts (1955), Moser and Ahlstrom (1970), and Smith and Fahay (1970).

Ichthyoplankton surveys involving many samples and many families

and species present a challenge as to the best method of identification. A method which has been used successfully by the authors and others (Schmidt, 1905; Tåning, 1918; Moser and Ahlstrom, 1970) is conducted on the premise that it is more efficient not to attempt positive identification of individual specimens initially. Therefore fish larvae collected at each station are sorted roughly into family groupings. After a sufficient number of larvae are placed in particular families, these individuals are examined in detail. Specimens are sorted until a developmental series is established for each species by tracing characters backwards from identifiable specimens to the smallest larva collected (see Schmidt, 1905). Finally the specimens selected for a developmental sequence are illustrated (photomicrographs may be used but usually are not explicit enough), and then morphometric and meristic data are analyzed.

## 2. Diagnostic Characters for Identification of Fish Larvae

Useful characters in larval fish identifications are 1) myomeres and vertebrae; 2) fins, i.e., the number of rays and sequence of development; and 3) other meristic characters.

Myomeres are equal to  $(-1)$ <sup>+</sup> the number of vertebrae, and the adult complement is formed by the late embryonic or early larval stage. The first myomere usually is considered to be the one immediately anterior to the first easily countable and "typical" myomere (Figure 2) and the last myomere is considered to be the one adjacent to the urostyle and immediately posterior to the last "typical"

myomere (Figure 2).

Vertebral counts are often divided into pre-caudal and caudal components. "The first caudal centrum is defined as the anterior-most centrum which lacks pleural ribs and has a median haemal spine" (Berry and Richards, in press).

After myomeres, fins are the next important structures to develop. First, finfolds appear, then fin ray buds, the number of which is usually equal to the adult complement of rays (Figure 2), and then fin rays differentiate. By definition, the larval stages terminate with acquisition of the adult fin-ray complement (Mansueti and Hardy, 1967; see discussion under Terminology).

The normal sequence of fin development in most fish species is the pectoral buds (though pectoral rays may be the last to form completely), the caudal fin, the dorsal and anal fins (usually simultaneously), and the pelvics (may begin last but may be completely formed before the pectorals). The pectorals allow for balancing and the caudal for propulsion, which may explain their early formation (Regan, 1916). The principal rays of the caudal fin are often the first rays to be completely formed and are usually helpful in distinguishing among families and orders, because "the number and arrangement of principal caudal rays are (in most groups) conservative and consistent within broad phylogenetic groups" (Berry and Richards, in press). For example, the number for most perciforms (perch-like fishes) is a constant 9 (dorsal) + 8 (ventral). However, an exception to this occurs in pleuronectiforms (flatfishes), in which principal

caudal rays range from 10 to 23.

Early in development of the dorsal and anal fin rays, it usually is not possible to distinguish between spines and soft rays (spines are often blunt and the soft rays are not yet segmented). In the case of Morone saxatilis one or more soft rays may develop into spines during or after the larval stage (Mansueti, 1958). The relative lengths of the dorsal and anal fins and their positions in relation to each other are important diagnostic characteristics in some families (see developmental notes under species of the families Clupeidae and Engraulidae, in illustrated portion).

Pectoral fin ray striations often are visible early in the yolk-sac larva but the rays may not actually form until the late post-larval stage. The pelvic ray complement in perciform families is usually constant at one spine and five rays.

The relative lengths of the anterior dorsal and pelvic spines are important diagnostic features in certain families. For example, one or more long spines or rays in both the dorsal and pelvic fins are found in some acanthurids (surgeonfishes), pleuronectiforms, gempylids (snake mackerels) and serranids (sea basses), whereas one or more long spines in the dorsal alone are characteristic of some balistids (triggerfishes and filefishes), bregmacerotids (codlets), carapids (pearlfishes), pleuronectiforms, and trichiurids (cutlassfishes).

Other developmental characters of varying usefulness depending on the family and the stage of development of the individual are:

branchiostegals (gill membrane supports); head and body spination; fleshy appendages; eye shape; larval teeth; nature and shape of gut; gillrakers; pigmentation, and morphometric measurements, e.g., standard length, head length, snout-vent length, eye diameter, body depth. The branchiostegal complement is often a helpful character within certain groups, but clearing and staining is normally required to see these structures. Gill rakers are usually of little value in identification of larvae because, in most fishes, the adult number is not attained until the juvenile stage. However, the number of gill rakers may be helpful if carefully studied (Potthoff and Richards, 1970).

Groups of fishes in which larval stages of some of the species may have spines or armor on the dorsal or lateral regions of the head or in the opercular region include bothids (lefteye flounders), branchiostegids (tilefishes), caproids (boarfishes), carangids (jacks), chaetodontids (butterflyfishes), dactylopterids (flying gurnards), holocentrids (squirrelfishes), istiophorids (billfishes), priacanthids (big eyes), scombrids (mackerels and tunas), scorpaenids (scorpionfishes), serranids and xiphiids (swordfishes).

Morphometric measurements may be useful to show allometric growth and to allow comparison between larval and adult morphology, but care must be taken to indicate the size of the specimen for which various measurements were taken.

Pigmentation, i.e., the arrangement and type of chromatophores, is useful diagnostically for differentiation between species, but one

must be aware of the pitfalls of assuming that any one characteristic can be used alone for identification. Melanophores (black and brown pigments) may be preserved in an aggregated or dispersed condition (Fujii, 1969: 334) and chromatophores other than melanophores usually fade during preservation. Colored pigment such as the red (erythrophores) of some balistids, bothids, pomadasyids (grunts), and scombrids fades in a matter of days or even hours, as does the yellow (xanthophores) of balistids, bothids and sparids (porgies).

For a more thorough treatment of this subject, refer to Berry and Richards (in press).

## B. Preservation and Sorting of Fish Eggs and Larvae

If plankton samples are not properly prepared in the field upon collection, and subsequently maintained in the lab after sorting, collections may be ruined in a relatively short period of time. Initial rough sorting and preservation of ichthyoplankton collections must be performed in the field followed by a more detailed treatment in the lab. The methods used may vary, but they all should attempt to allow for preserving and sorting out the highest percentage of specimens possible. Field techniques are usually dependent on the other organisms or materials being collected that might tend to interfere with sorting (Dovel, 1964). One method that is successful (de Sylva, 1970; Dovel, 1964) is to sort large organisms from a tow, e.g., ctenophores, macroscopic algae, and grasses, that are washed to rid them of adhering ichthyoplankton and then discarded. The remaining sample is passed through plankton netting of the same mesh as that of the collecting net (Dovel, 1964; Wickstead, 1965) or through wire screens and is then transferred to collecting jars. Care is taken to remove all of the sample from the wire screen or plankton netting by washing it with Formalin, and then the jar containing the sample is filled with Formalin (usually 10 percent is used in the field). Formalin should be added to the sample immediately after each tow to prevent deterioration of specimens.

The sample jars are then transported to the lab in a box in order to prevent damage to the jars and to prevent rapid fading of the fish eggs and larvae due to sunlight. In the lab, the field

sample jars should be kept out of sunlight and stored in cool areas. Heat in the field and during storage is the main reason why ichthyoplankton collections from tropical areas are often in poor condition.

#### 1. Preserving Solution

Two commonly used preserving solutions for biological specimens are ethyl alcohol and Formalin. Formalin is recommended for general use; ethyl alcohol is not recommended for use with fish eggs and larvae for the following reasons: 1) it often causes distortion and shrinkage during preservation, making subsequent measurement, identification, and illustration of questionable validity; 2) it is expensive, flammable, and evaporates rapidly; 3) it necessitates reducing the concentration in several steps for curatorial purposes, and 4) when mixed with water, alcohol causes specimens to gyrate, thus making them difficult to examine under a microscope.

The terms formaldehyde and Formalin are often confused. Formaldehyde is a colorless gas,  $\text{HCHO}$ , formed by partial combustion of methanol, whereas Formalin (a trade-mark) is a saturated solution of formaldehyde in water (plus 6 to 15 percent methanol, which prevents precipitation) giving the so-called 40 percent solution. If the 40 percent solution of Formalin is diluted 9 times its volume with water, this will give a 10 percent Formalin solution. Ten percent Formalin is the most commonly used for initial preservation of ichthyoplankton, while 3 or 5 percent solutions are used for maintaining collections. On board the collecting boat, 1 part Formalin may be added to 9 parts plankton and seawater to

give a 10 percent solution. A helpful practice, especially in rough seas, is to add the Formalin to collecting jars before sampling begins. A jar should never be filled more than 30 percent full of the collected sample, the remainder of the jar being filled with Formalin. When jars containing fish eggs and larvae are to be stored permanently, the Formalin solution should be changed within 5 to 10 days after the original preservation so that the specimens will definitely be fixed (Richards and Berry, in press).

## 2. Buffering Agent

Formalin solutions are slightly acidic, and therefore a buffer is added to make the solution neutral. Acidic solutions of Formalin will not harm fish larvae but will harm other planktonic organisms such as copepods, whereas basic solutions of Formalin will cause bleaching and clearing of fish larvae (William Richards, personal communication).

Several different buffering agents can be used, e.g., borax, hexamine (hexamethylamine), and marble chips. Borax is the most widely used buffer but it does not always hold a constant pH, and excess borax tends to bleach larvae. It may even adhere to a larva, causing white spots on the body surface. The addition of 2.5 grams of borax to 1 liter of 5 percent Formalin should provide effective buffering for a period of 4 or 5 years (Richards and Berry, in press). Hexamine is not recommended because it is expensive, may crystallize around the organisms, and will macerate, bleach, or clear larvae. Marble chips slowly leach, thus adding a buffer to the Formalin

solution over a period of time. Marble chips have been used with larval fishes for ten years by the Marine Research Laboratory of the Department of Natural Resources of the State of Florida (Mrs. Bonnie Eldred, personal communication) and other labs are beginning to do so (William Richards, personal communication). Approximately 30 marble chips are placed in the 5 gallon carboys used to store the 5 percent Formalin solution. No marble chips are added to small vials containing larvae.

Preserved fish larvae lose their pigment rapidly; however, a color preservative may help slow the loss of pigment. No more than 0.5 ml of IONOL CP-40, a widely used color preservative, should be added to an 8-oz. jar of plankton.

### 3. Laboratory Sorting

Sorting fish eggs and larvae is the most time-consuming aspect of an ichthyoplankton survey. Sorting time is the number of hours required to manually remove fish eggs and larvae from each field sample. (Now under development by the National Marine Fisheries Service is an automatic fish egg and larvae sorting machine that operates on the principle of centrifugation [William Richards, personal communication]). The time required for sorting fish eggs and larvae from a sample varies greatly, depending on such factors as size of fish larvae, variety and numbers of other organisms present, detritus, and most of all, efficiency of the individual sorters.

Various cost estimates for sorting fish larvae from 100 ml of a field sample range from \$20 to \$56 per sample (Richards and Berry, in

press). Oceanic plankton samples usually require less sorting time than do estuarine and bay samples of similar latitudes due to the relatively cleaner condition of oceanic collections. For example, in the study of the occurrence and distribution of fish larvae in Biscayne Bay, Florida (de Sylva, 1970; de Sylva and Scotton, 1972), the average sorting time for 100 ml of sample was 4 hours, and each 100 ml of sample contained an average of 100 fish larvae of 3-4 mm mean length (Robert Trumbull, personal communication). In this particular study, sorting time in man hours was approximately 6 times the actual boat time. The time above does not include identification of larvae, a job that often requires much more time than sorting.

Sorting accuracy can be enhanced by resorting until a sorter is proficient and then resorting is done randomly. In the study on Biscayne Bay, Florida, referred to above, 21 percent of fish larvae were missed on the first sorting.

An important recommendation is that subsamples or aliquots should not be taken of either the raw field sample or of the sorted larvae. Although subsampling often works with zooplankton samples, fish larvae usually make up less than one percent of a plankton sample and thus splitting is not statistically accurate. Also, rare larvae may be missed entirely if subsamples are taken. Further, some specimens float, while others sink, and thus the fish larvae are not randomly distributed throughout the total sample.

#### 4. Sorting Techniques

Sorting a plankton sample for fish larvae should be done under

magnification and illumination and against a dark background. A "magnifier-and-lamp" combination, in which a fluorescent light completely encircles the magnifying lens, is very useful. These lights are available from most biological supply houses for about \$50 each. Dissecting microscopes are also commonly used.

Only about 3 ml of plankton sample should be placed in the sorting dish at one time. (Dishes which are 5 inches in diameter and marked off in quarters work well). Attempting to sort too large a volume of sample at one time can lead to inaccuracy. Fish larvae are best removed using flexible, fine or blunt-pointed forceps (stiff forceps will damage larvae) or small artists' brushes. Each sample dish should be examined a second time to look for previously missed eggs and larvae.

After the larvae have been sorted they are counted, a small plastic hand counter being useful for this purpose. Then the larvae can be stored in small well-marked vials, such as 5-dram glass vials with lined nylon caps. The vials should be labeled both inside, using biological paper inscribed with waterproof ink, and on the caps. Vials containing larvae are then placed in sturdy boxes that are covered so that the larvae will not be exposed to light; vials should be easily accessible. The importance of conscientious sorting and handling of larvae in an ichthyoplankton survey cannot be overemphasized.

### C. Laboratory Rearing of Marine Fish Eggs and Larvae

The history and present status of the marine fish hatchery movement is covered by Shelbourne, 1964. Until recently there had been only limited success in rearing marine fishes, especially tropical species, from the egg to a recognizable size (Atz, 1964; Morris, 1956). This is also true of marine fish farming (Shelbourne, 1964; Iversen, 1968). Significant advances have been made in rearing cod (Dannevig, 1963), plaice (Shelbourne, 1963a, 1963b, 1964), the herring Clupea harengus (Blaxter, 1968), mackerel and sardines, Engraulis and Scomber (Schumann, 1967), and some species of tuna (Houde and Richards, 1969; Charles Mayo, personal communication). These strides can be attributed at least partly to several factors (Blaxter, 1969; Charles Mayo and William Richards, personal communication):

1. Development of adequate food: use of Artemia and Balanus nauplii, Mytilus trochophores, rotifers and oligochaetes, and natural plankton.
2. Use of antibiotics, especially with eggs of flatfish (Shelbourne, 1964); dosages of mixed sodium penicillin (50 IU/ml); and streptomycin sulfate (0.05 mg/ml).
3. Improved feeding success achieved by increasing the contrast between food and background through the use of black-walled tanks and uniform illumination.
4. Better overall water management and filtration systems (see Spotte, 1970).

#### D. Field Sampling of Fish Eggs and Larvae

When collecting marine organisms, including fish eggs and larvae, there are several important principles to bear in mind in order to obtain a representative and unbiased sample (Lagler, 1968: 7):

1. Most fish-capture methods are selective with respect to species and size of individual;
2. The soundness of sampling procedures is too often assumed and is seldom evaluated experimentally;
3. There is no substitute for actual field experience in capturing the organisms one desires to study.

In addition, the sampling techniques to be employed and the general design of the program depend on the following (Lagler, 1968: 8-17):

1. The hydrography of the area to be studied;
2. The habitats and morphology of the organisms to be studied;
3. The collection gear (do not rely simply on available gear, but use the best possible techniques for the circumstances);
4. The selectivity of the gear (evaluate and test gear selectivity until the best combination of gear is found);
5. The maintenance of good records;
6. The analysis of data.

The following remarks refer mainly to ichthyoplankton sampling

in an estuarine or coastal environment, but should be applicable to other regions as well.

Customarily, ichthyoplankton surveys seek to establish quantitative and qualitative determinations of numbers of fish eggs and larvae to make estimates of the size of the spawning population. These considerations require that standardized sampling techniques be established which are suitable for the larvae found in the body of water under consideration. The actual sampling of representatives of all the members of the fish larvae community necessitates overcoming the obstacles of net avoidance, vertical migration, demersal stages, and changes in spatial and temporal distribution.

A theoretically ideal sampling program for fish eggs and larvae in an estuary or bay may not be feasible because of the limits of time and funds. Consequently the investigator must be aware that he may be incompletely sampling the larval fish population.

#### 1. Net Avoidance

Net avoidance, i.e., the tendency of planktonic organisms, especially fish larvae, to avoid the collecting net, is a problem that must always be faced in ichthyoplankton sampling programs (see discussion on this subject by Clutter and Anraku, 1968; Barkley, 1972). Avoidance adversely affects population estimates and diversity indices (McGowan and Fraundorf, 1966). The reasons for avoidance in individual sampling programs are often difficult to pinpoint due to interfering factors that may be interpreted as avoidance. Some

of these factors are extrusion (the forcing of organisms through the meshes) (Vannucci, 1968), clogging, differences in filtering rates, plankton patchiness, and vertical migration. The response of fish larvae to certain physical factors also influences avoidance (Clutter and Anraku, 1968). For example, pressure waves moving ahead of sampling devices can be detected by the inner ear of fishes, changes in hydrostatic pressure are picked up by the lateral line system (Harris and Van Bergeijk, 1962), and changes in light intensities are perceived by the eyes of fishes. Fish larvae usually attain good visual perception when they are several days old, e.g., vision is fully developed in sardine larvae when they are five days old (Schwassmann, 1965).

## 2. Overcoming Net Avoidance

Results of avoidance experiments are inconsistent enough to prevent a standard solution and, of course, there is no "no-avoidance" net. However, in general, depending on the nature of the sampling program, ichthyoplankton samplers should be: 1) as large as practical, both in mouth diameter and in length (Barkley, 1964); 2) towed as fast as possible, e.g., the variety of fish larvae increases and escapement decreases with an increase in speed (Clutter and Anraku, 1968; Clarke, 1964); however, not towed so fast that extrusion is significant; 3) towed at a constant speed; 4) without obstructions over the mouth such as bridles, etc.; 5) colored so as to have as little contrast with the environment as possible, and free of any shiny surfaces or objects (Hester and

Taylor, 1965); and, 6) with proper mesh size depending on the worker's sampling interests. Preliminary sampling using a variety of nets enables an investigator to choose the correct sampler to accomplish the goals of his program.

In addition to the proper sampler, time of sampling is very important in an ichthyoplankton survey. Taking collections at the new moon may give best results because fish spawning activity may increase (de Sylva, 1970). Although results are not always consistent, most investigators have found that the numbers and sizes of most species of fish larvae increase if sampling is done at night (Ahlstrom, 1954; Bridger, 1956, 1958; Bowers, 1952; Daiber, 1963; Isaacs, 1964; Percy, 1962; Percy and Richards, 1962; Percy and Laurs, 1966; Russell, 1928; Silliman, 1943; and Tibbo, et al., 1958). The reason for increased catches at night is probably related to both decreased net avoidance and to diel changes in behavior of larvae, especially feeding stimuli, vertical migration, and phototaxis.

### 3. Types of Samplers and Sampling Techniques

"Variation in kinds, size, mobility, abundance, and distribution of marine zooplankton precludes use of the same sampler and methodology for all purposes" (Gehringer and Aron, 1968). Below is a partial list of various sampling devices and useful techniques for collecting fish eggs and larvae (for a more complete bibliography on the subject, refer to Jossi, 1970). After each sampler is a designation of the general ecological division in which the sampler is especially useful. This designation is arbitrary and is not meant

to imply that a particular piece of gear cannot be used in other areas. (S = Shallow waters [where gear cannot be easily towed]; E = Estuarine; C = Coastal and oceanic)

a. Gear

i. Stationary samplers

Buoyed and anchored nets (S, E): Croker, 1965;

Dovel, 1964; Graham and Davis, 1971; Graham and Venno, 1968; Hopkins, 1965.

Fry trap (S): Breder, 1960.

Dip net (S,E,C)

Channel net (E): Lewis et al., 1970.

Plankton purse seine (E, C): Murphy and Clutter, 1972.

ii. Standard cone-shaped plankton nets (for brief his-

tories of these trawls see Aron, 1962; Fraser, 1968:

11-18: Linger, 1960; Newell and Newell, 1967: 17-

25; Southward, 1970: 690-692; Wickstead,

1965).

Half-meter and associated nets (E,C) (e.g.,

Hensen net, Peterson young-fish trawl, etc.):

Clark, 1920; Dovel, 1964; Fraser, 1968; Nansen, 1915; Southward, 1970.

Meter net (E,C): Dovel, 1964; Kemp and Hardy,

1929; Southward, 1970.

Modified (hi-speed) meter net (E,C): Southward, 1970.

iii. Closing net (C): Bé et al., 1959; Bé, 1962;

Currie, 1962; Currie and Foxton, 1957; Foxton,

1963; Fraser, 1968; Yentsch et al., 1962.

iv. Hi-speed samplers (E,C):

Gulf III: Gehringer, 1962; Gehringer and Aron,  
1968; Sherman and Honey, 1971.

Gulf V: Clark et al., 1969.

'Hai': Kinzer, 1962.

Modified Icelandic high-speed sampler: Gehringer  
and Aron, 1968; Sameoto, 1971.

Bary catcher: Bary et al., 1958.

Others: Ahlstrom et al., 1958; Miller, 1961;  
Noble, 1969; Smith et al., 1964.

v. Miscellaneous samplers

Isaacs-Kidd midwater trawl (C): Aron, 1962;  
Isaacs and Kidd, 1953.

Multiple net sampler (C): Bé, 1962; Motoda, 1962.

Clark-Bumpus sampler (E,C): Clarke and Bumpus,  
1950; (C-B modified), Paquette et al.,  
1961.

Bongo net (E,C): Graham and Venno, 1968 (describes  
forerunner to the new bongo net); McGowan  
and Brown, 1966; Sherman and Honey, 1971.

Continuous plankton recorder (C): Glover, 1962;  
Hardy, 1939.

Plankton sled (E): Dovel, 1964; Frolander and  
Pratt, 1962.

Plankton pump: Aron, 1958; 1962.

vi. Flow meters

TSK flow meter (E,C): very reliable but easily clogged and requires maintenance.

Niskin flow meter (E,C): torpedo-shaped; not easily clogged and requires little maintenance; Niskin and Jones, 1963.

b. Techniques

i. Bottom tows: Dovel, 1964; Graham and Vaughan, 1966.

ii. Oblique tows: Gehringer and Aron, 1968; Herman, 1963; Motoda, 1962; Pearcy and Richards, 1962; Riley, 1959; Wheatland, 1956.

iii. Simultaneous surface and bottom tows: Herman, 1963; Hopkins, 1965; Joseph et al., 1960; Massmann et al., 1962.

iv. Other techniques: Aron et al., 1965; Colton et al., 1961; Mahnken and Jossi, 1967; Welch, 1948.

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## VI. GLOSSARY

(For a more complete glossary refer to Mansueti and Hardy, 1967: 9-11.)

- allometric growth -- disproportionate size of a structure during development in relation to the rest of the body
- anadromous -- type of fish that ascend rivers from the sea to spawn
- auditory vesicle -- sensory primordium from which the ear develops; clearly evident during early development
- branched ray -- soft ray with two or more branches distally
- branchiostegals -- struts of dermal bone (or cartilage) below the gill covers that originate on the hyoid arch and support the gill membranes of fishes
- caudal peduncle -- area of the body of a fish between the posterior end of the anal fin base and the base of the caudal fin
- chromatophores -- pigment-bearing cells; often capable of dispersal or aggregation causing changes in size and shape
- demersal egg -- an egg which remains on the bottom either free or attached to substrate
- dichotomous key -- a tabular arrangement of diagnostic data that assists identification by providing subdivisions of characteristics until a species is isolated
- dynamic technique -- for documenting fish developmental stages; involves describing in detail characteristics of the smallest fish larva available and then adding developmental sequences of significant features, such as the fins, head, and chromatophores
- fin bud -- swelling at the site of the future fin
- finfold -- median fold of integument which extends along the body of developing fishes and from which the median fins arise
- gas bladder -- (also called air bladder or swim bladder) -- gas-filled organ in teleosts usually located between the kidneys and alimentary canal
- ichthyoplankton -- term referring to the fish larvae of the plankton community

- inferior mouth -- mouth located near to or on the ventral side of head with snout usually overhanging upper lip
- larva -- in fishes, that period of development extending from hatching from the egg until completion of the adult complement of fin rays in all fins
- median haemal spine -- single spine which projects ventrally from most caudal vertebrae
- melanophores -- black and brown chromatophores
- meristic characters -- segmented or serially divided features such as the number of rays of fins
- morphometric measurements -- proportional lengths taken horizontally or vertically on the body of fish (refer to Figure 2)
- myomere -- serial muscle segment of the body
- notochord -- longitudinal supporting axis of body which is eventually replaced by vertebral column
- notochord length -- (abbreviated NL) -- measured from the tip of the snout along or parallel to the horizontal axis, to the posterior tip of the notochord
- ontogeny -- developmental history of a fish from the egg to the adult
- operculum -- gill cover
- pelagic egg -- buoyant egg; floats freely in the water
- peritoneum -- lining of abdominal cavity
- pleural rib -- rib-like projection on either side of a vertebra in the trunk region; imbedded in musculature of body wall
- principal ray -- branched or unbranched ray which is not rudimentary
- secondary ray -- branched or unbranched ray which is rudimentary
- standard length -- (abbreviated SL) -- measured from the tip of the snout, along or parallel to the horizontal axis, to the end of the median bones at the caudal base (the hypural bones)
- static technique -- method of documenting fish developmental stages in which various size increments are described in detail
- total length -- (abbreviated TL) -- measured from the tip of the snout, along or parallel to the horizontal axis, to the end of the

finfold, or a perpendicular to the end of the longest caudal  
fin ray

urostyle -- elongate last centrum of vertebral column

NOTES