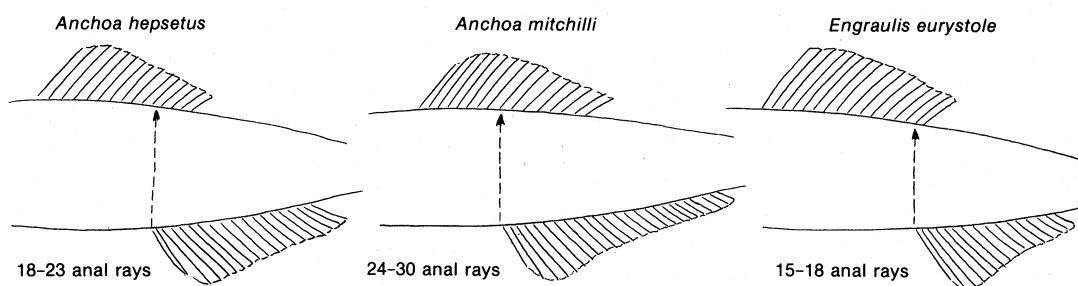


Clupeiformes

Meristic characters in species belonging to the order Clupeiformes whose adults or larvae have been collected in the study area. Families and genera are listed alphabetically. Rarely observed counts in parentheses. Sources: Munroe (2000; 2002a; 2002b). Also see species accounts.

| Family <i>Species</i> | Vertebrae | Dorsal Fin Rays | Anal Fin Rays | Pectoral Fin Rays | Pelvic Fin Rays |
|-----------------------------|-----------|--------------------|------------------|----------------------|--------------------|
| Clupeidae | | | | | |
| <i>Alosa aestivalis</i> | 47–53 | 15–20 | 15–21 | 14–18 | 9–11 |
| <i>Alosa mediocris</i> | 53–55 | 15–20 | 19–23 | 15–16 | 9 |
| <i>Alosa pseudoharengus</i> | 46–50 | 12–18 | 15–20 | 14–16 | 10 |
| <i>Alosa sapidissima</i> | 55–57 | (14)18–19(21) | (18)21–22(25) | 13–18 | 8–10 |
| <i>Brevoortia tyrannus</i> | 45–50 | 18–24 | 18–24 | 13–19 | 7 |
| <i>Clupea harengus</i> | 52–62 | (16)17–19(22) | (15)17–19(21) | 13–21 | 6–10 |
| <i>Dorosoma cepedianum</i> | 47–51 | 10–15 | 25–37 | 14–17 | 7–10 |
| <i>Dorosoma petenense</i> | 43–44 | 11–15 | 17–27 | 12–17 | (7)8 |
| <i>Etrumeus teres</i> | 46–50 | 15–22 | 10–13 | 14–16 | 8 |
| <i>Harengula jaguana</i> | 41–43 | 17–19 | 17–18 | 13–15 | (7)8 |
| <i>Opisthonema oglinum</i> | 45–49 | 17–22 | 20–25 | 15–19 | 8–9 |
| <i>Sardinella aurita</i> | 45–49 | 16–19 | 16–20 | 15–16 | 7–8 |
| Engraulidae | | | | | |
| <i>Anchoa hepsetus</i> | 40–44 | 13–16 | 19–23 | 13–15 | 7 |
| <i>Anchoa mitchilli</i> | 38–44 | 13–17 | 23–30 | 11–12 | 7 |
| <i>Engraulis eurystole</i> | 43–45 | 13–16 | 15–18 | 14–16 | 7 |

Note: Three species of engraulids can best be distinguished by the relative positions of their dorsal and anal fins and by anal fin ray counts. These characters are most reliable in larvae >10 mm, juveniles and adults. Dorsal and anal fin origins can be almost opposite each other in adult *A. mitchilli*.



Clupeiformes

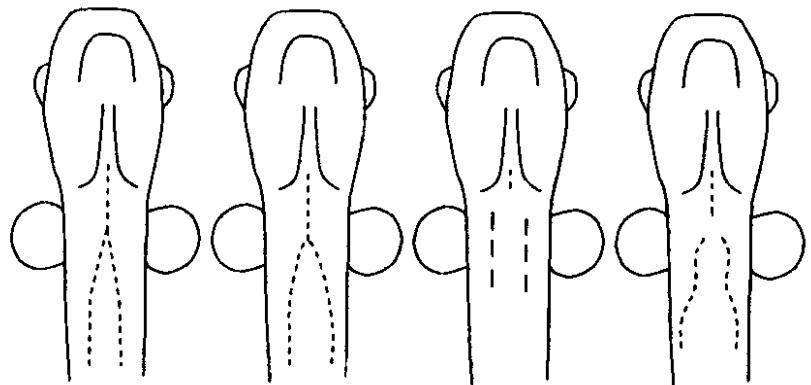
Synopsis of characters for distinguishing larvae of the Clupeidae. "Dors-Anal" refers to number of myomeres between posterior dorsal and anterior anal fins. This number decreases at transformation in most species, as fin positions shift. Note that this number remains relatively stable through ontogeny in the genus *Alosa*.

| | Total Myomeres | Preanal Myomeres | Predorsal Myomeres | Dors-Anal Myomeres | Notochord Pigment Dorsal Tip | Notochord Pigment Ventral Tip | Miscellaneous |
|-----------------------------|----------------|-------------------|--------------------|----------------------|------------------------------|-------------------------------|--------------------------------------|
| <i>Alosa aestivalis</i> | 47–53 | 42–45 | – | 11–13 | No | Yes | Slim-bodied, small-eyed |
| <i>Alosa mediocris</i> | 53–55 | 38–42 | – | 7–8 | In small larvae | Yes | – |
| <i>Alosa pseudoharengus</i> | 46–50 | 39–43 | – | 7–9 | Yes | Yes | Deep-bodied, large-eyed |
| <i>Alosa sapidissima</i> | 55–57 | 41–47 | – | 9 to 7 ¹ | No | Yes | – |
| <i>Brevoortia tyrannus</i> | 45–50 | 38–40, then 35–36 | 30–31, then 24–25 | 5 to 1 | In small larvae | Yes | High D and A fin ray counts |
| <i>Clupea harengus</i> | 52–62 | 47, then 41–46 | 33 to 25 | 8–9 to 4 | Varies | Yes | Late anal fin ray formation |
| <i>Dorosoma cepedianum</i> | 47–51 | 39–44 | – | 10 to 7 ¹ | No | No | Very high anal fin ray count |
| <i>Dorosoma petenense</i> | 43–44 | 36 | – | 10 to 7 ¹ | No | No | Scattered pigment on caudal peduncle |
| <i>Etrumeus teres</i> | 48–50 | 39–40, then 36 | 27–32, then 26 | 5 to 2 | No | Yes | Early teeth; low anal fin ray count |
| <i>Harengula jaguana</i> | 39–42 | 35, then 27 | 25, then 10 | 5 to 7 | Yes | If yes, forms late | Low myomere count |
| <i>Opisthonema oglinum</i> | 45–49 | 40–41, then 34–36 | 26–27, then 22–23 | 8–10 to 5–7 | No | Yes | High anal fin ray count |
| <i>Sardinella aurita</i> | 45–48 | 38–40, then 34 | 26–27, then 18 | 7–8 to 5 | No | Yes | – |

¹ Determined from illustrations; need confirmation

Patterns of ventral pigment, posterior to cleithrum, in larvae of four species of *Alosa*. These patterns may be incomplete in many larvae. (Walsh *et al.*, 2005, modified from Sismour, 1994.)

Walsh *et al.*, (2005) also provide a size-dependent key to larvae of these four species (plus *Dorosoma cepedianum*) from the southern part of the study area (Roanoke River, North Carolina).

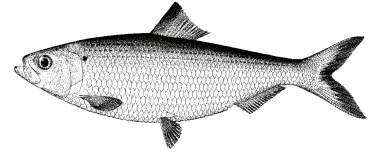


A. pseudoharengus

A. aestivalis

A. mediocris

A. sapidissima

Alosa aestivalis* (Mitchill, 1815)*Clupeidae****Blueback herring**

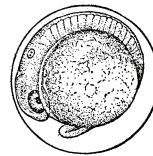
Range: Atlantic coast of North America from Nova Scotia to St. John's River, Florida

Habitat: Pelagic, schooling species, inhabiting coastal areas over the inner continental shelf (deeper during winter), moving into brackish or fresh waters to spawn

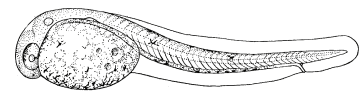
Spawning: Adults migrate into coastal rivers during spring for spawning; begins in late Apr, continues through May in southern part of range, as late as Sep in Connecticut

Eggs:

- Pelagic to semi-demersal, slightly adhesive
- Diameter: 0.87–1.11 mm
- Chorion: yellowish, semitransparent
- Chorion; somewhat thick, inner surface corrugated
- Oil globules small, unequal in size, scattered
- Yolk: granular
- Perivitelline space: wide

**Meristic Characters**

| | |
|--------------------|--------------|
| Myomeres: | 47–53 |
| Vertebrae: | 14–16+33–35 |
| Dorsal fin rays: | 15–20 |
| Anal fin rays: | 15–21 |
| Pectoral fin rays: | 14–18 |
| Pelvic fin rays: | 9–11 |
| Caudal fin rays: | 7–8+10+9+6–7 |



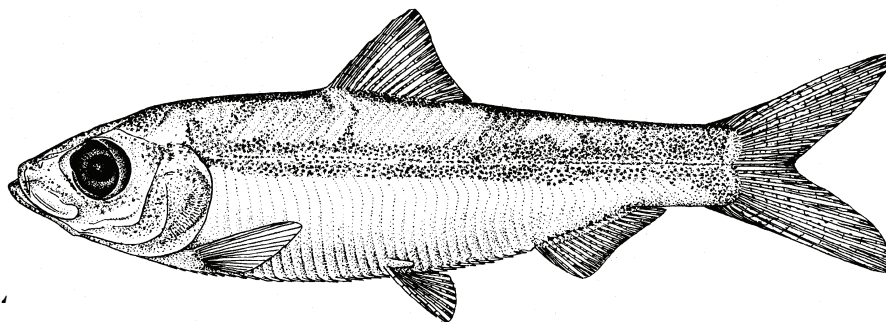
Yolk-sac larva

Larvae:

- Hatching occurs at 3.1–5.0 mmTL; eye pigmented
- Body elongate with long, straight gut; anus always posterior to dorsal fin
- Sequence of fin ray formation: D–C–A, P₁, P₂ (ossification sequence based on illustrations)
- 11–13 myomeres between posterior dorsal and anterior anal fins
- Discrete melanophores below pectoral fin base become a double line of pigment
- Pigment along upper and lower gut in distinct rows
- Notochord tip pigment present on ventral side only
- Transformation occurs between 20 and 30 mm

Note:

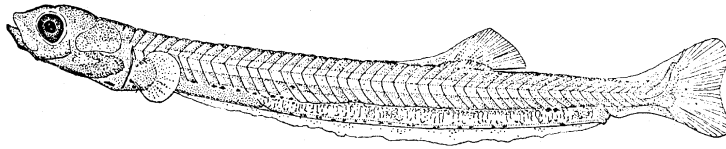
1. Slimmer and smaller-eyed than *A. pseudoharengus*
2. See comparative table in Clupeidae Introduction

Early Juvenile:**E. 45.0 mmTL.**

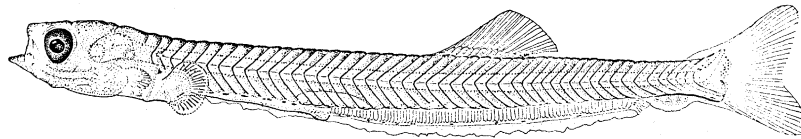
Figures: Adult: H.L. Todd (Hildebrand, 1963a); Egg and yolk-sac larva: Mansueti and Hardy, 1967; **A–B:** Chambers *et al.*, 1976; **C:** Ann S. Green (Hildebrand, 1963a); **D:** Nancy D. Patton (Hildebrand, 1963a); **E:** Mansueti and Hardy, 1967

References: Jones *et al.*, 1978; Able and Fahay, 1998; Munroe, 2000; 2002b

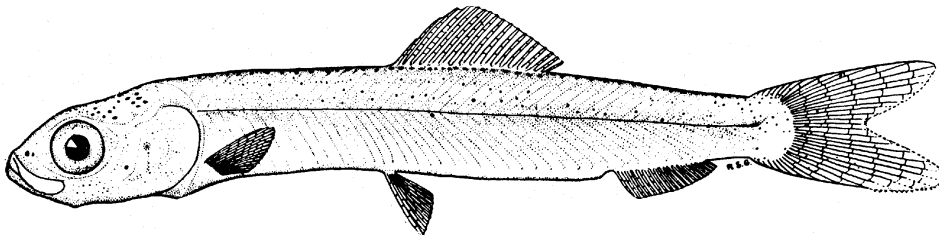
Alosa aestivalis



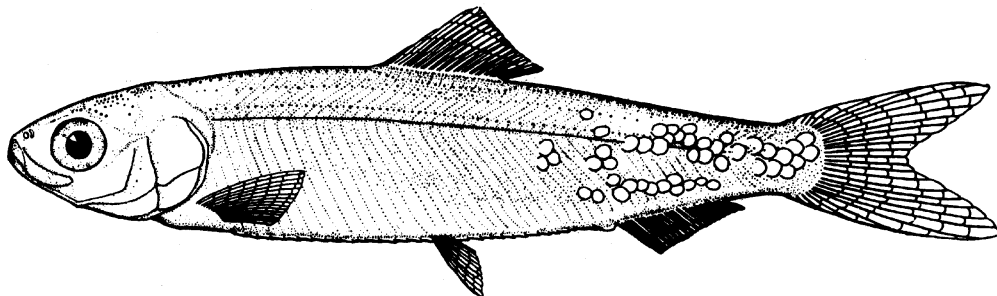
A. 12.0 mmTL



B. 14.8 mmTL

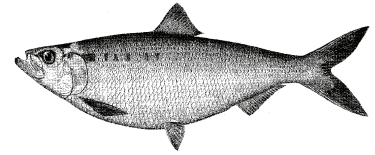


C. 20.5 mmTL



D. 25.0 mmTL

***Alosa mediocris* (Mitchill, 1814)**
Clupeidae
 Hickory shad

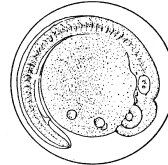


Range: Atlantic coast of North America from Bay of Fundy to Florida
Habitat: Inner continental shelf, estuaries, tidal rivers; oceanic distribution during winter not well known

Spawning: In tidal freshwater, late Apr through early Jun

Eggs:

- Spherical, semi-demersal, slightly adhesive
- Diameter: 0.96–1.65 mm
- Chorion: transparent, thick, finely corrugated
- Yolk: densely segmented, amber
- Oil globules: few, small
- Perivitelline space: very wide

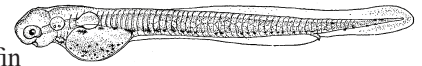


Meristic Characters

| | |
|--------------------|----------|
| Myomeres: | 53–55 |
| Vertebrae: | 17+37 |
| Dorsal fin rays: | 15–20 |
| Anal fin rays: | 19–23 |
| Pectoral fin rays: | 15–16 |
| Pelvic fin rays: | 9 |
| Caudal fin rays: | 9+10+9+7 |

Larvae:

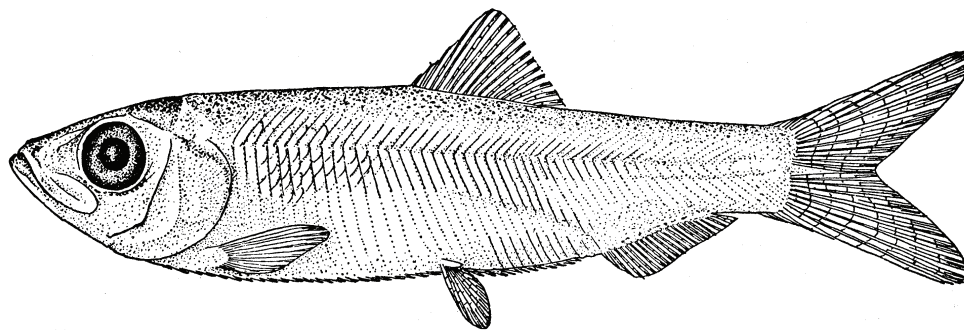
- Hatching occurs at 5.2–6.5 mm; eye pigmented
- Body elongate with long, straight gut; anus always posterior to dorsal fin
- Preanus length 80–86% TL
- Posterior gut with muscle-band striations
- Flexion occurs at 10–15 mm
- Sequence of fin ray formation: D–C, A, P₂–P₁ (ossification sequence based on illustrations)
- Pigmentation includes elongate melanophores along ventral surface of gut with few spots on dorsal surface in early larvae; later larvae have melanophores on ventrum from throat area to region above anal fin
- Transformation occurs between 20 and 30 mm



Yolk-sac larva

Note: 1. See comparative table in Clupeidae Introduction

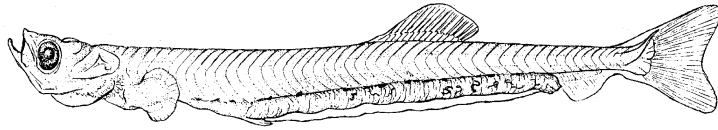
Early Juvenile:



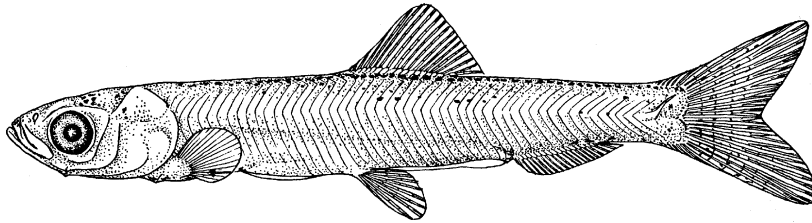
E. 35.2 mmTL

Figures: Adult: H.L. Todd (Hildebrand, 1963a); Egg, yolk-sac larva and A–E: Mansueti, 1962
References: Jones *et al.* 1978; Able and Fahay, 1998; Munroe, 2000; 2002b

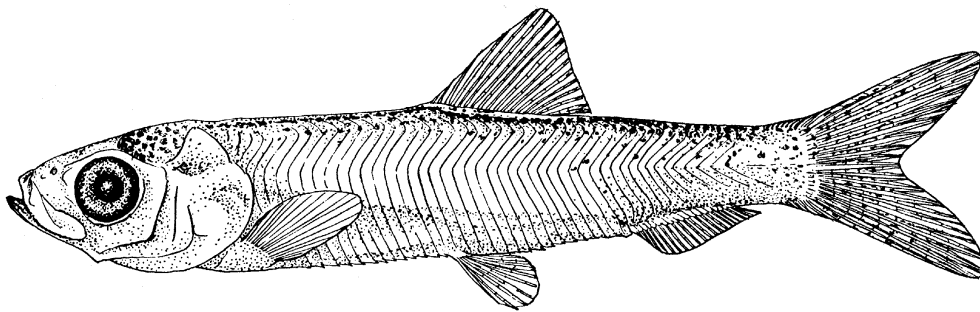
Alosa mediocris



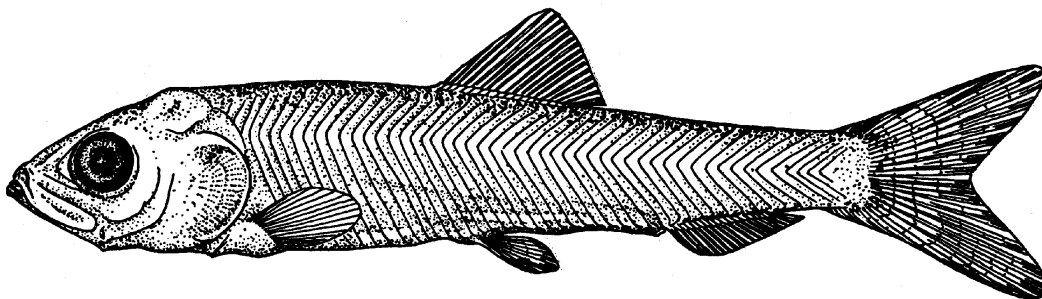
A. 15.8 mmTL



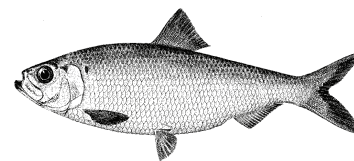
B. 19.5 mmTL



C. 24.3 mmTL



D. 27.0 mmTL

Alosa pseudoharengus* (Wilson, 1811)*Clupeidae****Alewife**

Range: Atlantic coast of North America from Newfoundland to South Carolina, most abundant between Gulf of Maine and Chesapeake Bay; also land-locked populations, Great Lakes and New York

Habitat: Pelagic, schooling species, inhabiting coastal areas adjacent to freshwater nursery areas; spends fall and winter in continental shelf waters 56–110 m deep, primarily off Southern New England, Georges Bank and Gulf of Maine

Spawning: Adults migrate into coastal rivers during spring for spawning; larvae and juveniles occur in estuaries throughout range, except those with limited freshwater input.

Eggs:

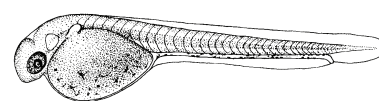
- Demersal and adhesive
- Diameter: 0.87–1.11 mm
- Chorion: semitransparent and yellowish
- Yolk: segmented
- Oil globules: small, unequal in size, scattered
- Perivitelline space: wide

**Meristic Characters**

| | |
|--------------------|------------|
| Myomeres: | 46–50 |
| Vertebrae: | 46–50 |
| Dorsal fin rays: | 12–18 |
| Anal fin rays: | 15–20 |
| Pectoral fin rays: | 14–16 |
| Pelvic fin rays: | 9–10 |
| Caudal fin rays: | 10+9 (PrC) |

Larvae:

- Hatching occurs at 3.1–5.0 mm; eyes pigmented
- Body elongate with long, straight gut; anus always posterior to dorsal fin
- Preanus length about 80% TL
- Posterior gut with muscle-band striations at sizes >10.0 mm
- Flexion occurs at about 9.0 mmSL
- Sequence of fin ray formation: D, C – A – P₂ – P₁ (ossification sequence based on illustrations)
- Pigmentation includes row of spots on dorsal half of anterior gut, ventral surfaces of posterior gut; early larvae have rows of spots on dorsal and ventral surfaces of caudal peduncle; 1 large melanophore above base of pectoral fin; dorsolateral pigment appears in larger larvae
- Transformation occurs between 25 and 30 mm



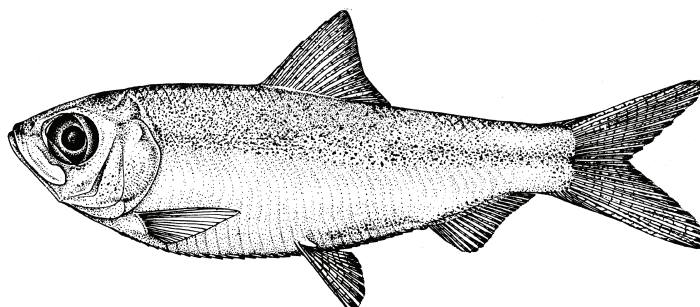
Yolk-sac larva

Note:

1. Deeper-bodied and larger-eyed than *Alosa aestivalis*
2. See comparative table in Clupeidae Introduction

Early Juvenile:

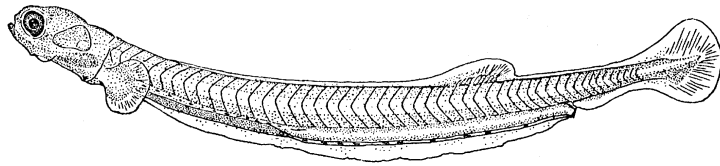
- Larger juveniles have single, dark spot on side posterior to opercle
- Sharp scutes form along midline of belly

**E. 42.0 mmTL**

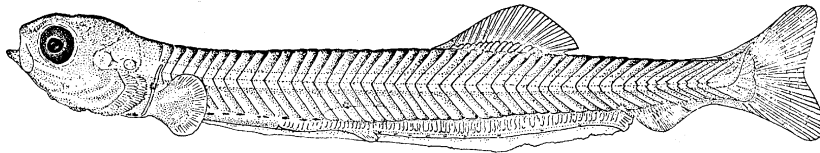
Figures: Adult: H.L. Todd (Hildebrand, 1963a); Egg, yolk-sac larva: Mansueti and Hardy, 1967; A–B: Chambers *et al.*, 1976; C: Norden, 1967; D: Ann S. Green (Hildebrand, 1963); E: Mansueti and Hardy, 1967

References: Jones *et al.*, 1978; Able and Fahay, 1998; Munroe, 2000; 2002b

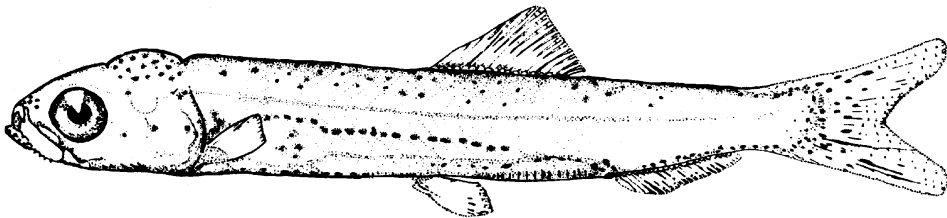
Alosa pseudoharengus



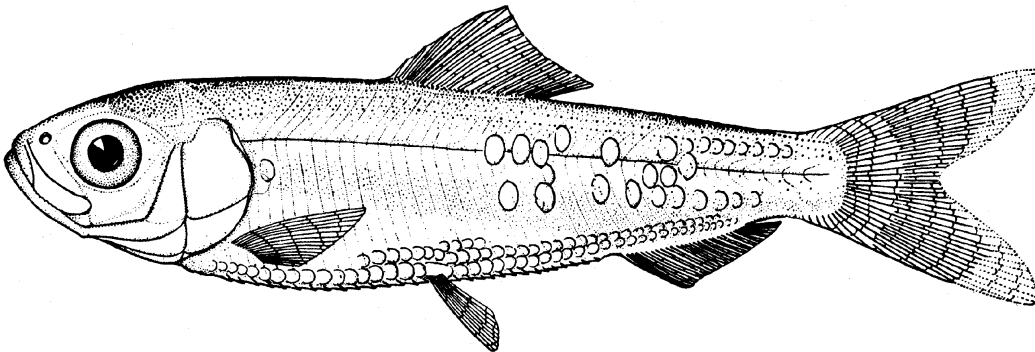
A. 9.0 mmTL



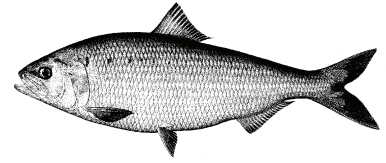
B. 15.0 mmTL



C. 24.5 mmTL



D. 29.0 mmTL

Alosa sapidissima* (Wilson, 1811)*Clupeidae****American shad**

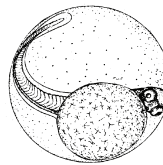
Range: Atlantic coast of North America from Labrador to Florida; most abundant between Connecticut and North Carolina

Habitat: Congregate in Gulf of Maine during summer and fall, then most overwinter off Middle Atlantic Bight, at depths to 230 m

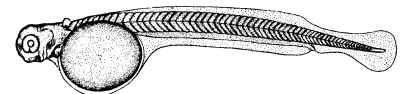
Spawning: Adults migrate into coastal rivers to spawn during spring; larvae develop in freshwater, juveniles form schools as they drift downstream summer and fall

Eggs:

- Demersal, adhesive early stages
- Later stages non-adhesive
- Diameter: 2.5–3.8 mm
- Chorion: Transparent, pale pink or amber
- Yolk: segmented
- Oil globules: none
- Perivitelline space: wide

**Meristic Characters**

| | |
|--------------------|------------|
| Myomeres: | 55–57 |
| Vertebrae: | 55–57 |
| Dorsal fin rays: | 14–21 |
| Anal fin rays: | 18–25 |
| Pectoral fin rays: | 13–18 |
| Pelvic fin rays: | 8–10 |
| Caudal fin rays: | 10+9 (PrC) |



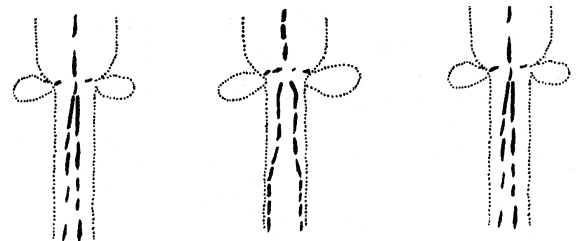
Yolk-sac Larva

Larvae:

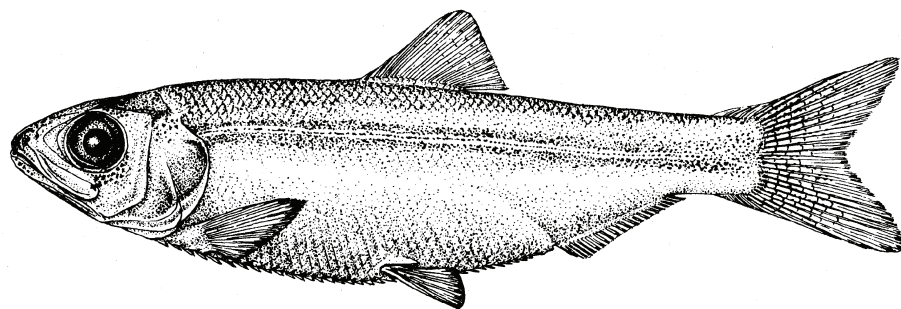
- Hatching occurs at 5.7–10.0 mm
- Body elongate with long, straight gut; anus always posterior to dorsal fin
- Air bladder obvious by 14 mm TL
- Preanal finfold retained throughout larval development
- Sequence of fin ray formation: D, C – A – P₂ – P₁ (ossification sequence based on illustrations)
- Transformation occurs between 25 and 30 mm

Note:

1. See comparative table in Clupeidae Introduction
2. Ventral pigment in small *A. sapidissima* (center) differs from that in *A. aestivalis* (left) and *A. pseudoharengus* (right) in sizes <13.0 mmTL (after Sismour, 1994)



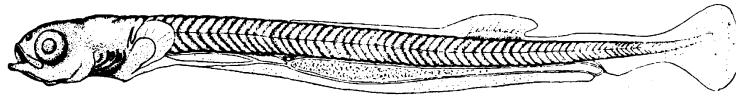
Early Juvenile:

**E. 51.8 mmTL**

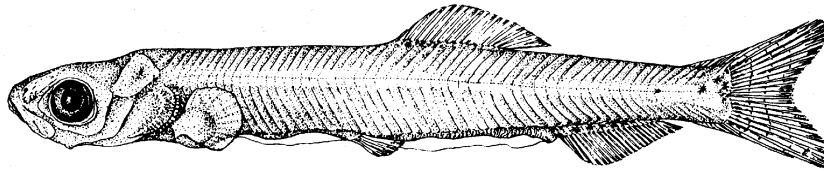
Figures: Adult: H.L. Todd (Hildebrand, 1963a); Egg, yolk-sac larva and A: Ryder, 1887; B–E: Mansueti and Hardy, 1967

References: Jones *et al.*, 1978; Able and Fahay, 1998; Munroe, 2000; 2002b

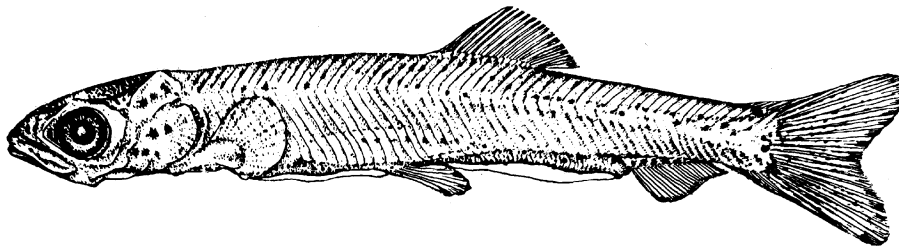
Alosa sapidissima



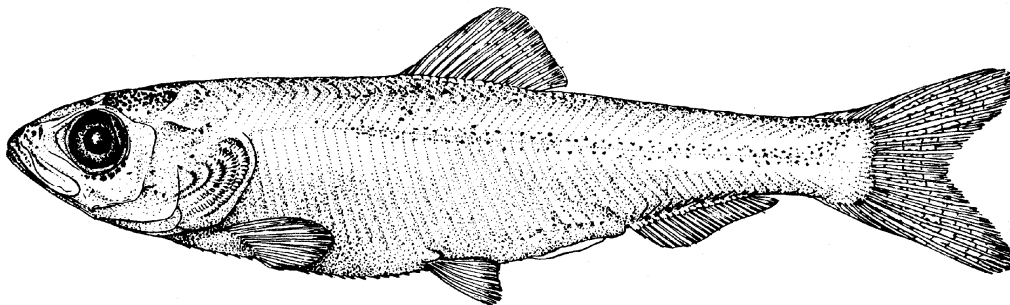
A. 14.0 mmTL



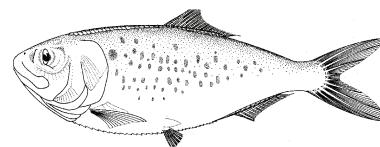
B. 22.9 mmTL



C. 21.0 mmTL



D. 31.8 mmTL

Brevoortia tyrannus* (Latrobe, 1802)*Clupeidae****Atlantic menhaden**

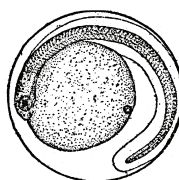
Range: Atlantic coast of North America from the Gulf of St. Lawrence to northern Florida

Habitat: Pelagic, brackish estuaries and bays as well as inner continental shelf; rarely far from land

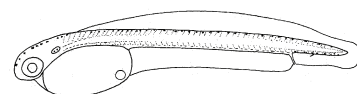
Spawning: May spawn during every month of the year, depending on location, with peaks during spring and fall; in the study area, most larvae occur in the Middle Atlantic Bight during fall into winter, with more limited occurrences in coastal waters during spring

Eggs:

- Pelagic, spherical
- Diameter: 1.30–1.95 mm
- Chorion: smooth and thin
- Yolk: segmented
- Oil globules: single, 0.11–0.17 mm in diameter
- Perivitelline space: wide
- Late embryo has 2 rows of dorsolateral spots from snout to tail

**Meristic Characters**

| | |
|--------------------|--------------|
| Myomeres: | 45–50 |
| Vertebrae: | 45–50 |
| Dorsal fin rays: | 18–24 |
| Anal fin rays: | 18–24 |
| Pectoral fin rays: | 13–19 |
| Pelvic fin rays: | 7 |
| Caudal fin rays: | 7–9+10+9+6–7 |



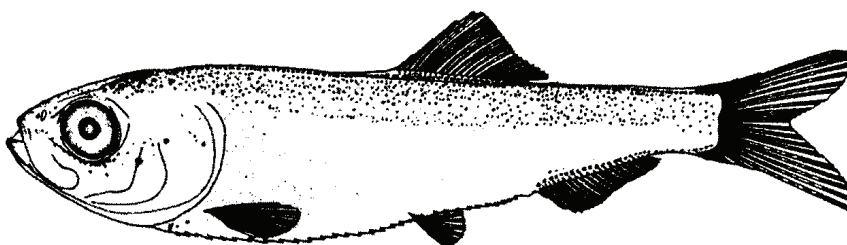
Yolk-sac larva

Larvae:

- Hatching occurs at 2.4–4.5 mm; eyes unpigmented
- Body elongate, with straight gut 70–80% TL; anus always posterior to dorsal fin
- Flexion occurs at 8–10 mm
- Posterior gut has obvious muscle-band striations
- Air bladder evident at about 11 mm
- No teeth until 20 mm
- Sequence of fin ray formation: C, D, A – P₂ – P₁
- Pigmentation includes spots along entire dorsal surface of gut and along ventral surface of posterior half of gut in larvae larger than about 5 mm; few melanophores along dorsum of body disappear at 5–6 mm; pigment present on ventral side of notochord tip; dorsal notochord tip pigment only present in small larvae
- When spawned offshore, larvae enter estuaries after about 1 month at sizes of 10+ mm
- Transformation occurs at about 30 mm (in estuaries)

Note:

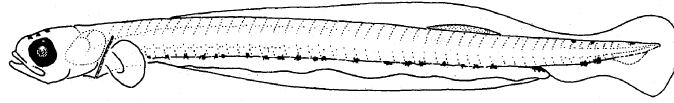
1. High number of dorsal and anal rays compared to other clupeids
2. Myomeres between posterior dorsal and anterior anal fins decrease from 5 to 1
3. *Brevoortia smithi* occurs only as far north as Cape Hatteras; 45–47 myomeres; transforms at 20–23 mm

Early juvenile:**F. 32.0 mm**

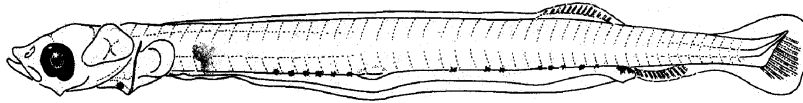
Figures: Adult: Whitehead, 1977; Egg and yolk-sac larva: Kuntz and Radcliffe, 1917 (redrawn); A–D: Mansueti and Hardy, 1967 (redrawn); E–F: Lewis *et al.*, 1972

References: Houde and Swanson, 1975; Ditty *et al.* 1994; Munroe, 2000; 2002b

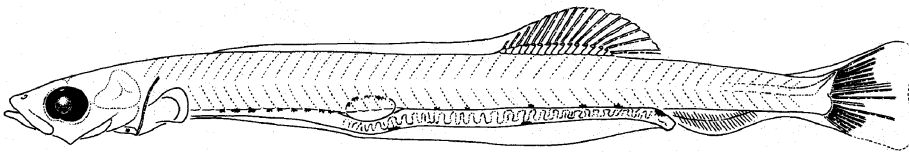
Brevoortia tyrannus



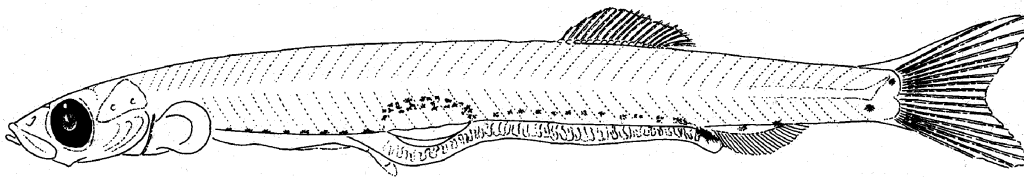
A. 8.3 mmTL



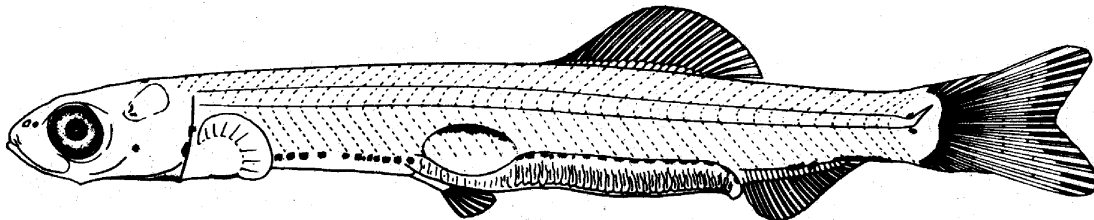
B. 10.7 mmTL



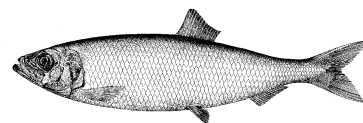
C. 16.6 mmTL



D. 23.1 mmTL



E. 27.0 mmTL

Clupea harengus* Linnaeus, 1758*Clupeidae****Atlantic herring**

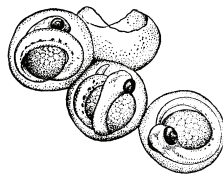
Range: Both sides of North Atlantic Ocean; in the western North Atlantic from Greenland and Labrador to Cape Hatteras; separate stocks occur in Gulf of St. Lawrence, Banquereau Bank, Scotian Shelf, Gulf of Maine and Georges Bank

Habitat: Pelagic, schooling; mostly offshore and migrating into deeper waters during winter; some populations move into coastal waters for spawning

Spawning: Mostly in fall, with a peak in Sep; also a spring spawn, peaking in May; occurs in bays and offshore banks, usually over substrates of rock, cobble or gravel. Georges Bank and periphery of Gulf of Maine are important centers; larvae seldom occur south of Hudson Canyon or off Nw Jersey

Eggs:

- Demersal, adhesive, clumping, off-round
- Diameter: 1.0–1.4 mm
- Chorion: smooth, transparent and thick
- Yolk: segmented
- Oil globules: none
- Perivitelline space: wide

**Meristic Characters**

| | |
|--------------------|----------------|
| Myomeres: | 52–62 |
| Vertebrae: | 52–62 |
| Dorsal fin rays: | 16–22 |
| Anal fin rays: | 15–21 |
| Pectoral fin rays: | 13–21 |
| Pelvic fin rays: | 6–10 |
| Caudal fin rays: | 10–13+10+9+8–9 |



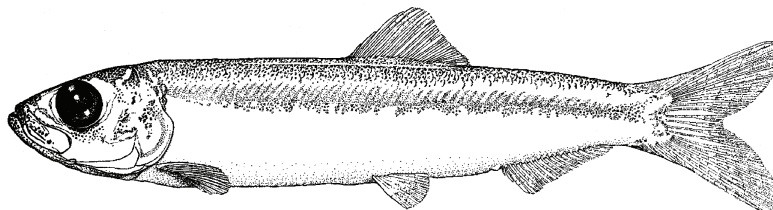
Yolk-sac larva

Larvae:

- Hatching occurs at 4–10 mmTL; eyes pigmented
- Body elongate with long straight gut; anus always posterior to dorsal fin
- Preanus length 80%TL
- Flexion occurs at 16–17 mm
- Posterior gut has obvious muscle-band striations
- Air bladder forms at 5–10 mm, but not obvious until 30 mm
- Sequence of fin ray formation: C – D, A – P₂ – P₁
- Pigmentation includes melanophores along the dorsal surface of the gut anteriorly, ventral surface of the gut posteriorly; larger larvae have only dorsal gut pigment; early larvae have single streak of pigment on midline of isthmus; large melanophores occur near anus, and at base of caudal fin; pigment present on ventral surface of notochord tip, variable on dorsal surface
- Transformation occurs at about 30 mm

Note:

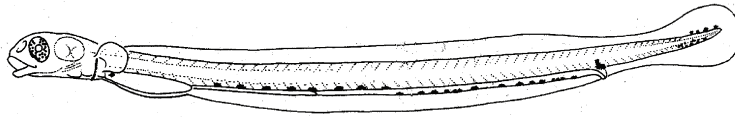
1. High myomere count and late forming anal fin rays are unique for North Atlantic clupeids
2. Myomeres between posterior dorsal and anterior anal fins decrease from 8–9 to 4
3. See *Mallotus villosus* for note on similar larva

Early Juvenile:**F. 46.0 mmSL**

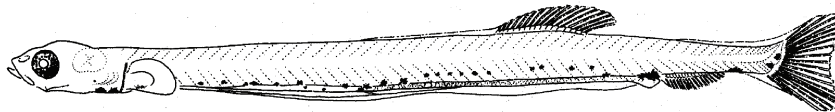
Figures: Adult: Hildebrand, 1963a; Eggs: Berg *et al.*, 1949; Yolk-sac larva, **A–B, D**: Krevanovsky, 1956 (redrawn); **C**: Ehrenbaum, 1909 (redrawn); **E**: Fage, 1920 (redrawn); **F**: Susan Kaiser (Able and Fahay, 1998)

References: Russell, 1976; Jones *et al.*, 1978; Able and Fahay, 1998; Munroe, 2000; 2002b

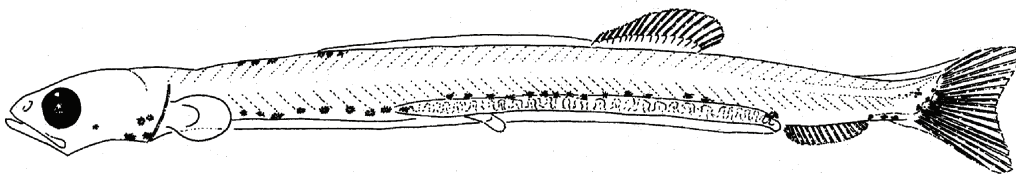
Clupea harengus



A. 8.2 mmTL

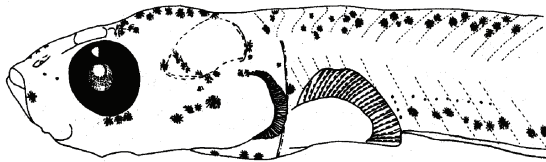


B. 20.2 mmTL

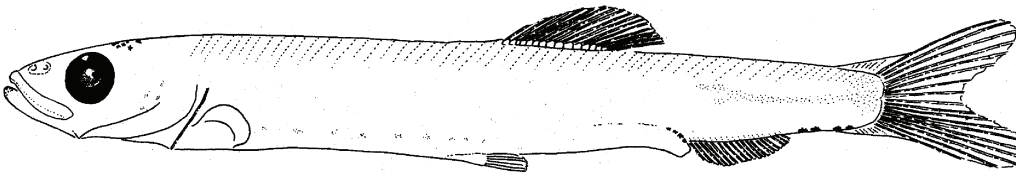


C. 29.0 mmTL

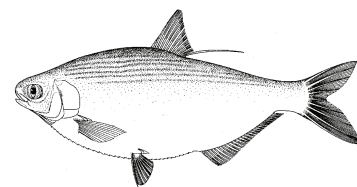
Pigment increases on head
and dorso-lateral region



**D. 29.0 mmTL
(Head Region)**



E. 41.0 mmTL

Dorosoma cepedianum* (Lesueur, 1818)*Clupeidae****Gizzard shad**

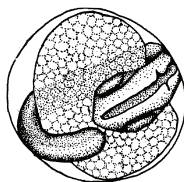
Range: North American fresh water drainages into the Atlantic Ocean and Gulf of Mexico; reaches estuarine waters of Chesapeake and Delaware bays and as far north as Hudson River estuary

Habitat: Near surface in open, quiet waters, deeper in fall and winter; found in submerged vegetation and over mud, sand and gravel substrates

Spawning: In fresh water in sloughs, ponds, lakes and larger rivers; spring through summer, with peak Apr–Jun

Eggs:

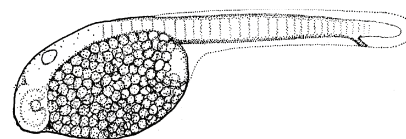
- Demersal, adhesive
- Diameter: 0.75 mm
- Chorion: smooth, tough
- Yolk: finely granular
- Oil globule: 1 large and 1–5 smaller ones
- Perivitelline space: narrow

**Meristic Characters**

| | |
|--------------------|-------------|
| Myomeres: | 47–51 |
| Vertebrae: | 47–51 |
| Dorsal fin rays: | 10–15 |
| Anal fin rays: | 25–37 |
| Pectoral fin rays: | 14–17 |
| Pelvic fin rays: | 7–10 |
| Caudal fin rays: | 9–11+10+9+7 |

Larvae:

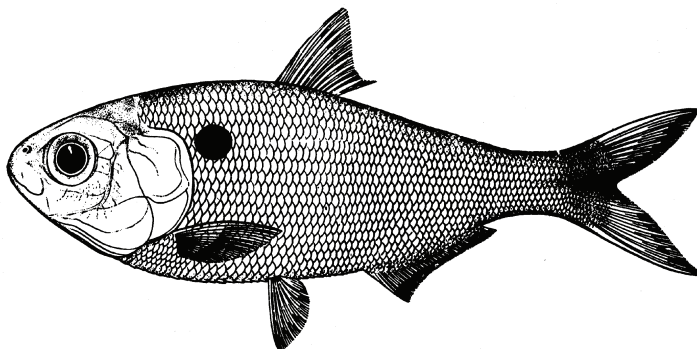
- Hatching occurs at about 3.2 mm
- Body elongate with long straight gut; anus always posterior to dorsal fin
- Remnant of preanal finfold still present at 17 mm
- Flexion occurs between 11 and 17 mm
- Sequence of fin ray formation: D – C – A, P₂ – P₁
- Pigmentation includes large melanophores near anus, and a series of spots on dorsal surface of anterior gut; larger larvae develop scattered pigment on caudal fin along base of anal fin, and dorsolaterally on body
- Transformation occurs at sizes larger than 24 mm; body begins to deepen at about 35 mm



Yolk-sac larva

Early Juvenile:

- Scales complete at about 50 mm
- Large melanophore forms behind opercle in juveniles
- Ventral scutes form at about 35 mm
- Note high anal fin ray count

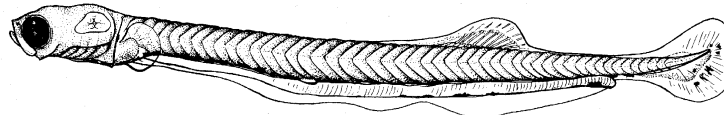
F. 50.0 mmTL

Figures: Adult: H.L. Todd (Goode, 1884); Egg, yolk-sac larva, and B–C: Warner, 1940; A, D: Lippson and Moran, 1974; E: Fowler, 1935; F: Fowler, 1945

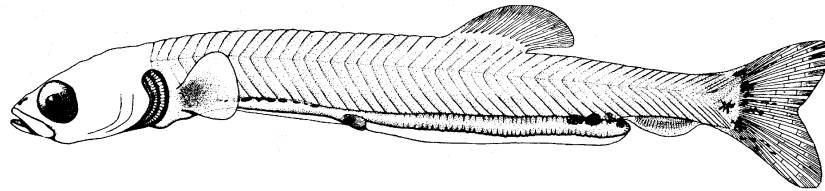
References: Lippson and Moran, 1974; Jones *et al.*, 1978

Dorosoma cepedianum

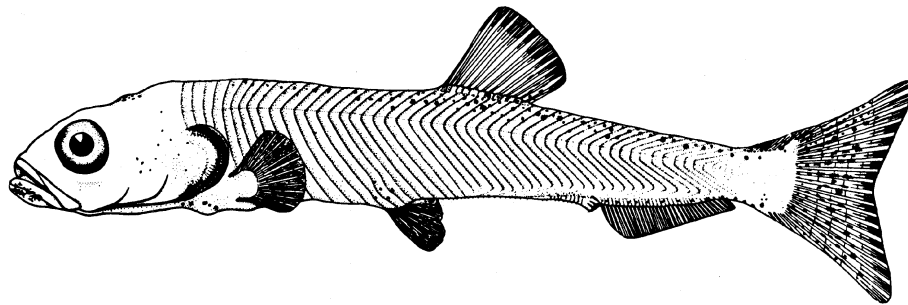
A. 11.0 mmTL



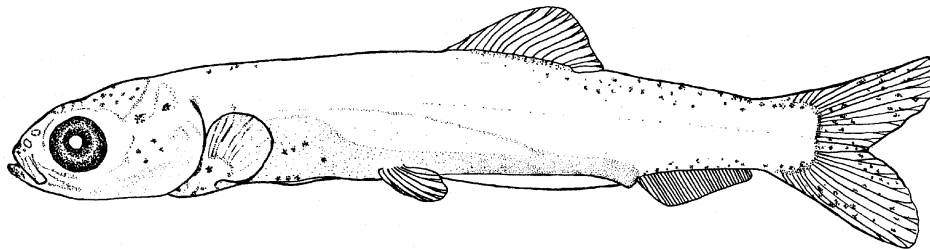
B. 17.5 mmTL



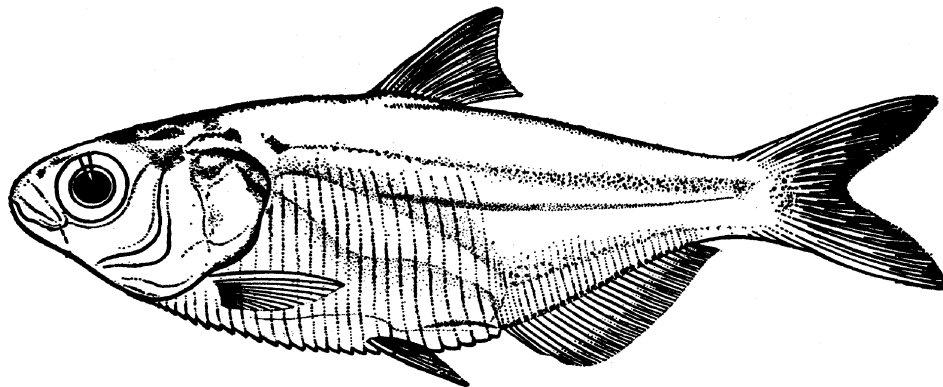
C. 22.0 mmTL

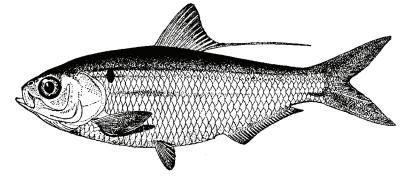


D. 24.2 mmTL



E. 35 mmTL



Dorosoma petenense* (Günther, 1867)*Clupeidae****Threadfin shad**

Range: Ohio River drainage of North America to fresh waters of northern Guatemala and Belize; introduced into Chesapeake Bay drainages and occurs in Chesapeake and Delaware Canal

Habitat: Pelagic, schooling, in large bays, lakes, reservoirs, estuaries; in salinities 0–32 ppt, but mostly below 5 ppt

Spawning: Eggs and larvae may be restricted to fresh water, although juveniles and adults are occasionally collected in estuarine conditions

Eggs:

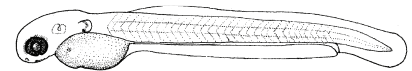
- Demersal, adhesive
- Diameter: 0.75 mm
- No other data

Larvae:

- Hatching occurs at 4.1–4.4 mm
- Body elongate with long, straight gut; anus always posterior to dorsal fin
- Flexion occurs at about 10 mmTL
- About 36 preanal myomeres
- Sequence of fin ray formation: C, D – A – P₂ – P₁ (ossification sequence based on illustrations)
- Adult fin ray complement present by 18–20 mm
- Pigmentation includes a series of melanophores on dorsal surface of anterior gut, and scattered pigment over the anal fin base and caudal peduncle
- Transformation begins at about 20 mm

Meristic Characters

| | |
|--------------------|------------|
| Myomeres: | 43–44 |
| Vertebrae: | 43–44 |
| Dorsal fin rays: | 11–15 |
| Anal fin rays: | 17–27 |
| Pectoral fin rays: | 12–17 |
| Pelvic fin rays: | (7) 8 |
| Caudal fin rays: | 10+9 (PrC) |

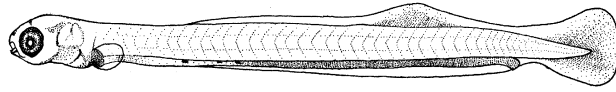


Yolk-sac larva

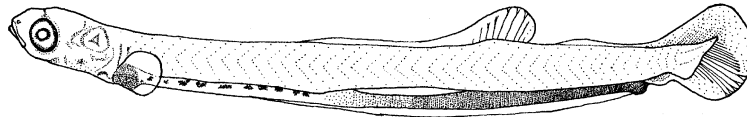
Figures: Adult: Miller, 1963; Yolk-sac larva and A–E: Taber, 1969

References: Lippson and Moran, 1974; Jones *et al.*, 1978

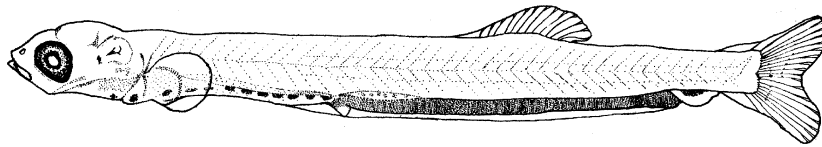
Dorosoma petenense



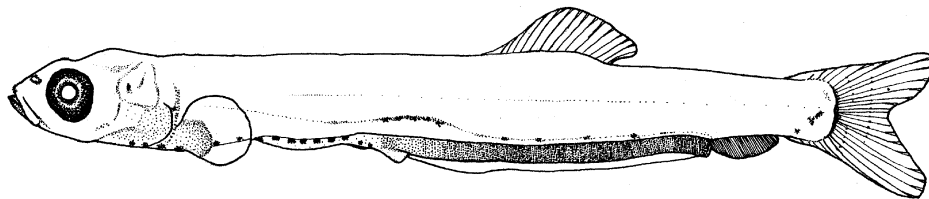
A. 8.2 mmTL



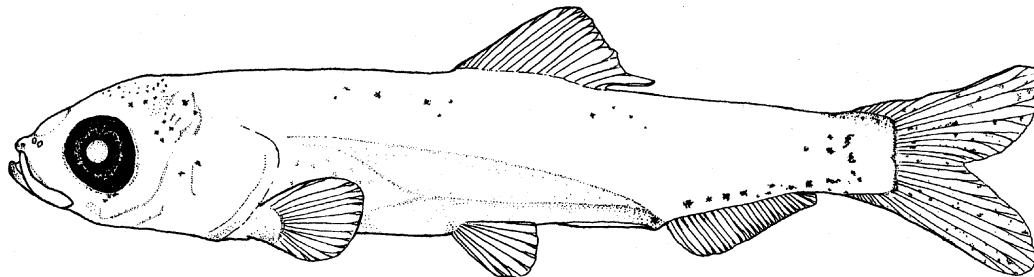
B. 11.0 mmTL



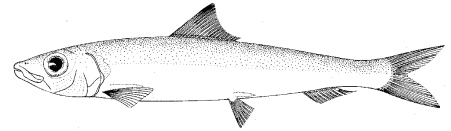
C. 15.6 mmTL



D. 17.4 mmTL



E. 20.3 mmTL

Etrumeus teres* (DeKay, 1842)*Clupeidae****Round herring**

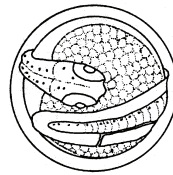
Range: Western North Atlantic Ocean from Bay of Fundy to Florida and Gulf of Mexico; also eastern Pacific and Indo-Pacific oceans

Habitat: Pelagic, schooling in continental shelf waters; occasionally in bays and coastal waters, but mostly over outer continental shelf depths

Spawning: Not well-described; possibly restricted to south of Cape Hatteras and Gulf of Mexico; larvae occasionally collected in study area

Eggs:

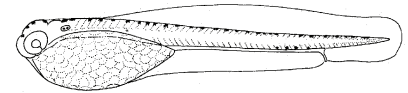
- Pelagic, spherical
- Diameter: 1.17–1.37 mm
- Chorion: smooth, transparent and thick
- Yolk: segmented
- Oil globules: none
- Perivitelline space: narrow

**Meristic Characters**

| | |
|--------------------|----------------|
| Myomeres: | 46–50 |
| Vertebrae: | 15–17+32–34 |
| Dorsal fin rays: | 15–22 |
| Anal fin rays: | 10–13 |
| Pectoral fin rays: | 14–16 |
| Pelvic fin rays: | 8 |
| Caudal fin rays: | 10–13+10+9+8–9 |

Larvae:

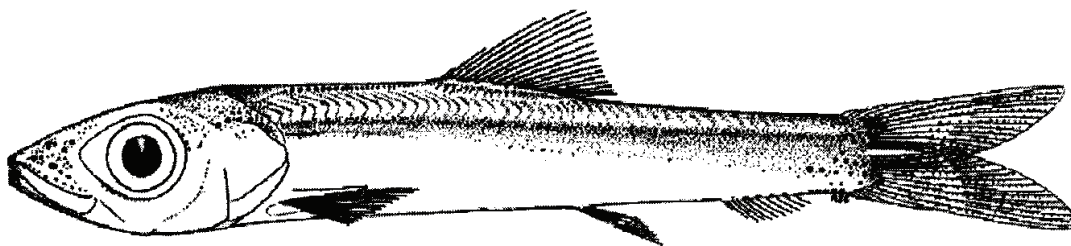
- Hatching occurs at 3.8–4.8 mm; eyes unpigmented
- Body elongate with long, straight gut; anus always posterior to dorsal fin
- Teeth apparent at about 6 mmTL
- Snout long and pointed in small larvae
- Flexion occurs at 8–10 mmSL
- Posterior gut has obvious muscle-band striations
- Sequence of fin ray formation: C, D – A – P₂ – P₁
- Fin rays not complete until transformation; pelvic forms late and migrates posteriorly
- Pigmentation includes about 8 widely spaced, large spots over anterior gut; small spots in double row form over posterior gut; a large melanophore over anus; spot at tip of lower jaw in some larvae
- Diagonal streaks of pigment over lower caudal fin base are distinctive
- Transformation occurs at 30–33 mmTL



Yolk-sac Larva

Note:

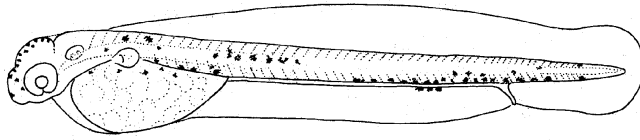
1. Early teeth formation and low anal fin ray count are unique among clupeid larvae
2. Myomeres between posterior dorsal and anterior anal fins decrease from 5 to 2

Early Juvenile:**F. 42.5 mmTL**

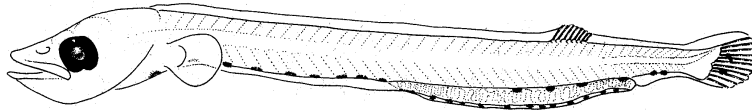
Figures: Adult: Whitehead, 1977; Egg: O'Toole and King, 1974; Yolk-sac larva: Mito, 1961a; **A:** Mito, 1961; **B:** Houde and Fore, 1973; **C:** Uchida *et al.* 1958; **D:** Nancy Arthur (Moser *et al.* 1996); **E–F:** Hildebrand, 1963a (Yolk-sac larva and **A–C** redrawn)

References: E.D. Houde, 1981 (pers. comm.); Shaw and Drullinger, 1990; Munroe, 2000; 2002b

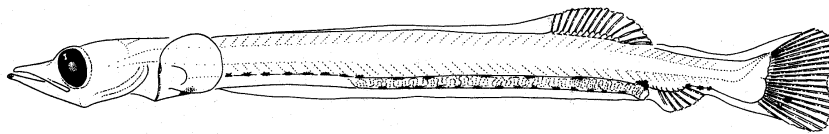
Etrumeus teres



A. 5.7 mmTL

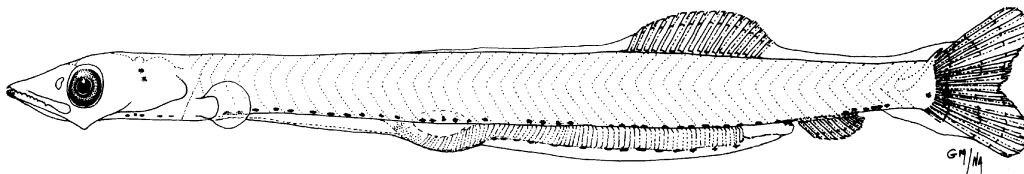


B. 8.5 mmTL

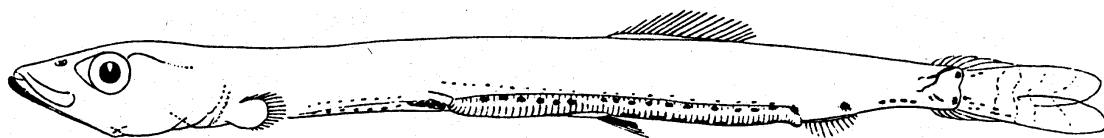


C. 15.3 mmTL

Eye oval in early stages, becomes round at transformation

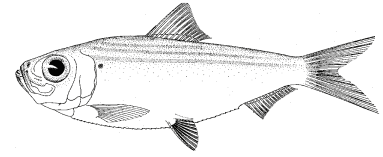


D. 17.7 mmTL



E. 27.5 mmTL

***Harengula jaguana* Poey, 1865**
Clupeidae
 Scaled sardine



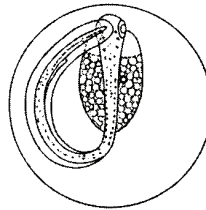
Range: Western North Atlantic Ocean from New Jersey to southern Brazil, including Gulf of Mexico and Caribbean Sea

Habitat: Pelagic and demersal in coastal waters, over mud or sand substrates; often in bays, estuaries or high salinity lagoons

Spawning: Jan–Sep (peak Apr–Aug); most activity over inner continental shelf at night

Eggs:

- Pelagic, spherical
- Diameter: 1.55–1.85 mm
- Chorion: transparent
- Yolk: segmented
- Oil globule: single, 0.07–0.10 mm in diameter
- Perivitelline space: wide



Meristic Characters

| | |
|--------------------|------------|
| Myomeres: | 39–42 |
| Vertebrae: | 41–43 |
| Dorsal fin rays: | 17–18 (19) |
| Anal fin rays: | 17–18 |
| Pectoral fin rays: | (13) 14–15 |
| Pelvic fin rays: | (7) 8 |
| Caudal fin rays: | 8–9+10+9+7 |

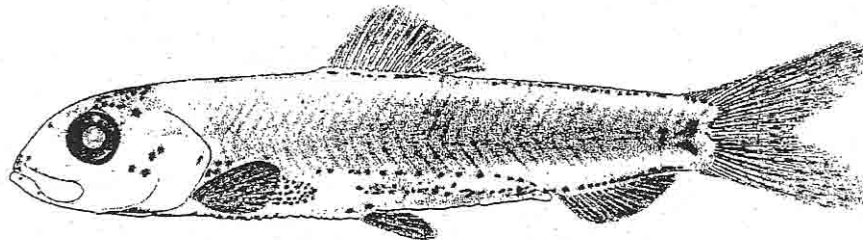
Larvae:

- Hatch at about 2.5 mmTL, eyes unpigmented, mouth parts unformed
- Body elongate, with straight gut 85–90% TL (decreases to 75% at transformation)
- Anus always posterior to dorsal fin
- Preanus myomeres 35 at 6.0 mm, 27 at 22 mm
- Predorsal myomeres 25 at 6.0 mm, 10 at 22 mm
- Flexion occurs at 9–11 mm
- Posterior gut has obvious muscle-band striations
- Air bladder evident at 6.0 mm
- Sequence of fin ray formation: C, D – A – P₂ – P₁
- Dorsal fin rays complete at 14–16 mm; anal fin rays complete at 13–15 mm
- Pigment sparse on head; early larvae have spots on dorsal (and ventral) tip of notochord, spots at cleithral symphysis, 2 spots near anus, ventral row of spots along posterior gut plus row of spots along dorsum of anterior gut; later larvae form row of spots along dorsum of posterior gut, few spots on bases of caudal fin rays; largest larvae add short rows of spots under dorsal fin and from posterior anal fin on venter of caudal peduncle; few spots also on hindbrain and on "cheek" area
- Transformation occurs at about 14–22 mm

Note: 1. Low total myomere count; myomeres between dorsal and anal fins 5–7

Early Juvenile:

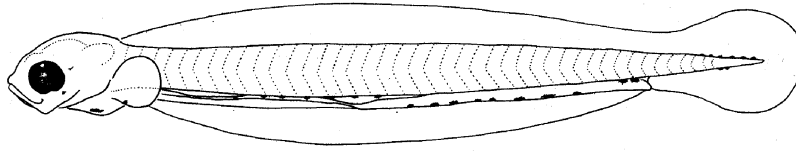
F. 21.3 mmSL



Figures: Adult: Munroe and Nizinski, 2002; Egg: Gorbunova and Zvyagina, 1975; **A, C, E–F:** Houde *et al.*, 1974 (redrawn); **B, D:** Ditty *et al.*, 2006

References: Houde *et al.*, 1974; Gorbunova and Zvyagina, 1975; Fahay, 1983; Munroe and Nizinski, 2002

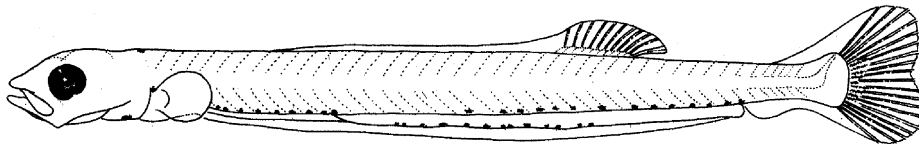
Harengula jaguana



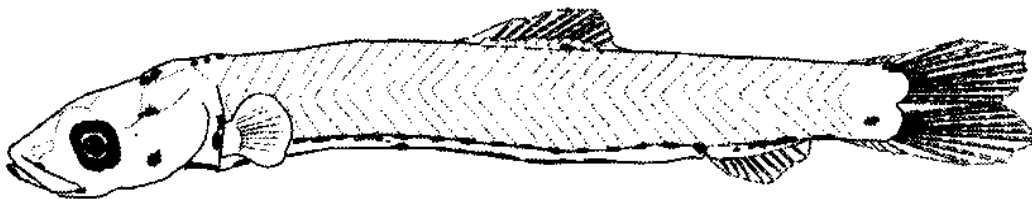
A. 6.0 mmSL



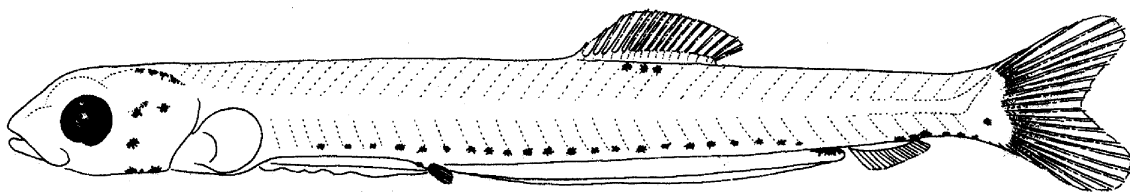
B. 8.6 mmSL



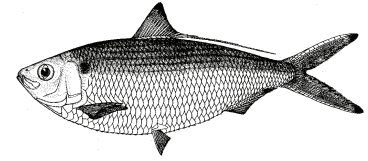
C. 11.5 mmSL



D. 14.4 mmSL



E. 16.1 mmSL

Opisthonema oglinum* (Lesueur, 1817)*Clupeidae****Atlantic thread herring**

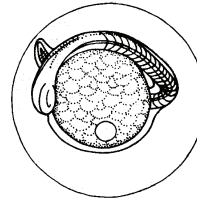
Range: Western North Atlantic Ocean from southern New England and Bermuda, through the Gulf of Mexico, Caribbean Sea and West Indies; mostly tropical and sub-tropical waters; also eastern Pacific Ocean

Habitat: Pelagic, schooling in coastal waters, usually in high salinity, more rarely in bays or estuaries

Spawning: May–Jun off North Carolina; larvae rarely collected in study area

Eggs:

- Pelagic, spherical
- Diameter: 1.08–1.31 mm
- Chorion: smooth, thin and clear
- Yolk: lightly segmented
- Oil globule: single; 0.12–0.16 mm in diameter
- Perivitelline space: wide
- Paired dorsolateral series of melanophores on late embryo

**Meristic Characters**

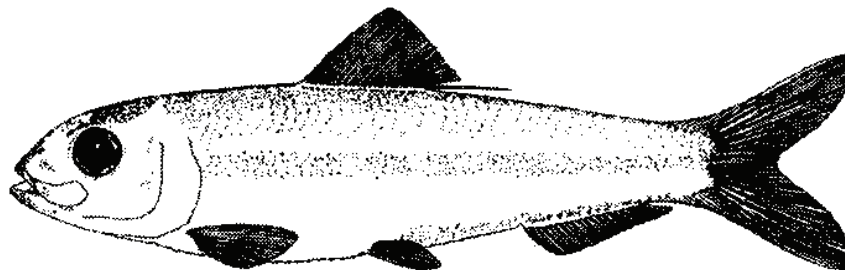
| | |
|--------------------|-------------|
| Myomeres: | 45–49 |
| Vertebrae: | 12–13+32–36 |
| Dorsal fin rays: | 17–22 |
| Anal fin rays: | 20–25 |
| Pectoral fin rays: | 15–19 |
| Pelvic fin rays: | 8–9 |
| Caudal fin rays: | 9+10+9+6–7 |

Larvae:

- Hatching occurs at >3.0 mm; eyes unpigmented
- Body elongate with long, straight gut; anus always posterior to dorsal fin
- Preanus length decreases from 86–91% TL before flexion to 75% SL after transformation
- Predorsal myomeres decrease from 25 to 15
- Flexion occurs at about 10 mmSL
- Posterior gut has obvious muscle-band striations
- Air bladder present, but not obvious until transformation
- Sequence of fin ray formation: C – D – A – P₂ – P₁
- Pigmentation: in early larvae, melanophores on ventral midline under pectoral fins, posterior to anus, a double row along ventral surface of hindgut, and a dorsolateral row on each side of foregut
- Internal pigment over posterior gut well-defined; internal spots over air bladder prominent
- Transformation occurs at 15–25 mmSL

Note:

1. Myomeres between posterior dorsal and anterior anal fins decrease from 8–10 (<16 mm) to 5–7 at transformation
2. Notochord tip pigment restricted to ventral side
3. High anal fin ray count
4. Pigment increases on dorsum of head at about 24 mmSL

Early Juvenile:**H. 30.8 mmSL**

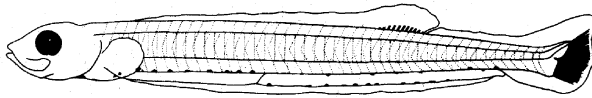
Figures: Adult: A.S. Green (Munroe, 2002b); Egg and A–H: Richards *et al.*, 1974

References: Richards *et al.*, 1974; Munroe, 2000; 2002b; Munroe and Nizinski, 2002

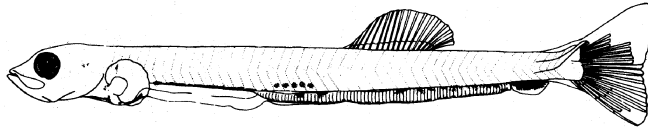
Opisthonema oglinum



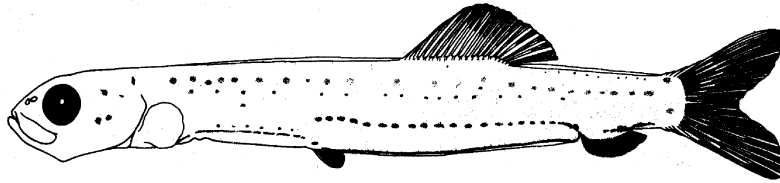
A. 4.0 mmTL



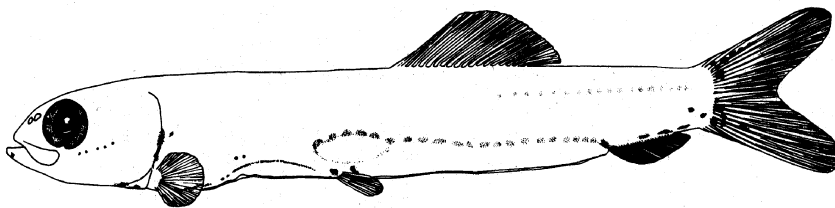
B. 10.7 mmSL



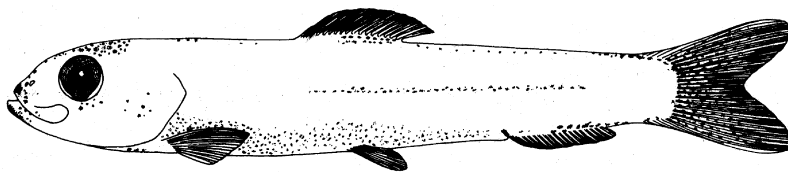
C. 13.7 mmSL



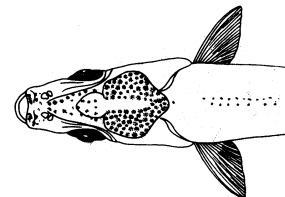
D. 17.1 mmSL



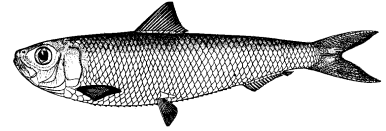
E. 19.7 mmSL



F. 24.4 mmSL



**G. 24.4 mmSL
(Dorsal Head)**

Sardinella aurita* Valenciennes, 1847*Clupeidae****Spanish sardine**

Range: Eastern and western North Atlantic Ocean and Mediterranean Sea; in the western North Atlantic from Cape Cod and Bermuda to Brazil, including Gulf of Mexico and Caribbean Sea

Habitat: Pelagic in inner continental shelf waters

Spawning: Year-round with distinct peaks in different areas; fall–winter off Florida; Nov–Jun (peak Jan–Feb) off Venezuela; mid-Jun–Sep off North America; Sep–Feb in Gulf of Mexico; larvae uncommonly collected in study area during spring

Eggs:

- Pelagic and spherical
- Diameter: 1.03–1.12 (1.25) mm
- Chorion: thin, unsculptured, unpigmented
- Yolk: vaguely segmented
- Oil globule: single, 0.13–0.18 mm in diameter
- Perivitelline space: moderately wide

Larvae:

- Hatching occurs at 2.5 mm, eyes and body unpigmented, yolk-sac elliptical with oil globule posteriorly
- Preanal length ranges from 83–89% SL, then decreases to 73% SL at transformation; head length ranges from 14–27% SL, then increases to 29% SL at transformation; body depth ranges from 8–12% SL, then increases to 25% SL at transformation
- Dorsal fin migrates forward: predorsal length 60–68% SL until transformation when it decreases to 41% SL
- Myomeres between posterior dorsal fin and anterior anal fin decrease from 7–8 to 5
- Flexion occurs at 7.5 to 9.5 mm
- Sequence of fin ray formation: C – D, A – P₂ – P₁
- Pigmentation: melanophores occur on nape, over brain and in area of cleithral symphysis; row of elongate melanophores along dorsal aspect of foregut; increasing number of spots along dorsal aspect of hindgut, fewer spots along ventral aspect of hindgut; other melanophores occur along dorsal fin base and lateral body after 16 mm; a few internal melanophores over the anteriormost vertebrae; pigment at notochord tip usually only ventral; pigment on caudal fin increases in larger larvae
- Transformation occurs at 16–23 mm

Note: 1. See Clupeidae comparative table on Clupeiformes Introductory page

2. Lower anal fin ray count than in *Opisthonema oglinum*

Early juvenile: – In early juveniles, last ray of anal fin is longer than other rays, but last ray of dorsal fin is not elongate; no dark spot on body behind opercle

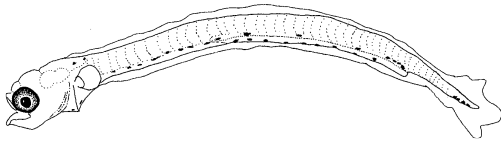
Meristic Characters

| | |
|--------------------|----------|
| Myomeres: | 43–48 |
| Vertebrae: | 45–49 |
| Dorsal fin rays: | 16–19 |
| Anal fin rays: | 16–20 |
| Pectoral fin rays: | 15–16 |
| Pelvic fin rays: | 7–8 |
| Caudal fin rays: | 8+10+9+7 |

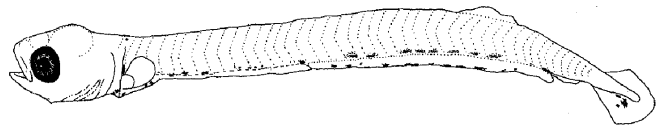
Figures: Adult: Hildebrand, 1963a; A–F: Ditty *et al.*, 1994

References: Fage, 1920; Matsuura, 1972, 1975; Houde and Fore, 1973; E. D. Houde, 1981 (pers. comm.); Munroe and Nizinski, 2002

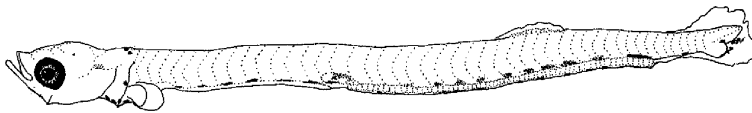
Sardinella aurita



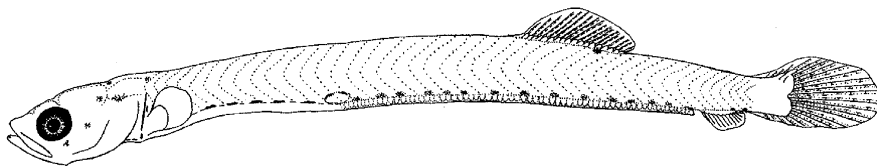
A. 3.6 mmSL



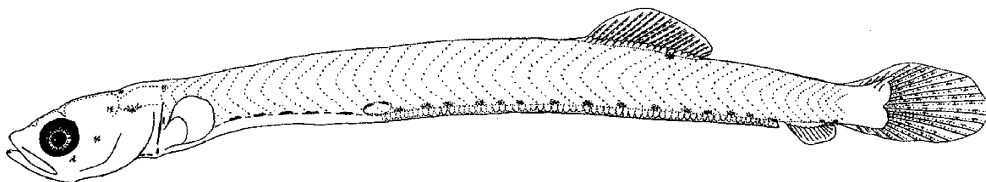
B. 5.5 mmSL



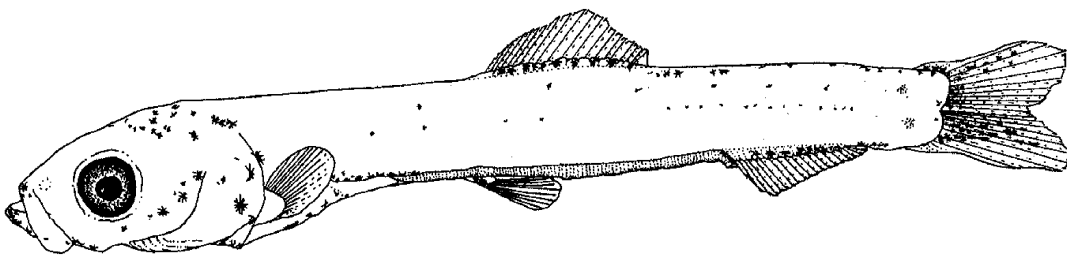
C. 8.1 mmSL



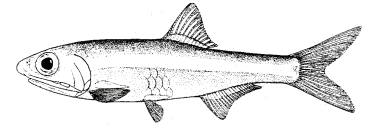
D. 11.8 mmSL



E. 14.0 mmSL



F. 19.0 mmSL

Anchoa hepsetus (Linnaeus, 1758)**Engraulidae****Striped anchovy**

Range: Atlantic coasts of North America and South America from Nova Scotia to Uruguay; absent from Florida Keys and most of Caribbean Sea

Habitat: Schooling, pelagic, in estuarine and oceanic waters; mostly over inner continental shelf; oceanic occurrences not well-described

Spawning: Spring and summer; Apr–Sep off NE United States, with peak May–Jul; commences near Cape Hatteras, later in southern New England waters; mostly over inner continental shelf; sporadic occurrences until Sep

Eggs:

- Pelagic, elliptical
- Diameter: long axis 1.20–1.66 mm; short axis 0.70–0.94 mm
- Chorion: smooth and transparent
- Yolk: segmented
- Oil globules: none
- Perivitelline space: narrow

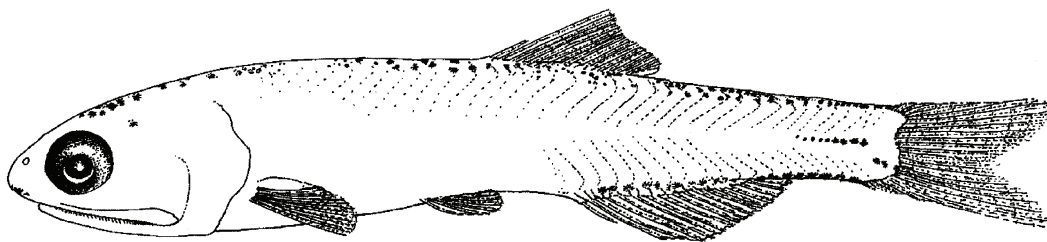
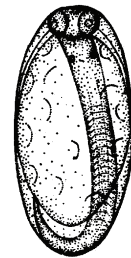
Larvae:

- Hatching occurs at 3.6–4.0 mm; yolk mass tapers posteriorly
- Body long and slender; anus under dorsal fin
- Mouth large, terminal, extends to under middle of eye; becomes sub-terminal
- Flexion occurs between 5 and 10 mm
- Gut with muscle-band striations posteriorly
- Sequence of fin ray formation: C, D, A – P₂ – P₁
- Pigment very light; series of melanophores along dorsal surface of gut and along anal fin base

Note: 1. Amount of overlap between dorsal and anal fins and number of anal fin rays best characters for distinguishing this species from 2 other engraulid species in study area (see Clupeiformes Introduction)

Early Juvenile:**Meristic Characters**

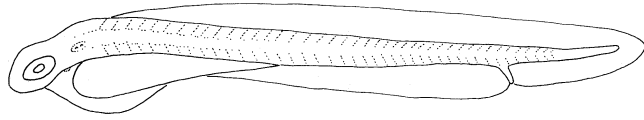
| | |
|--------------------|--------------|
| Myomeres: | 41–44 |
| Vertebrae: | 40–44 |
| Dorsal fin rays: | 13–16 |
| Anal fin rays: | 19–23 |
| Pectoral fin rays: | 13–15 |
| Pelvic fin rays: | 7 |
| Caudal fin rays: | 7–9+10+9+7–8 |

**E. 34.0 mmTL**

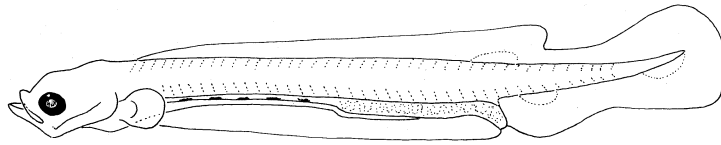
Figures: Adult: Whitehead *et al.*, 1988; Egg, **A–B**: Hildebrand and Cable, 1930; **C**: Wayne LaRoche (Farooqi *et al.*, 1995); **D**: Lippson and Moran, 1974; **E**: Nancy Arthur (Able and Fahay, 1998) (**A, B, D** redrawn)

References: Able and Fahay, 1998; Berrien and Sibunka, 1999; Munroe, 2000; 2002a; Nizinski and Munroe, 2002

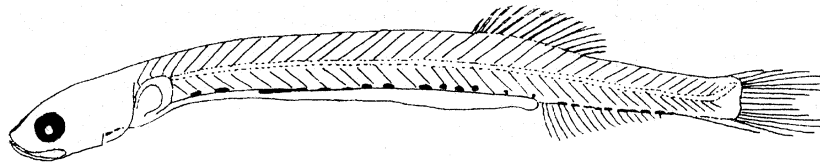
Anchoa hepsetus



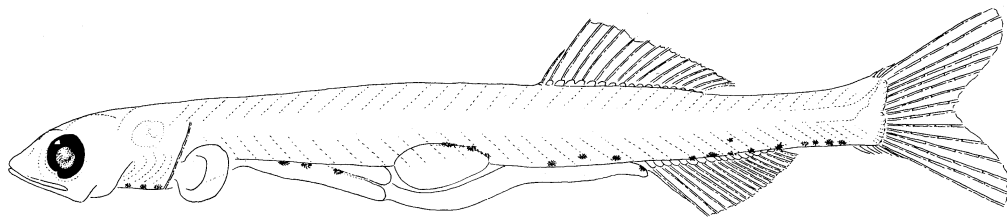
A. 3.6 mmTL



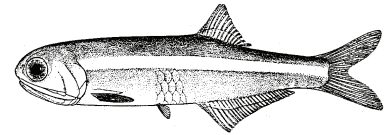
B. 5.6 mmTL



C. 10.3 mmSL



D. 15.0 mmTL

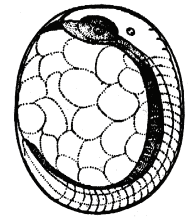
Anchoa mitchilli* (Valenciennes, 1848)*Engraulidae****Bay anchovy**

- Range:** Atlantic coast of North America from Maine to Florida, through Gulf of Mexico to Yucatan Peninsula, Mexico
- Habitat:** Schooling, pelagic; estuarine and coastal ocean; sandy beaches, open bays, muddy coves
- Spawning:** Primarily in water <20 m deep in bays, estuaries, sounds and coastal ocean; begins as early as Apr off Cape Hatteras, expands rapidly northward over inner continental shelf waters during May and June, occurs as far north and east as Long Island to Narragansett Bay, Rhode Island in July; declines between September and October

Meristic Characters

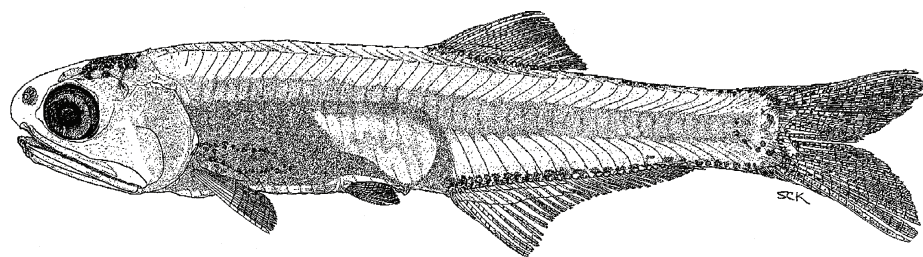
| | |
|--------------------|------------|
| Myomeres: | 38–41 |
| Vertebrae: | 38–44 |
| Dorsal fin rays: | 13–17 |
| Anal fin rays: | 23–30 |
| Pectoral fin rays: | 11–12 |
| Pelvic fin rays: | 7 |
| Caudal fin rays: | 9+10+9+7–8 |

- Eggs:**
- Pelagic, slightly elliptical
 - Diameter: long axis: 0.84–1.11 mm
 - Chorion: smooth and transparent
 - Yolk: segmented
 - Oil globules: none
 - Perivitelline space: narrow



- Larvae:**
- Hatching occurs at 1.8–2.7 mm (smaller than other engraulids); yolk tapers posteriorly
 - Body long and slender, with anus under dorsal fin
 - Mouth large and terminal, extends to middle of eye; becomes sub-terminal
 - Flexion occurs at 7–8 mm
 - Gut with muscle-band striations posteriorly
 - Sequence of fin ray formation: C, D, A – P₂ – P₁
 - Pigment very light, but somewhat more dense than in larvae of 2 other engraulids in study area; series of melanophores along dorsal surface of gut and along anal fin base
 - Transformation occurs at about 20mm

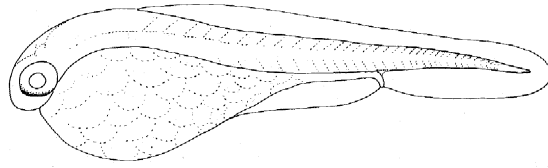
- Note:** 1. Amount of overlap between dorsal and anal fins and number of anal fin rays best characters for distinguishing this species from 2 other engraulid species in study area (see Clupeiformes Introduction)

Early Juvenile:**F. 33.0 mmSL**

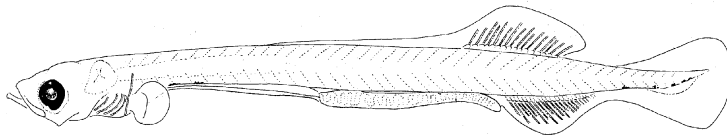
- Figures:** Adult: Whitehead *et al.* 1988; Egg, **A**, **C**: Kuntz, 1915; **B**: Lippson and Moran, 1974; **D**: Mansueti and Hardy, 1967; **E**: Fowler, 1945; **F**: Susan Kaiser (Able and Fahay, 1998) (**A–E** redrawn)

- References:** E. D. Houde, 1982 (pers. commun.); Vouglitois, *et al.*, 1987; Able and Fahay, 1998; Berrien and Sibunka, 1999; Munroe, 2000; 2002a

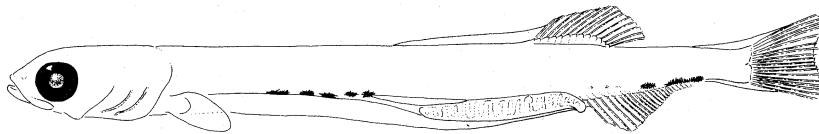
Anchoa mitchilli



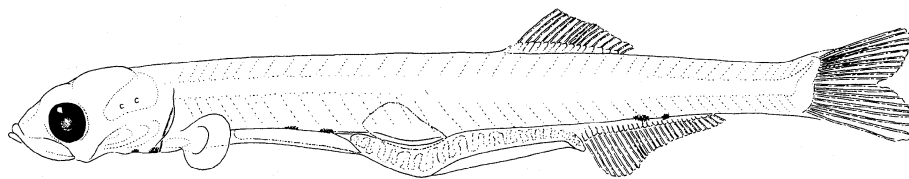
A. 1.9 mmTL



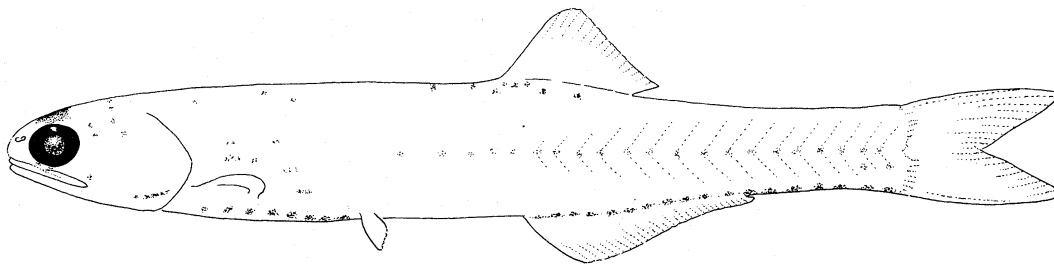
B. 8.4 mmTL



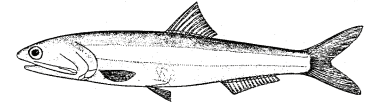
C. 10.0 mmTL



D. 12.0 mmTL



E. 19.5 mmTL

Engraulis eurystole* (Swain and Meek, 1885)*Engraulidae****Silver anchovy**

Range: Atlantic coast of North America from Massachusetts to northern Gulf of Mexico; also Venezuela to northern Brazil; larvae occur as far north as Scotian Shelf

Habitat: Schooling, pelagic; mostly over continental shelf waters

Spawning: Spring into fall; not well-described; larvae rarely collected in estuaries, or as far offshore as Gulf Stream

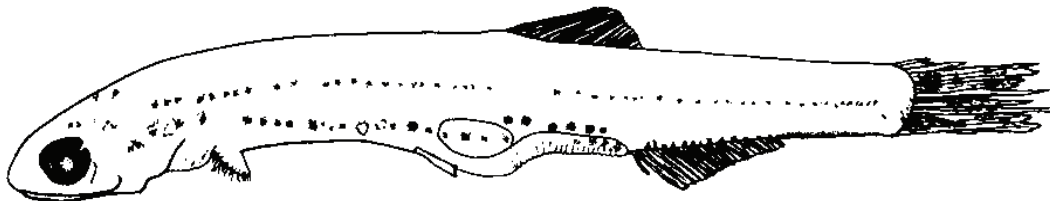
Eggs:

- Pelagic, elliptical
- Diameter: long axis: 1.02–1.25 mm; short axis: 0.50–0.80 mm
- Chorion: smooth and transparent
- Yolk: segmented
- Oil globules: none
- Perivitelline space: narrow

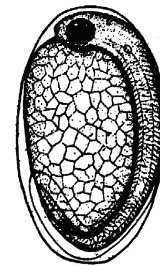
Larvae:

- Hatching occurs at 2–3 mm; yolk tapers posteriorly
- Body long and slender; anus under dorsal fin
- Mouth large, terminal; extends to middle of eye; becomes subterminal
- Gut with muscle-band striations posteriorly
- Air bladder prominent in larger larvae (Fig. D and F)
- Sequence of fin ray formation: C, D, A – P₂ – P₁
- Pigment very light, increases with development; note ventral series of melanophores along dorsal surface of gut and along anal fin base; row of elongate spots forms along mid-isthmus in larger larvae; larvae near transformation develop pigment on head, along lateral midline, on caudal fin rays and on dorsal peritoneum
- Transformation occurs between 20 and 23 mm

Note: 1. Amount of overlap between dorsal and anal fins and number of anal fin rays best characters for distinguishing this species from 2 other engraulid species in study area (see Clupeiformes Introduction)

Early Juvenile:**F. 27.4 mmSL****Meristic Characters**

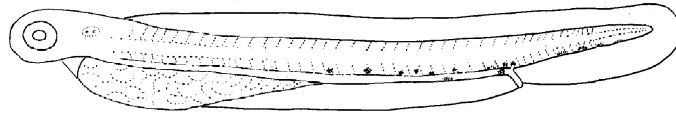
| | |
|--------------------|-------------------|
| Myomeres: | 43–45 |
| Vertebrae: | 25–27+17–19=43–45 |
| Dorsal fin rays: | 13–16 |
| Anal fin rays: | 15–18 |
| Pectoral fin rays: | 14–16 |
| Pelvic fin rays: | 7 |
| Caudal fin rays: | ?+10+9+? |



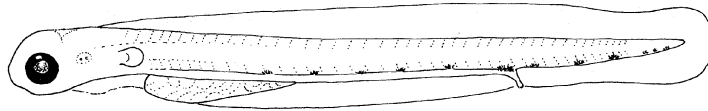
Figures: Adult: Whitehead *et al.*, 1988; Egg, A–C: Kuntz and Radcliffe, 1917; E: Lippson and Moran, 1974; D, F: Markle *et al.*, 1980 (A–C, E redrawn)

References: Markle *et al.*, 1980; Able and Fahay, 1998; Berrien and Sibunka, 1999; Nizinski and Munroe, 2002

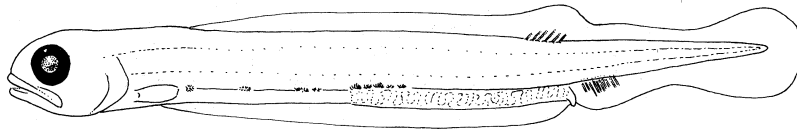
Engraulis eurystole



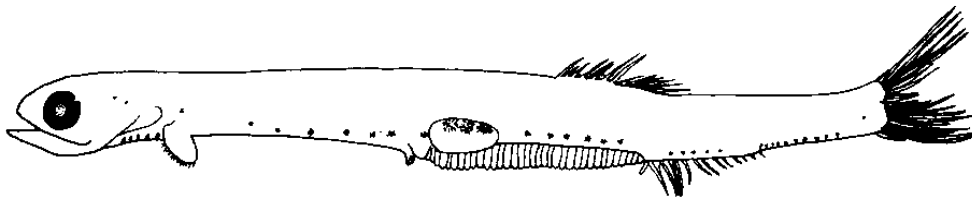
A. 3.2 mmTL



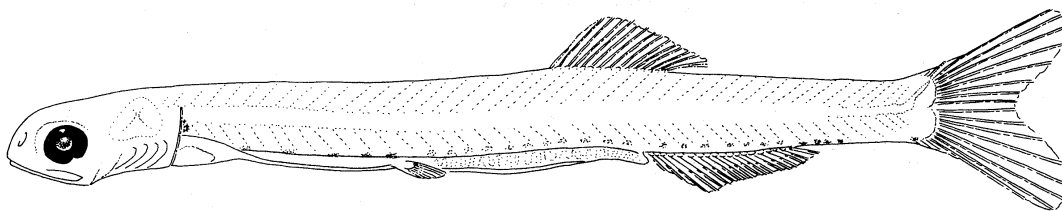
B. 3.4 mmTL



C. 5.2 mmTL



D. 18.0 mmSL



E. 22.8 mmTL