Batrachoidiformes – Atheriniformes – Cyprinodontiformes

Fishes in these orders primarily occur in coastal or estuarine waters, although some batrachoidids may also occur offshore on the continental shelf. Except for the Cyprinodontiformes, these orders are most diverse in the tropics or subtropics, and only a relative few occur regularly in temperate waters. These orders are grouped here for convenience, without implications that they are related. The sequence of orders in the Checklist (Introductory Chapter) inserts the Lophiiformes between Batrachoidiformes and Atheriniformes. Fishes in the order Lophiiformes follow this chapter.

Selected meristic characters in species belonging to the above orders whose adults or larvae have been collected in the study area. Nomenclature and classification sequence follows Saeed *et al*. (1994) (Atheriniformes), Parenti (1981) (Fundulidae) and Eschmeyer (1990).

Order Family *Species*	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Pelvic Fin Rays	Principal Caudal Fin Rays
Batrachoidiformes						
Batrachoididae						
Opsanus tau	34–35	II–III, 24–28	20–24	19–21	I, 2–3	7+7
Porichthys plectrodon	41–47	II, 32–39	31–37	15–19	I, 2	6+7
Atheriniformes						
Atherinopsidae						
Membras martinica	40–44	II–VII, 6–9	I, 15–23	11–15	I, 5	9+8
Menidia beryllina	36–41	IV–VI, 7–11	I, 13–20	12–14	I, 5	9+8
Menidia menidia	37–47	III–VII, 7–11	I, 19–29	12–16	I, 5	9+8
Cyprinodontiformes						
Cyprinodontidae						
Cyprinodon variegatus	25–27	9–13	9–12	14–17	5–7	14–16
Fundulidae						
Fundulus confluentus	–	8–13	7–12	13–18	6	13–20
Fundulus diaphanus	35–36	9–16	9–13	13–19	6	14–17
Fundulus heteroclitus	33–35	10–14	9–12	16–20	6–7	17–22
Fundulus luciae	31–33	7–9	9–11	15–17	6	–
Fundulus majalis	34–35	11–16	10–12	18–20	6	14–20
Lucania parva	25–30	9–14	8–13	10–15	4–7	12–18
Poeciliidae						
Gambusia holbrooki	30–34	7–8	9	12–14	6	–

Batrachoidiformes – Atheriniformes – Cyprinodontiformes

Batrachoidiformes: Little has been published on the early life history stages of fishes in this order. Species in the family Batrachoididae, two of which occur in the study area, do not appear to have a pelagic larval stage. Therefore their early stages are not subject to collection in commonly used plankton nets. Eggs are demersal and are typically attached to objects on the substrate. Parental care of the brood (usually by the male, in those species studied) is another feature of their reproduction. The species included here occur exclusively in estuarine habitats (*Opsanus tau*) or are found on soft substrates in continental shelf habitats (*Porichthys plectrodon*). The latter species is found in tropical and subtropical waters only as far north as Cape Henry, Virginia. There is very limited information on early life history stages of this species. Eggs are 3.5 mm in diameter (mean) but are otherwise undescribed. Fin rays are completely formed before yolk absorption, thus they hatch as "juveniles", are free-swimming at sizes between 12 and 15 mm, and resemble adults in both morphology and pigmentation. Larval development is probably similar to development in a congener from the eastern Pacific Ocean (Watson, 1996f).

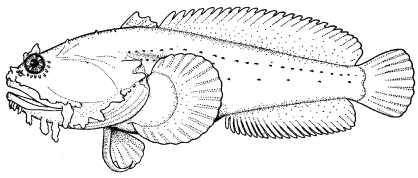
Atheriniformes: Three species in the family Atherinopsidae occur commonly in the study area, although most species in this family occur in tropical or subtropical waters. Most are coastal, estuarine or marginally freshwater residents. Eggs have few to many long, adhesive filaments attached at a particular point on the chorion. Larvae are typically very slender and have very short preanus lengths. Caudal fin rays are typically the first to form, pelvic fin buds form in mid-sequence, and first dorsal and anal fin spines form last. Pigment patterns are similar in all larvae described: melanophores cover the top of the head, top and sides of the gut, and occur in a single row mid-laterally on the body, as well as along the dorsal and ventral margins. Myomeres range from 36 to 47 in the 3 locally occurring species, and precaudal vertebrae typically number 22–23.

Cyprinodontiformes: Members of this large order are generally small fishes found worldwide in temperate and tropical waters, usually in shallow, fresh or brackish, estuarine habitats. Eight species in three families (*sensu* Parenti, 1981) occur along the coast in the study area. Some early life history information is available for all of these species, but there has been very little recent work on ontogeny that includes details on osteological development and some caudal fin characters are unreported. Below are summaries of early life history characteristics for the 3 families represented in the present study area.

Summary of egg characters in families of Cyprinodontiformes from the study area. (After Hardy, 1978a; Able, 1984)

Family	No. of Species in Study Area	Egg Diameters	No. of Oil Globules	Chorion Surface	Hatching Length
Cyprinodontidae	1	1.1–1.7 mm	1, large	Filaments evenly distributed	3.7–4.3 mm
Fundulidae	6	(1.0) 1.5–3.0	5–180, mostly small	Filaments in most, punctate or tufts	4.0–7.7 mm in most; 7.0–11.0 in one species
Poeciliidae	1	1.6–2.1	Many, scattered under chorion	No filaments	Viviparous, 'born' at 5.1–6.2 mm

Opsanus tau (Linnaeus, 1766)
Batrachoididae
Oyster toadfish



Range: Western North Atlantic Ocean from Massachusetts to Cape Sable, Florida; few records north of Cape Cod

Habitat: Bays and estuaries over sand or mud bottoms near oyster reefs, rocky outcrops, benthic debris and aquatic vegetation; mostly in shallow waters, but may overwinter in deeper channels

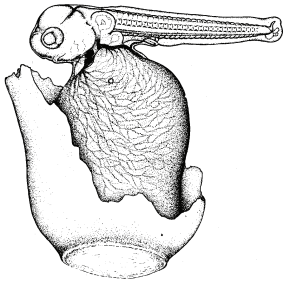
Meristic Characters

Myomeres:	34–35
Vertebrae:	34–35
Dorsal fin rays:	II–III, 24–28
Anal fin rays:	20–24
Pectoral fin rays:	19–21
Pelvic fin rays:	I, 2–3
Caudal fin rays:	7+7 (PrC)

Spawning: Apr–Aug, later off Massachusetts, possibly split into two parts locally; eggs often deposited in cavities among shells or rocks, or in artificial habitats (cans, bottles, etc.)

Eggs:
- Large, spherical, but flattened where attached to substrate or objects
- Diameter: 5.0–5.5 mm
- Chorion: yellow
- Yolk: homogeneous

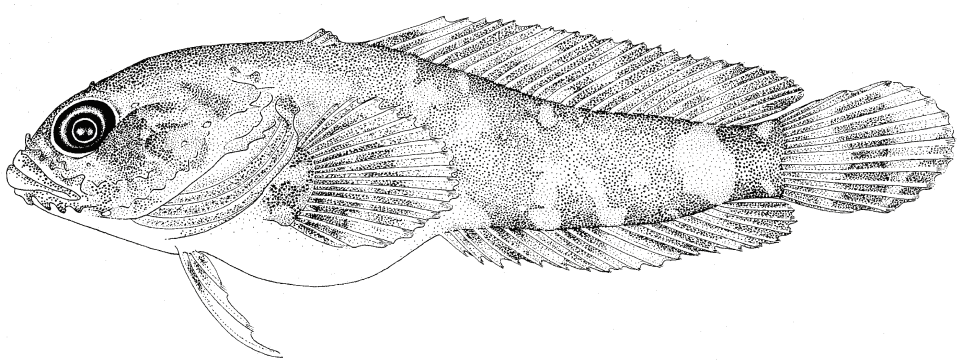
Larvae:
- Larvae hatch at 6.0–7.4 mm; yolk absorbed at about 16–18 mmTL
- Head length increases from about 25% TL to 33% TL
- Body form similar to adults before yolk absorbed
- Cirri form along lower jaw margin by 14 mmTL
- Adult complement of median fin rays formed by 11–14 mmTL
- Pigment includes barred pattern crossing body and fins
- Young stay in nest with male parent 5–18 days after yolk absorption
- Transformation is gradual; adult characters attained about 20 days after hatching



Yolk-sac larva
7.4 mmTL

Note: 1. Juveniles have a few, soft, flexible anterior dorsal spines, followed by a long second dorsal fin; mouth is large and wide and a series of cirri develops along the lower jaw; scales are lacking.

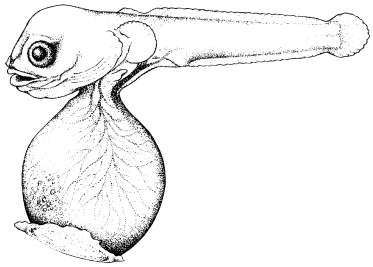
Early Juvenile:



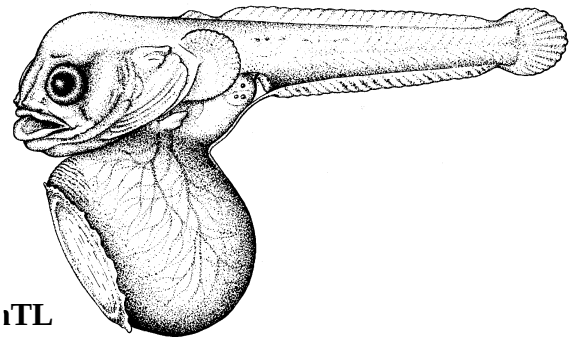
G. 23.0 mmTL

Figures: Adult: Bigelow and Schroeder, 1953; Yolk-sac larva and **A–F**: Dovel, 1960; **G**: Nancy Arthur (Able and Fahay, 1998)
References: Ryder, 1886; Dovel, 1960; Martin and Drewry, 1978; Able and Fahay, 1998

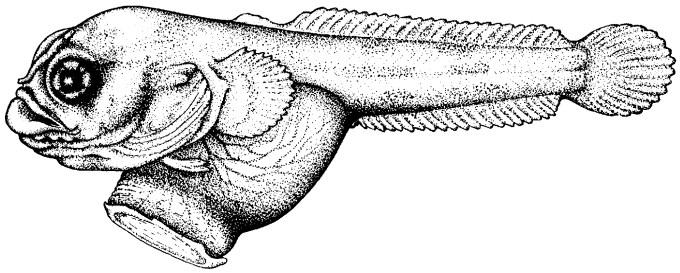
Opsanus tau



A. 10.8 mmTL

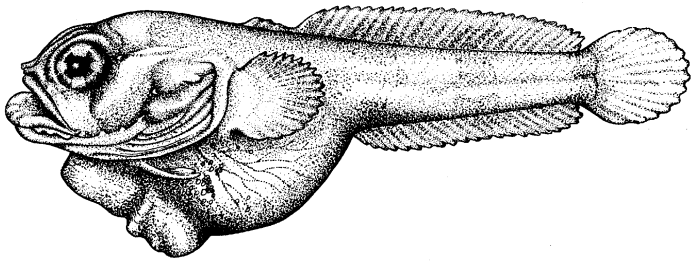


B. 12.4 mmTL



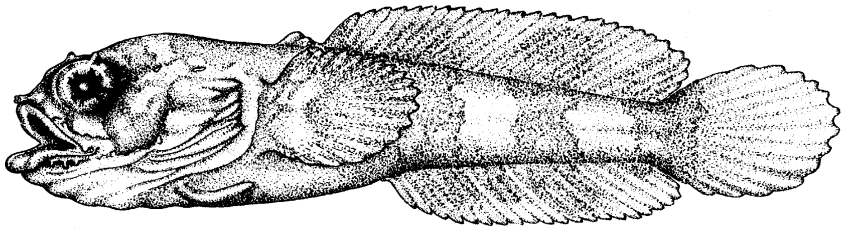
C. 13.7 mmTL

Larvae and yolk attached to substrate

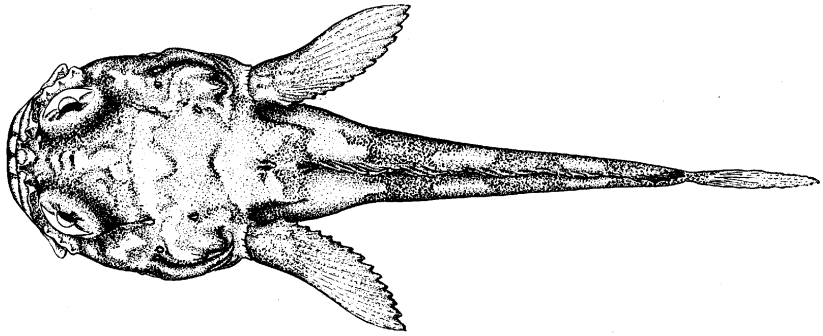


D. 15.3 mmTL

Larvae released from substrate after yolk is absorbed, at a length of about 16-18 mmTL

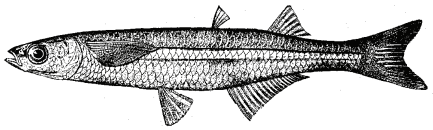


E. 17.1 mmTL



F. 17.1 mmTL (Dorsal View)

Membras martinica (Valenciennes, 1835)
Atherinopsidae
Rough silverside



Range: Western North Atlantic Ocean from New York to Yucatan Peninsula, Mexico, including Gulf of Mexico; more common in southern part of range

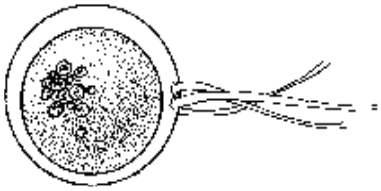
Habitat: Shallow, open waters of bays, estuaries and coastal ocean, usually along exposed shorelines and sandy beaches; not closely associated with vegetation

Spawning: Late spring through summer, based on sampling in Delaware Bay

Meristic Characters

Myomeres:	40–44
Vertebrae:	40–44
Dorsal fin rays:	II–VII, 6–9
Anal fin rays:	I, 15–23
Pectoral fin rays:	11–15
Pelvic fin rays:	I, 5
Caudal fin rays:	9+8

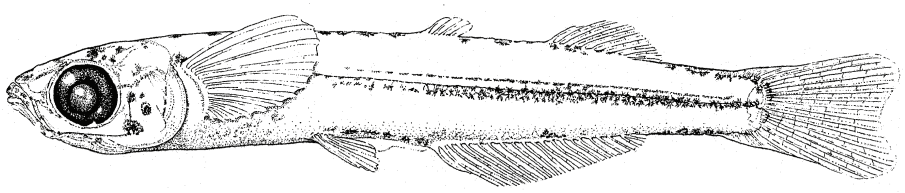
Eggs:
- Demersal, spherical, yellowish
- Diameter: 0.7–0.8 mm
- Oil globules: 8–15 in early stages, fewer in older stages
- 1–3 large attachment filaments originate from single point on chorion
- Perivitelline space: narrow



Larvae:
- Hatching occurs at 3.0–5.0 mmTL
- Body elongate with very short preanus length
- Head short, snout short and pointy, mouth small, gape not reaching level of eye
- Flexion occurs at about 8.0 mmSL
- Sequence of fin ray formation: $C_1 - D_2, A - C_2 - P_1 - P_2 - D_1$
- Dorsal fin spines and pelvic fin rays form very late
- Pigment typically consists of a line of melanophores along midline of body, a row of spots along the mid-dorsal ridge, and a ventral row of spots along the bases of anal fin rays; few spots on top of head and tip of snout; melanophores may occur on opercle and on base of pectoral fin
- Transformation occurs at sizes >20 mmTL

Note: 1. Juveniles have a few, large, widely spaced melanophores along the dorsal midline; the upper sides are usually clear of pigment; note anal fin ray count (I, 15–23)

Early Juvenile:

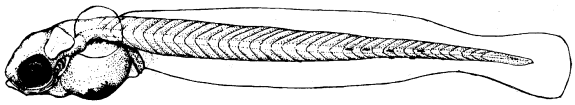


G. 16.0 mmSL

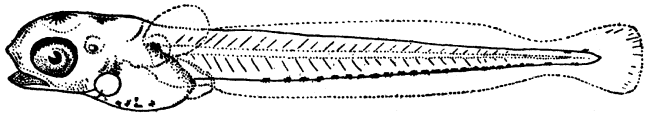
Figures: Adult: Jordan, 1905; Egg and **A**: Wang, 1974; **B, E**: Kuntz, 1916; **C–D, F**: Kolba, 1972; **G:** Susan Kaiser (Able and Fahay, 1998)

References: Wang, 1974; Martin and Drewry, 1978; Able and Fahay, 1998

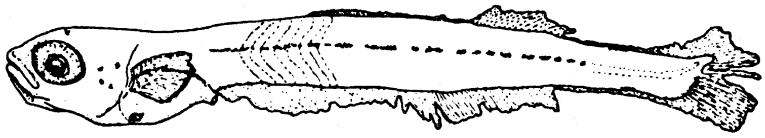
Membras martinica



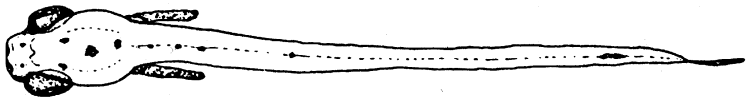
A. 3.8 mmTL



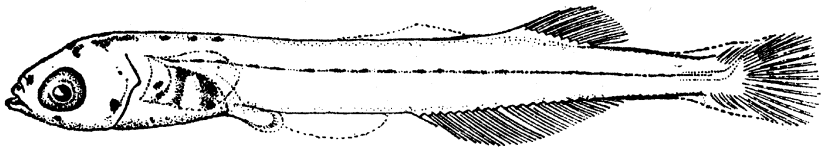
B. 5.0 mmTL



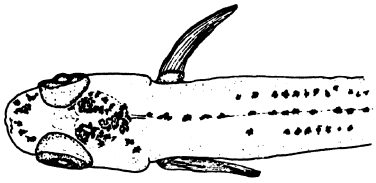
C. 7.3 mmTL



D. 7.3 mmTL
(Dorsal View)



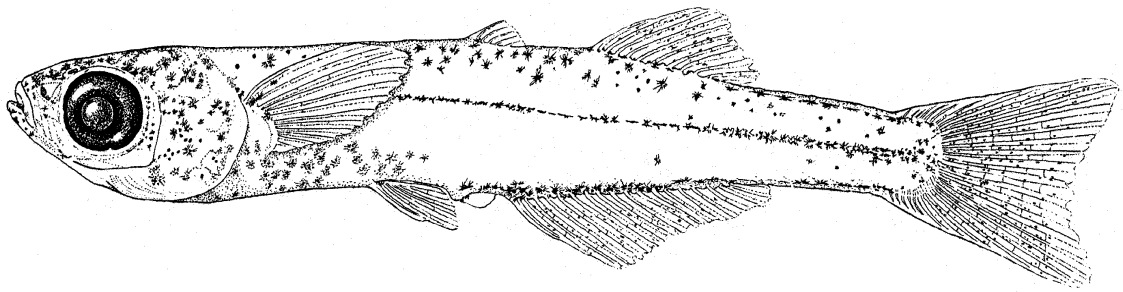
E. 11.0 mmTL



F. 23.1 mmTL
(Dorsal View)

Errata

The figure on the lower part of Page 702 is also incorrect.
Please insert the following figure in its place.



F. 10.3 mmSL

The remainder of the page is correct, including credits and citations.

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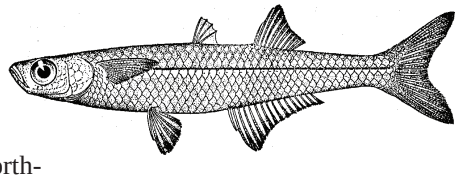
Menidia beryllina (Cope, 1866)
Atherinopsidae
Inland silverside



Range: Western North Atlantic Ocean from Cape Cod, Massachusetts to northeastern Mexico, including Gulf of Mexico

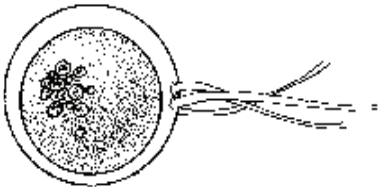
Habitat: Shallow estuarine and freshwater marshes; commonly found in tidal channels, especially near submerged vegetation; migrates into deeper habitats during the winter

Spawning: Jun–Jul in Rhode Island; May–Aug in New Jersey and Delaware Bay salt marshes; primarily in oligohaline waters

Meristic Characters

Myomeres:	36–41
Vertebrae:	36–41
Dorsal fin rays:	IV–VI, 7–11
Anal fin rays:	I, 13–20
Pectoral fin rays:	12–14
Pelvic fin rays:	I, 5
Caudal fin rays:	9+8

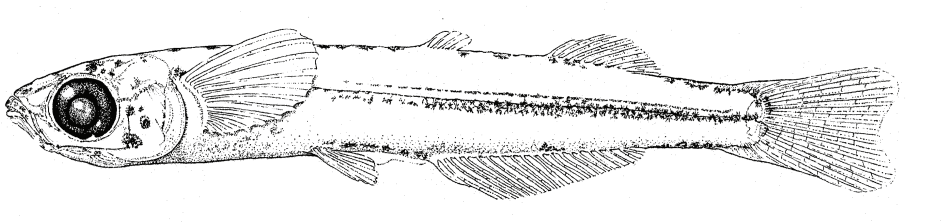
Eggs:
- Demersal, spherical
- Diameter: 0.8–0.9 mm
- Oil globules: 1–3 large (various sizes)
- 1 large, 5 or more smaller attachment filaments originate from single point on chorion
- Perivitelline space: narrow



Larvae:
- Hatching occurs at 3.5–4.0 mmTL
- Body elongate with very short preanus length
- Head short, snout short and blunt, mouth small, gape not reaching level of eye
- Flexion occurs at 7.8–8.9 mmSL
- Sequence of fin ray formation: $C_1 - D_2$, A, $P_1 - C_2 - P_2 - D_1$
- Pigment typically consists of a line of melanophores along midline of body, weak pigment along mid-dorsal ridge and a weak line of pigment along ventral margin of body behind anus; melanophores also occur on head, above gut; spot also forms on opercle
- Transformation occurs at 16.0–24.0 mmTL

Note:
1. Juveniles have scattering of small pigment spots along dorsal midline, extending down onto upper sides; note anal fin ray count (I, 13–20)

Early Juvenile:

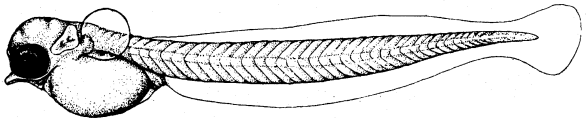


G. 16.0 mmSL

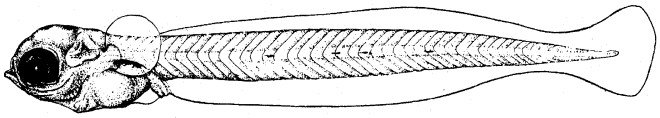
Figures: Adult: Kendall, 1902; Egg and **A–B**, **E**: Wang, 1974; **C–D**: A. J. Lippson (Martin and Drewry, 1978); **F:** Susan Kaiser (Able and Fahay, 1998)

References: Wang, 1974; Martin and Drewry, 1978; Able and Fahay, 1998

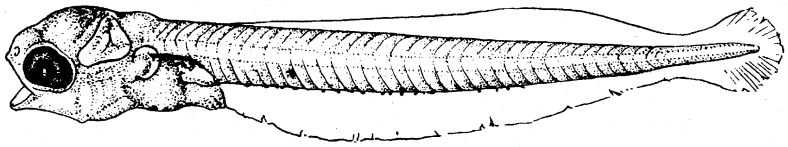
Menidia beryllina



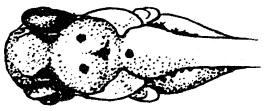
A. 3.7 mmTL



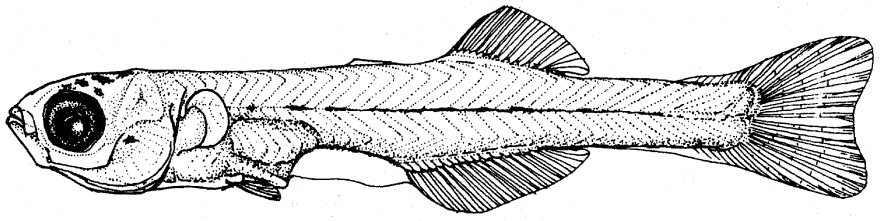
B. 4.7 mmTL



C. 6.7 mmTL

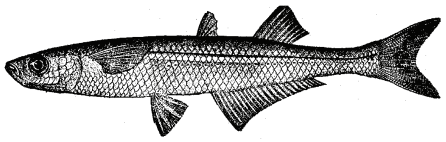


D. 6.7 mmTL
(Dorsal View)



E. 8.9 mmTL

Menidia menidia (Linnaeus, 1766)
Atherinopsidae
Atlantic silverside



Range: Western North Atlantic Ocean from Gulf of St. Lawrence to Florida; most abundant from Cape Cod to South Carolina

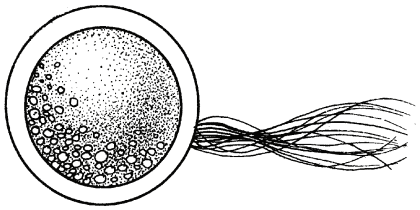
Habitat: Shallow estuarine and marine waters; commonly on open beaches over sand or gravel bottoms or in tidal creeks; typically move offshore into oceanic waters during winter

Spawning: Apr–Jun in Massachusetts; late Apr-early July in Rhode Island; May–Jul in New Jersey; spawns intertidally during daytime high tides

Meristic Characters

Myomeres:	37–47
Vertebrae:	37–47
Dorsal fin rays:	III–VII, 7–11
Anal fin rays:	I, 19–29
Pectoral fin rays:	12–16
Pelvic fin rays:	I, 5
Caudal fin rays:	9+8

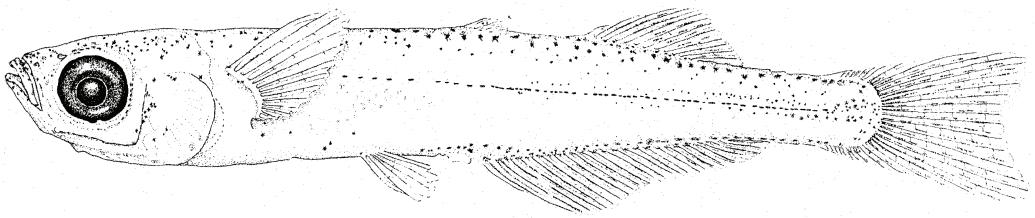
Eggs:
- Demersal, spherical
- Diameter: 1.0–1.5 mm
- Oil globules: 5–12 large
- Numerous long attachment filaments form a tuft on chorion
- Perivitelline space: narrow



Larvae:
- Hatching occurs at 3.8–5.0 mmTL
- Body elongate with very short preanus length
- Head short, snout short and blunt; mouth small, gape not reaching level of eye
- Flexion occurs at about 9.0 mmSL
- Sequence of fin ray formation: C_1 – A, D_2 – C_2 – P_1 – P_2 – D_1
- Pigment includes scattering of large melanophores on both sides of dorsum; prominent spots on top of head; paired line of spots along base of anal fin; row of spots forms along midline
- Transformation occurs at 16.0–24.0 mmSL

Note:
1. Juveniles have a scattering of pigment on upper sides and a silvery stripe extending along the side; note anal fin ray count (I, 19–29)

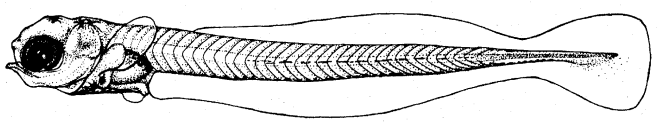
Early Juvenile:



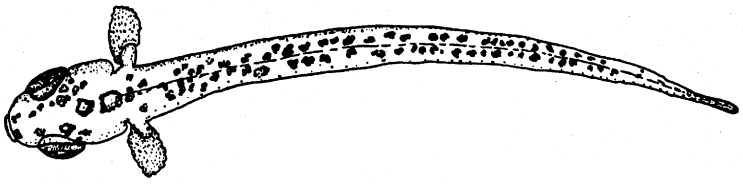
E. 17.4 mmSL

Figures: Adult: Kendall, 1902; Egg and **A**: Wang, 1974; **B–D**: Kolba, 1972; **E**: Susan Kaiser (Able and Fahay, 1998)
References: Wang, 1974; Martin and Drewry, 1978; Able and Fahay, 1998

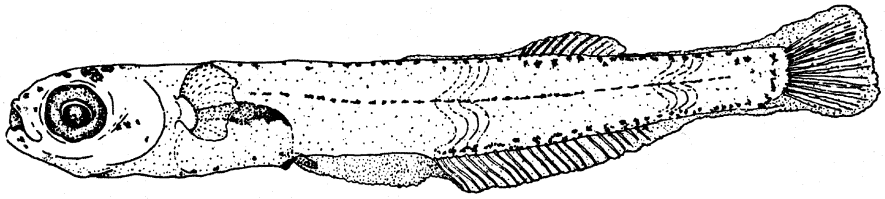
Menidia menidia



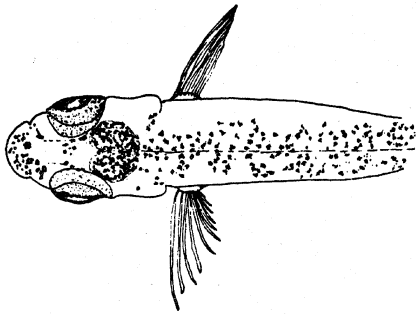
A. 7.0 mmTL



B. 9.2 mmSL
(Dorsal View)

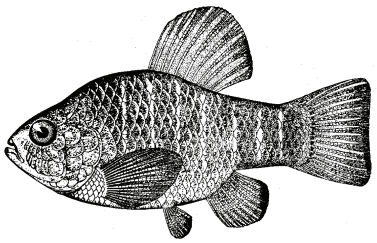


C. 12.1 mmSL



D. 23.8 mmSL
(Dorsal View)

Cyprinodon variegatus Lacepède, 1803
Cyprinodontidae
Sheepshead minnow



Range: Western North Atlantic Ocean from Cape Cod, Massachusetts to Yucatan Peninsula, Mexico

Habitat: Very shallow estuarine waters, in depths typically <0.5 m; common in protected coves, bays, ponds and especially salt marshes

Spawning: Spring and summer in estuaries between New Jersey and North Carolina; most spawning in vegetated marsh surface pools

Meristic Characters

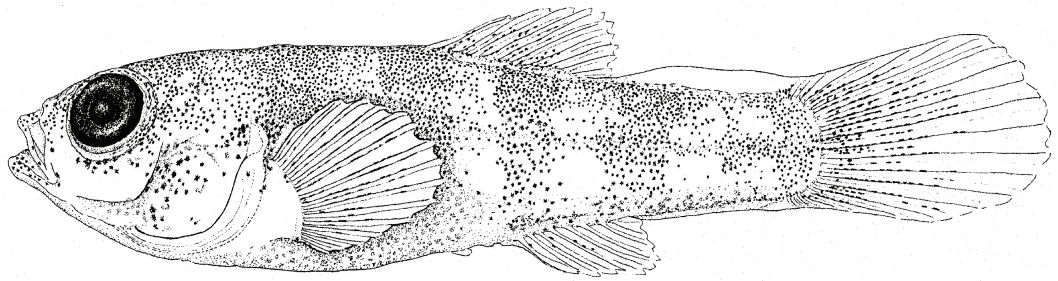
Myomeres:	25–27
Vertebrae:	25–27
Dorsal fin rays:	9–13
Anal fin rays:	9–12
Pectoral fin rays:	14–17
Pelvic fin rays:	5–7
Caudal fin rays:	14–16

Eggs:
- Demersal, spherical
- Diameter: 1.2–1.4 mm
- Oil globules: 1 large (about 0.24 mm) and many tinier
- Many attachment filaments cover chorion (not shown)
- Perivitelline space: narrow

Larvae:
- Hatching occurs at about 4.2–5.2 mmTL
- Body initially fairly elongate, with bulging gut; becomes more plump
- Head small, with short, blunt snout and small mouth
- Flexion occurs at about 5.0 mmTL
- Fin ray formation: caudal fin rays form first, pelvic fin rays form late; all fin rays complete by 12.0 mm
- Pigmentation includes 6 or more bars crossing body, although some specimens described as lacking pigment pattern; melanophores at base of caudal fin rays
- Transformation occurs at about 12.0 mmTL

Note:
1. Juveniles characterized by plump body and vague, barred pigment pattern
2. A current study presents molecular evidence that the northern population of this species (that portion within the present study area, e.g. Cape Cod to Chesapeake Bay) should be elevated to full species status as *Cyprinodon ovinus* (Mitchill). (Finne, K. L. and B. J. Turner. In Press.) *Cyprinodon ovinus*: molecular evidence for a distinctive northern lineage of the sheepshead pupfish, *Cyprinodon variegatus* (Cyprinodontidae). Environmental Biology of Fishes.)

Early Juvenile:

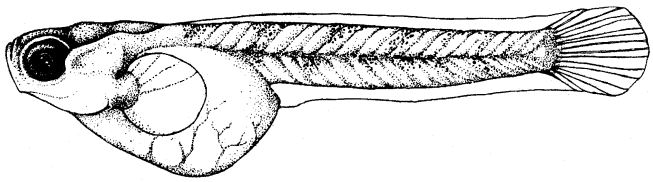


D. 10.6 mmTL

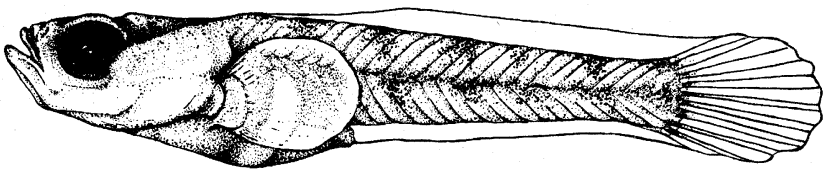
Figures: Adult: Jordan and Evermann, 1896–1900; Egg and **C**: Kuntz, 1916; **A–B**: R. Lynn Moran (Foster, 1974); **D**: Susan Kaiser (Able and Fahay, 1998)

References: Kuntz, 1916; Hardy, 1978; Foster, 1974; Talbot and Able, 1984; Smith, 1995

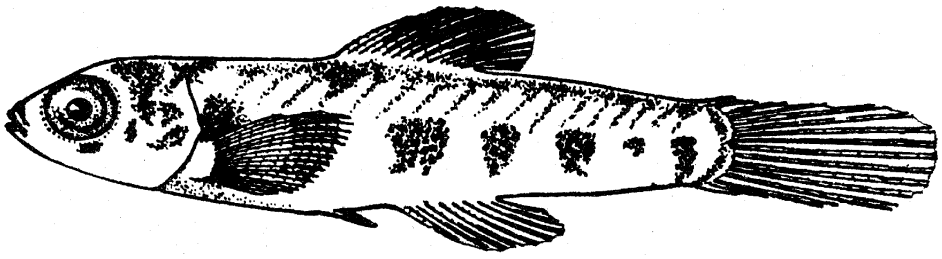
Cyprinodon variegatus



A. 3.4 mmTL

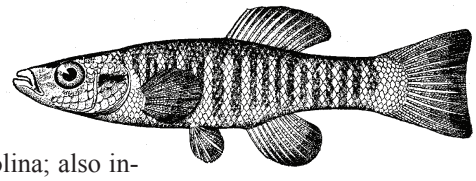


B. 4.2 mmTL



C. 9.0 mm

Fundulus diaphanus (Lesueur, 1817)
Fundulidae
Banded killifish



Range: Atlantic coast of North America from Newfoundland to South Carolina; also inland locations from southern Canada to Iowa, Illinois, Indiana, Ohio and Pennsylvania

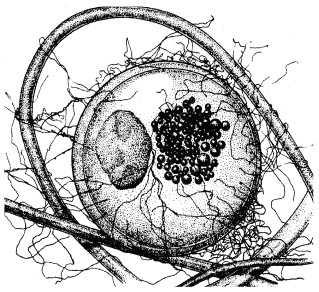
Habitat: Shallow depths in fresh, tidal fresh, and brackish waters; estuarine areas along open, sandy shores, especially near mouths of freshwater streams; also tidal pools and creeks; may co-occur with *Fundulus heteroclitus*, but probably does not co-occur with *Fundulus majalis*, which prefers higher salinities

Meristic Characters

Myomeres:	35–36
Vertebrae:	35–36
Dorsal fin rays:	9–16
Anal fin rays:	9–13
Pectoral fin rays:	13–19
Pelvic fin rays:	6
Caudal fin rays:	14–17

Spawning: Spring to early fall; eggs deposited on fibrous or grassy bottoms, in fresh (occasionally brackish) shallows

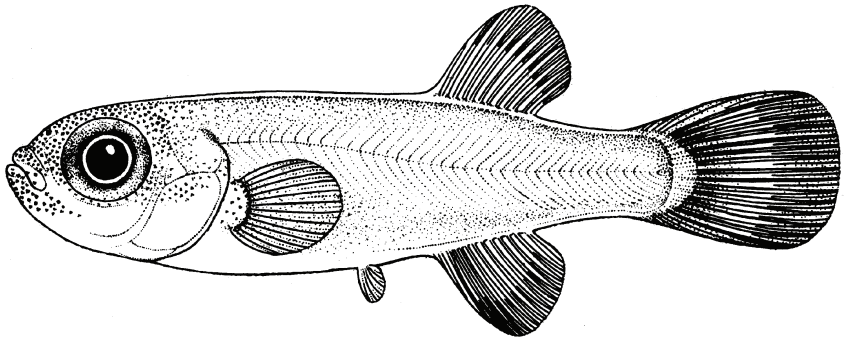
Eggs:
- Demersal, spherical, light yellow
- Diameter: 1.5–2.0 mm
- Oil globules: many
- Perivitelline space: wide
- Attached to vegetation by many adhesive filaments



Larvae:
- Hatching occurs at about 5.0–5.5 mm
- Body in early larvae somewhat more slender than in *Fundulus heteroclitus*
- Head small with large eye
- Mouth very small; gape not reaching level of eye
- Dorsal fin origin posterior to anal fin origin in early larvae
- Pigment light; melanophores follow myosepta on body; top of head and area near snout and mouth well-pigmented
- Caudal fin rays form first, followed by pectoral fin rays; dorsal, anal and pelvic form later

Note:
1. Juveniles develop 16–20 vertical bars on body, meeting on mid-dorsal ridge (cf. fewer bars in *F. heteroclitus*)
2. Longitudinal scale rows >40 (cf. <39 in other fundulids in study area)
3. A congener, *Fundulus confluentus* Goode and Bean, may co-occur with *F. diaphanus* in marsh habitats from Virginia to South Carolina. Eggs are demersal, 1.6–1.8 mm in diameter, and have 10–15 oil globules. They are either buried in substrate or attached to algae or vegetation with attachment filaments. Larvae are not well described. (See Hardy, 1978a.)

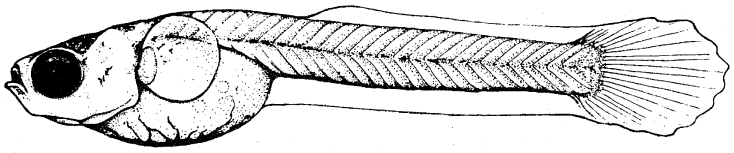
Early Juvenile:



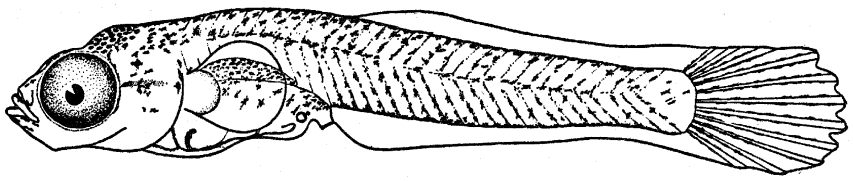
D. 14.0 mmTL

Figures: Adult: Smith, H.M., 1892; **Egg**: Foster, 1971; **A**: R. Lynn Moran (Foster, 1974); **B–C**: Fish, 1932; **D**: Fowler, 1945
References: Fish, 1932; Foster, 1974; Hardy, 1978a

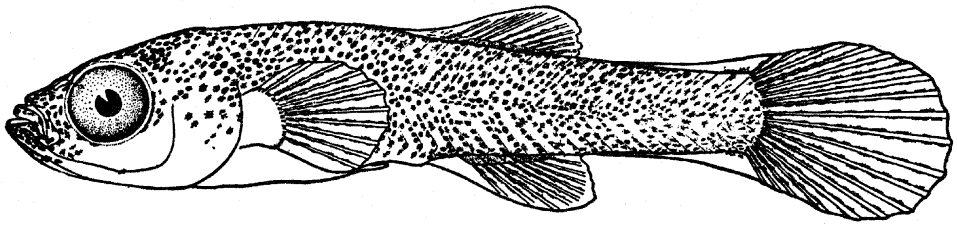
Fundulus diaphanus



A. 5.6 mmTL

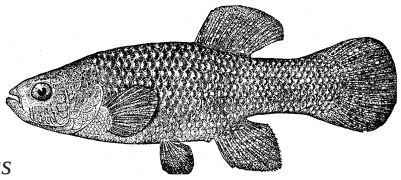


B. 7.1 mmTL



C. 12.3 mmTL

Fundulus heteroclitus (Linnaeus, 1766)
Fundulidae
Mummichog



Range: Atlantic coast of North America; subspecies *Fundulus h. macrolepidotus* occurs from Connecticut to Newfoundland, with disjunct populations in upper Delaware and Chesapeake bays; subspecies *Fundulus h. heteroclitus* occurs from northern New Jersey to Florida, including lower Delaware and Chesapeake bays

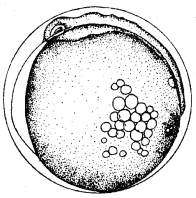
Habitat: Shallow estuarine waters including high marsh surface pools, ponds, ditches; also in eel grass beds and open shorelines over sand or silt

Spawning: May–Jul in Massachusetts; Apr–Aug in New Jersey; Mar–Aug in North Carolina; eggs deposited in cracks, crevices and small interstices, intertidally; deposition substrates differ by subspecies

Meristic Characters

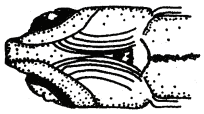
Myomeres:	33–35
Vertebrae:	33–35
Dorsal fin rays:	10–14
Anal fin rays:	9–12
Pectoral fin rays:	16–20
Pelvic fin rays:	6–7
Caudal fin rays:	17–22

Eggs:
- *Fundulus h. heteroclitus*: 2.0–2.2 mm diameter; numerous small-diameter short attachment filaments on chorion; numerous oil globules;
- *Fundulus h. macrolepidotus*: 1.6–1.9 mm diameter; few, large diameter long attachment filaments on chorion; few oil globules



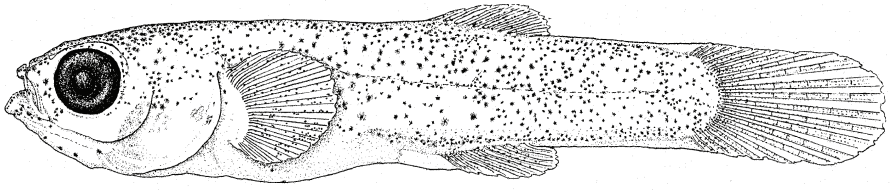
Larvae:
- Hatching occurs at 4.8–5.5 mmTL, depending on subspecies; larger in *Fundulus h. heteroclitus*
- Body elongate with bulging yolk, becomes deeper with development
- Head small with large eye, small, terminal mouth
- Dorsal and anal fin origins at about mid-point of body
- Caudal fin rays form first, pectoral fin rays next; pelvic fin rays last to form
- Pigment includes dense melanophores on dorsum of head and double row of spots on mid-dorsal and mid-ventral regions
- Transformation occurs at about 20 mm, when full complements of fin rays are formed

Note:
1. In larger juveniles, 9–17 short, vertical bars form on lateral body and a dense patch of melanophores forms anterior to dorsal fin
2. Ventral view of head (compare to *Fundulus majalis*):



Early Juvenile: Usually 5, evenly spaced branchiostegals; distinct line of intense, thoracic melanophores; short snout, blunt head

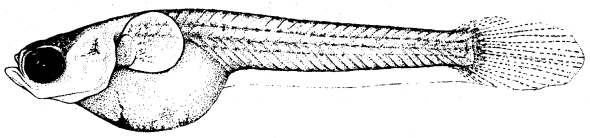
G. 11.0 mmTL



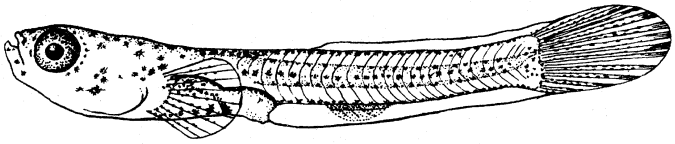
Figures: Adult: Jordan and Evermann, 1896–1900; Egg: Armstrong and Child, 1965; **A**: R. Lynn Moran (Foster, 1974); **B**: Oscar Sette (Hardy, 1978a); **C**: Newman, 1908; ventral view of head and **D–E**: Richards and McBean, 1966; **F**: Byrne, 1976; **G**: Susan Kaiser (Able and Fahay, 1998)

References: Lippson and Moran, 1974; Hardy, 1978a; Able and Fahay, 1998

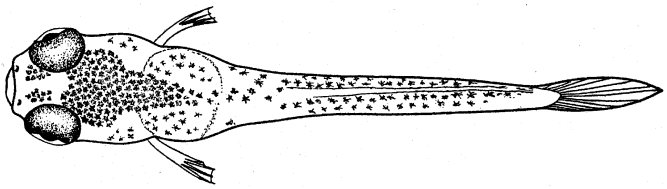
Fundulus heteroclitus



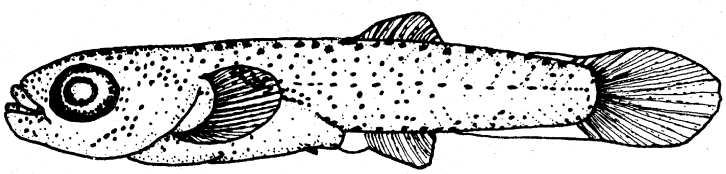
A. 5.2 mmTL



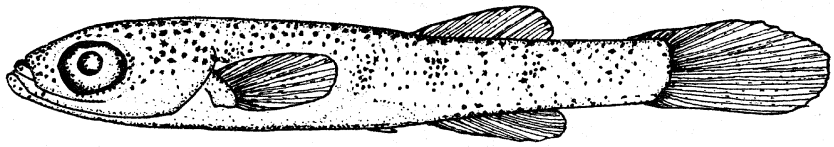
B. 7.3 mmTL



C. 7.3 mmTL
(Dorsal View)

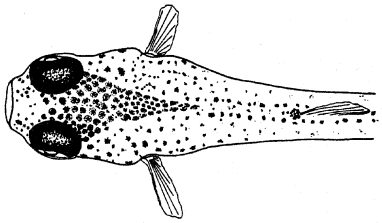


D. 11.8 mmTL



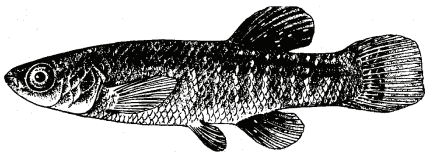
E. 18.3 mmTL

Compare dorsal pigmentation to that of *Fundulus luciae*



F. Size unknown
(Dorsal View)

Fundulus luciae (Baird, 1855)
Fundulidae
Spotfin killifish



Range: Atlantic coast of the United States from Massachusetts to Georgia; most reports of early life history stages originate in southern part of present study area

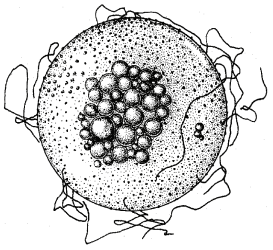
Habitat: Occurs in wide range of estuarine salinities and temperatures; usually in shallow pools on marsh surface; also intertidal creeks; apparently little or no migration to deeper habitats during winter

Spawning: Late May–Jul in New Jersey; Apr–Sep in Chesapeake Bay; eggs deposited (buried) in sand substrates in shallow, intertidal pools

Meristic Characters

Myomeres:	31–33
Vertebrae:	31–33
Dorsal fin rays:	7–9
Anal fin rays:	9–11
Pectoral fin rays:	15–17
Pelvic fin rays:	6
Caudal fin rays:	–

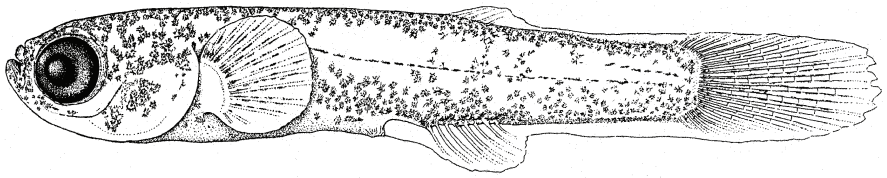
Eggs:
- Demersal, spherical
- Diameter: 2.0–3.0 mm
- Oil globules: about 50
- Perivitelline space: narrow
- Large attachment filaments over chorion, with micro-filaments on the larger filaments and on surface of chorion



Larvae:
- Hatching occurs at lengths of 4.8–6.3 mmTL, depending on duration of incubation
- Large yolk mass at hatching; later larvae are slightly deeper through pectoral area than posteriorly
- Dorsal and anal fins originate at about mid-body
- Caudal fin rays form first; pelvic fin rays form last
- Pigment includes scattering of melanophores on top and sides of head and along dorsum of body; sides of body and belly typically unpigmented; mid-dorsal stripe of pigment well-developed by about 11.0 mm
- Transformation occurs at about 13.0 mmTL

Note:
1. *Fundulus luciae* have 5 branchiostegal rays; *Fundulus heteroclitus* have 5; *Fundulus majalis* have 6
2. A congener, *Fundulus confluentus* Goode and Bean, may co-occur with *F. luciae* in marsh habitats from Virginia to Georgia. Eggs are demersal, 1.6–1.8 mm in diameter, and have 10–15 oil globules. They are either buried in substrate or attached to algae or vegetation with attachment filaments. Larvae are not well described. (See Hardy, 1978a.)

Early Juvenile:

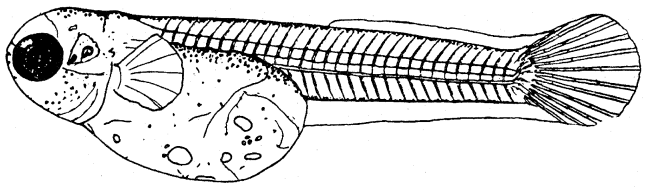


E. 6.9 mmSL

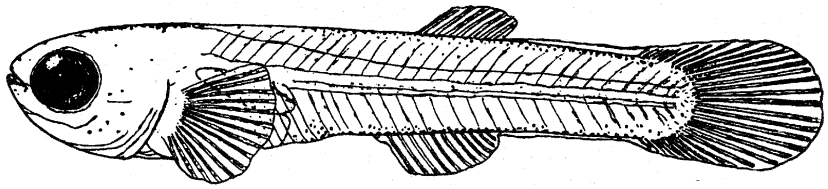
Figures: Adult: Hildebrand and Schroeder, 1928; Egg: Elizabeth Peters (Hardy, 1978a); **A–D**: Byrne, 1976; **E**: Susan Kaiser (Able and Fahay, 1988)

References: Byrne, 1976; Hardy, 1978a; Talbot and Able, 1984; Able and Fahay, 1998

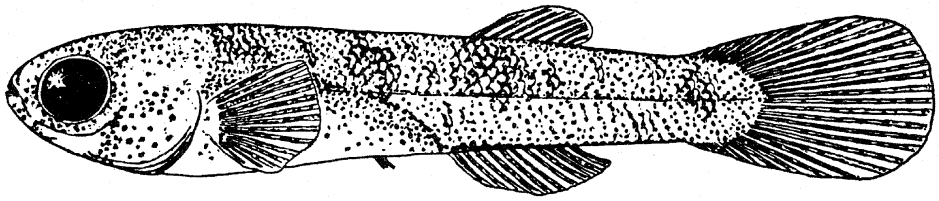
Fundulus luciae



A. 5.3 mmTL

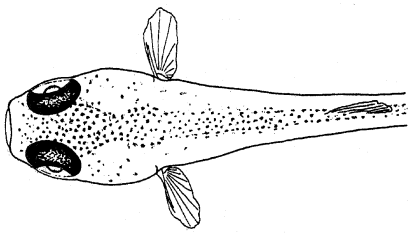


B. 9.5 mmTL



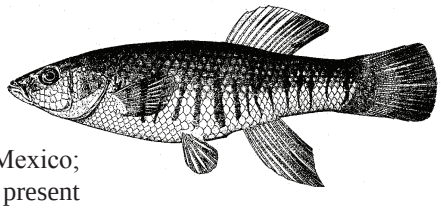
C. 11.2 mmTL

Compare dorsal pigmentation to that of *Fundulus heteroclitus*



D. Size unknown (Dorsal View)

Fundulus majalis (Walbaum, 1792)
Fundulidae
Striped killifish



Range: Atlantic coast of the United States from New Hampshire to the Gulf of Mexico; most reports of early life history stages originate in southern part of present study area

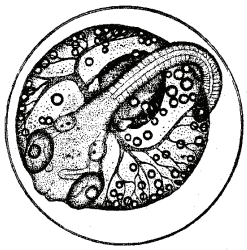
Habitat: Occurs in a variety of shallow habitats from open beaches to coves, bays and occasionally marsh creeks; found in salinities of 1.0–37.0 ppt, but usually most abundant in higher salinities

Meristic Characters

Myomeres:	34–35
Vertebrae:	34–35
Dorsal fin rays:	11–16
Anal fin rays:	10–12
Pectoral fin rays:	18–20
Pelvic fin rays:	6
Caudal fin rays:	14–20

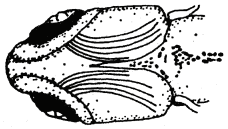
Spawning: Late May–Jul in New Jersey; Apr–Sep in Chesapeake Bay; multiple cohorts suggest 2 or 3 spawning peaks, possibly associated with spring tides; eggs deposited (possibly buried) in shallow, intertidal pools over sandy substrates

Eggs:
- Demersal, spherical, yellowish or amber
- Diameter: 2.0–3.0 mm
- Oil globules: about 50
- Perivitelline space: narrow
- Large attachment filaments over chorion, with micro-filaments on the larger filaments and on the chorion (not shown in illustration)



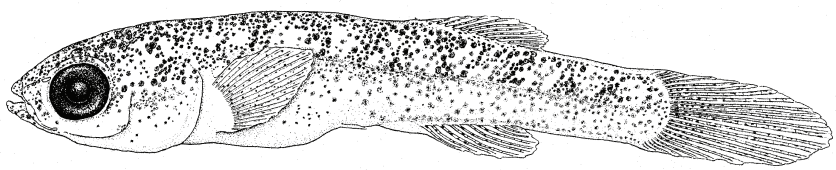
Larvae:
- Hatching occurs at lengths of 7.0–11.0 mm
- Body is moderately elongate with bulging yolk; becomes deeper-bodied in later stages
- Head small with fairly large eye; snout longer than in *Fundulus heteroclitus*, with small, terminal mouth
- Dorsal and anal fin origins at about mid-point of body
- Caudal fin rays first to form, pectoral fin rays next, pelvic fin rays last to form
- Pigmentation includes numerous, large melanophores on dorsal surface of head and body and along bases of finfolds; a distinct aggregation of spots occurs at origin of dorsal fin; larger larvae develop a pattern of 5–7, then 6–12 long bars that reach the dorsum

Note:
1. Juveniles are more slender than those of *Fundulus heteroclitus* and have a longer snout. They also develop a more strongly barred pigment pattern than *F. heteroclitus*.
2. Ventral view of head (compare to *F. heteroclitus*):



Early Juvenile: Usually 6 branchiostegal rays, the 1st 2 closely spaced; diffuse pattern of thoracic spots; snout long, head tapered

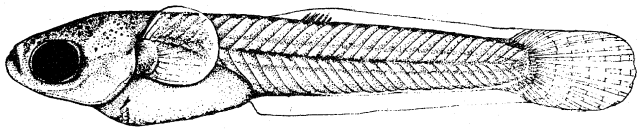
E. 14.5 mmTL



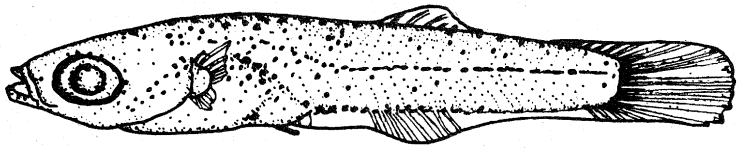
Figures: Adult: Bigelow and Schroeder, 1953; Egg: Ryder, 1885; **A**: R. Lynn Moran (Foster, 1974); ventral view of head and **B–D**: Richards and McBean, 1966; **E**: Susan Kaiser (Able and Fahay, 1998)

References: Richards and McBean, 1966; Hardy, 1978a; Able and Fahay, 1998

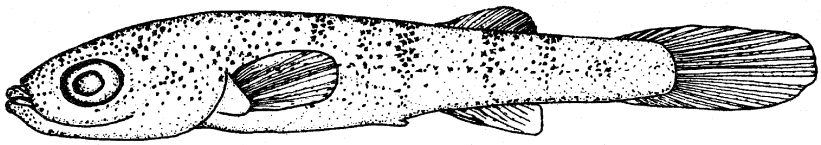
Fundulus majalis



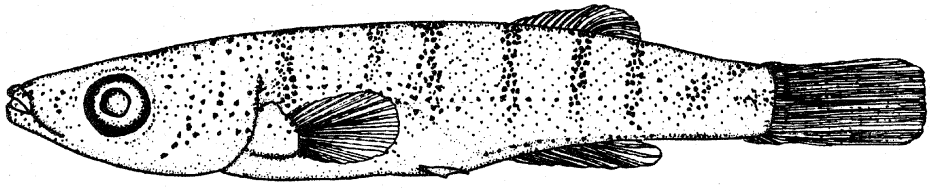
A. 8.9 mmTL



B. 11.8 mmTL



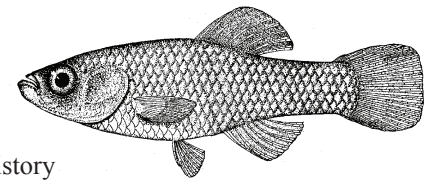
C. 19.5 mmTL



D. 23.8 mmTL

Larvae and juveniles of *Fundulus majalis* and *F. heteroclitus* are best distinguished by pigment patterns and head shape (in larvae <10 mm) or by numbers of branchiostegal rays and head shape (in those >10 mm). *Fundulus majalis* have a more barred pigment pattern, longer snout and 6 branchiostegal rays. *Fundulus heteroclitus* are more evenly pigmented, with a slight suggestion of barring at mid-body, have a shorter snout and 5 branchiostegal rays. Morphometric and meristic data and a series of comparative illustrations of early stages in the 2 species are provided by Richards and McBean (1966).

Lucania parva (Baird and Girard, 1855)
Fundulidae
Rainwater killifish



Range: Atlantic coast of North America from Cape Cod to Mexico; early life history stages less frequently reported from northern part of this range; some inland populations in Florida and New Mexico; introduced elsewhere

Habitat: Shallow, vegetated or open shore habitats in coves, flats, bays and creeks; rarely offshore in marine waters; occur in salinities ranging from 48.2 ppt to totally freshwater

Spawning: Jun–Aug in New Jersey; May–Jul in Delaware; occurs in freshwater and in polyhaline marshes; male courtship behavior near clumps of vegetation; eggs often deposited on fibrous substrates near surface

Meristic Characters

Myomeres:	25–30
Vertebrae:	25–30
Dorsal fin rays:	9–14
Anal fin rays:	8–13
Pectoral fin rays:	10–15
Pelvic fin rays:	4–7
Caudal fin rays:	12–18

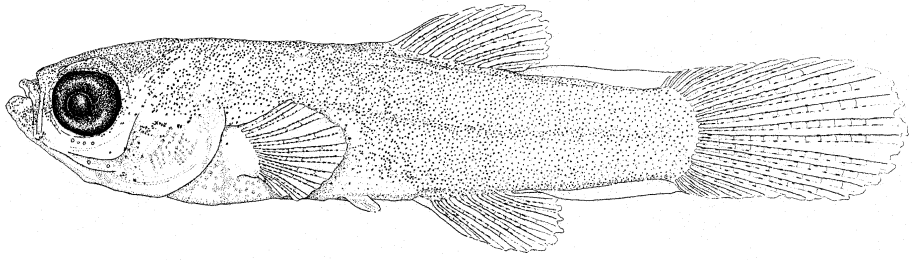
Eggs:
- Demersal, spherical, yellowish
- Diameter: 1.0–1.3 mm
- Oil globules: typically 12–20, unequal in size
- Perivitelline space: very narrow
- Attachment filaments over chorion, but most concentrated in one area

Larvae:
- Hatching occurs at 4.0–5.0 mm
- Head length about half the preanus distance
- Small larvae uniformly covered with small melanophores
- Caudal fin large, rays form early; pectoral fin rays form next
- Pigment includes a row of spots mid-laterally, another row along mid-dorsal ridge, and a third row ventrally from over gut to base of caudal fin; spots also develop on base of caudal fin, on opercle, and on top of head

Note:
1. Juveniles are lighter than adults and have a silvery band on the side; bars along the sides are lacking (cf: *Fundulus* sp. juveniles); black spots develop on the dorsal fin of males
2. Another killifish, *Fundulus confluentus* Goode and Bean, may co-occur with *L. parva* in marsh habitats from Virginia to Texas. Eggs are demersal, 1.6–1.8 mm in diameter, and have 10–15 oil globules. They are either buried in substrate or attached to algae or vegetation with attachment filaments. Larvae are not well described. (See Hardy, 1978a.)

Early Juvenile:

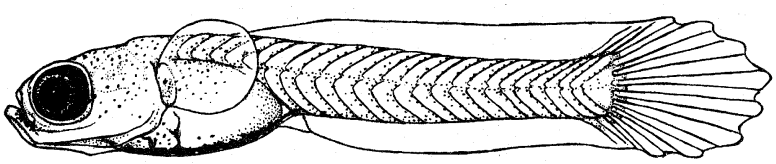
C. 11.1 mmTL



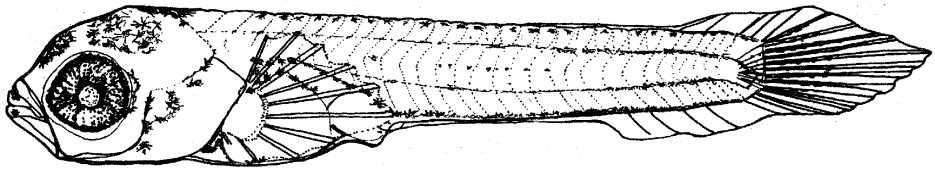
Figures: Adult: Bean, 1888; Egg: Kuntz, 1916; **A**: R. Lynn Moran (Foster, 1974); **B**: Nancy Schenk Smith (Hardy, 1978a); **C**: Susan Kaiser (Able and Fahay, 1998)

References: Hardy, 1978a; Wang and Kernehan, 1979; Talbot and Able, 1984; Able, 1990; Able and Fahay, 1998

Lucania parva

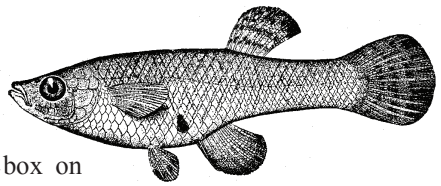


A. 4.0 mmTL



B. 6.5 mmTL

Gambusia holbrooki Girard, 1859
Poeciliidae
Eastern mosquitofish



Range: Atlantic coast of United States, south of Delaware Bay; (see note box on figure page, opposite)

Habitat: Quiet, shallow, fresh and brackish pools and marshes; often in stagnant waters, but also in a wide variety of habitats; occurs in wide range of salinities and temperatures, but 10°C considered critical minimum

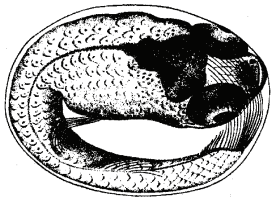
Spawning: Late spring-summer in New Jersey; May–Sep in Chesapeake Bay; fertilization and egg development is internal

Eggs:
- (Ovarian): diameter at late embryo stage: 1.5–2.4 mm

Larvae:
- Hatching occurs at 8–10 mm
- Almost all fin rays and scales completely developed at birth
- Pelvic fin rays formed by about 10 mm
- Anal fin origin well anterior to dorsal fin origin
- Pigment includes an over-all yellowish color, with dusky fins and a series of spots crossing the caudal fin; a prominent blotch on top of head, extending posteriorly; a discrete row forms along mid-lateral line; larger larvae have 2 or 3 rows of spots across dorsal fin and the anal fin has dark margin; series of spots on caudal fin aligns into 3 or 4 rows
- Individuals >13.0 mm are considered juveniles; sexual dimorphism in the anal fins (including the formation of intromittent organ in males) begins at about 20.0 mm

Meristic Characters

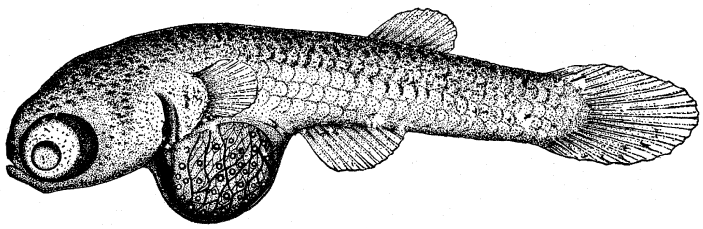
Myomeres:	30–34
Vertebrae:	30–34
Dorsal fin rays:	7–8
Anal fin rays:	9
Pectoral fin rays:	12–14
Pelvic fin rays:	6
Caudal fin rays:	–



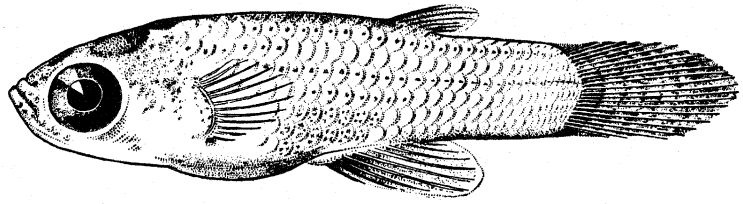
Figures: Adult: Hildebrand, 1919; Ovarian egg and embryo: Kuntz, 1914; **A**: Ryder, 1885; **B–D**: Kuntz, 1914

References: Kuntz, 1914; Hildebrand and Schroeder, 1928; Wang and Kernehan, 1979; Wooten *et al*., 1988; Able and Fahay, 1998

Gambusia holbrooki

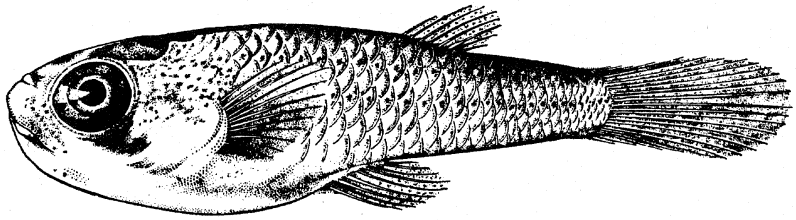


A. 7.1 mmTL (Embryo)

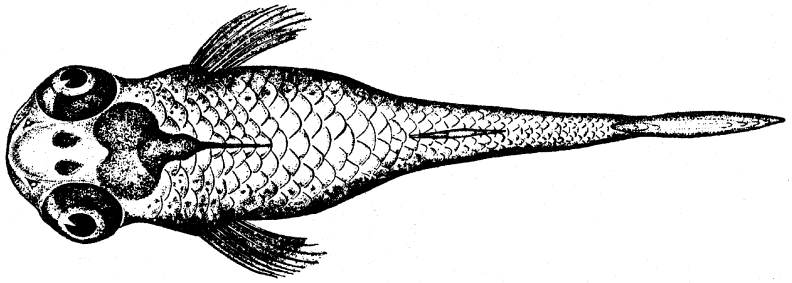


B. 6.3 mmTL (Embryo) (See note below)

C. 7.4 mmTL



D. 7.4 mmTL (Dorsal View)



Two species of *Gambusia* occur in the eastern United States. The native, coastal species is *Gambusia holbrooki* Girard, 1859. *Gambusia affinis* (Baird and Girard, 1853) originates from the central part of North America, but has been widely introduced into other areas (including the east coast of the U.S.) for mosquito control. Because of the collection date (Kuntz, 1914) and location (North Carolina), the embryo and larva in Figs. B and C are most likely *Gambusia holbrooki*. *Gambusia holbrooki* has also been widely introduced within and beyond its range, and therefore the resulting ranges of the two species are not clearly delineated or described.