

Zeiformes and Gasterosteiformes

Selected meristic characters in species belonging to the orders Zeiformes and Gasterosteiformes whose adults or larvae have been collected in the study area. Classification sequence follows Eschmeyer (1990), but see discussion of classification on next page. Gasterosteiformes are not closely related to Zeiformes (sensu Johnson and Patterson, 1993), are more closely related to the Perciformes, and are treated here simply as an entry in a sequence of orders. Sources: Berry (1959b); Uyeno *et al.*, 1983; Scott and Scott, 1988; Ditty, 2003; Tyler *et al.*, 2003

| Order/Family <i>Species</i> | Vertebrae | Dorsal Fin Rays | Anal Fin Rays | Pectoral Fin Rays | Pelvic Fin Rays |
|--|-------------------|--------------------|------------------|----------------------|--------------------|
| ZEIFORMES | | | | | |
| PARAZENIDAE | | | | | |
| <i>Parazen pacificus</i> | 12+22=34 | VI–VIII, 30–32 | I, 32–33 | 15–16 | 0, 7 |
| MACRUROCYTTIDAE ³ | | | | | |
| <i>Zenion hololepis</i> | 11+16=27 | VI–VII, 26–31 | II, 23–29 | 16–18 | I, 6 |
| ZEIDAE | | | | | |
| <i>Cyttopsis rosea</i> | 11+21=32 | VII–VIII, 27–30 | I–II, 28–30 | 13–15 | 0, 9 |
| <i>Zenopsis conchifera</i> | 14–15+20–21=34–36 | VIII–X, 24–27 | III, 24–26 | 12–13 | 0, 6 |
| OREOSOMATIDAE | | | | | |
| <i>Neocyttus helgae</i> ¹ | – | VII, 34–36 | IV, 30–32 | – | I, 6 |
| <i>Pseudocyttus maculatus</i> ² | 14–15+27–28=41–42 | V–VII, 34–36 | II–III, 31–34 | 19–22 | I, 5–6 |
| GRAMMICOLEPIDIDAE | | | | | |
| <i>Grammicolepis brachiusculus</i> | 11+32–35=43–46 | VI–VII, 28–35 | II–III, 28–36 | 14–15 | I, 6–7 |
| <i>Xenolepidichthys dalgleishi</i> | 10+26–28=36–38 | V–VI, 27–31 | II, 27–29 | 14–15 | I, 6–7 |
| CAPROIDAE | | | | | |
| <i>Antigonia capros</i> | 22 | VII–IX, 31–38 | III, 29–34 | I, 12–14 | I, 5 |
| <i>Antigonia combatia</i> | 22 | VIII–X, 26–30 | III, 23–28 | I, 11–13 | I, 5 |
| GASTEROSTEIFORMES | | | | | |
| GASTEROSTEIDAE | | | | | |
| <i>Apeltes quadracus</i> | 29–34 | II–IV, 9–14 | I, 7–11 | 11–12 | I, 2 |
| <i>Gasterosteus aculeatus</i> | 29–33 | II–V, 6–13 | I, 6–13 | 9–11 | I |
| <i>Gasterosteus wheatlandi</i> | 27–29 | III, 9 | I, 6–8 | 9–10 | I, 1–3 |
| <i>Pungitius pungitius</i> | 32–34 | IX, 9–11 | I, 8–10 | 10 | I, 1 |

¹ Extralimital; occurs over Mid-Atlantic Ridge and may be found on New England Seamount Chain (not well-explored)

² A rarely collected species, not yet recorded from study area, but has occurred off Iceland and Suriname, and might be found in study area in the future. Early stages are undescribed

³ Zeniontidae of some authors

Zeiformes and Gasterosteiformes

The composition of the Zeiformes (in particular the placement of Caproidae within the order) is equivocal. A brief history of its classification follows:

Heemstra, 1980

Rosen, 1984

Heemstra, 1986

Whitehead *et al.*, 1986

Eschmeyer, 1990

Johnson and Patterson, 1993

Nelson, 1994

Tyler *et al.*, 2003

Heemstra, 2002a and Parin, 2002b

Several other recent revisions

Caproidae excluded from Zeiformes

Caproidae a sister group to Zeiformes and Tetraodontiformes, the latter 2 closely related, caproids with many perciform characters

Caproidae allocated to Perciformes

Caproidae included in Zeiformes

Caproidae included in Zeiformes

Caproidae excluded from Zeiformes; included in Perciformes

Caproidae included in Zeiformes

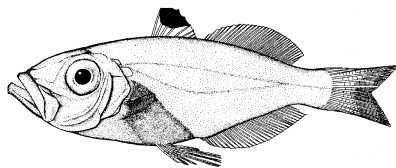
Questionable placement of Caproidae in or near a restricted Zeiformes

Caproidae included in Zeiformes

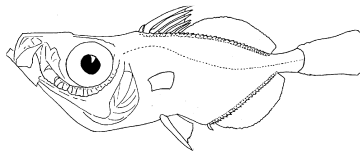
Caproidae included in Zeiformes

The monophyly of Zeiformes (less Caproidae) has been established (Tyler *et al.*, 2003; also see Johnson and Patterson, 1993), based on 9 characters: 1) Mobile, obliquely oriented palatine; 2) $3\frac{1}{2}$ gills, 7 hemibranchs; 3) Dorsal, anal and pectoral fin rays unbranched; 4) No uncinat process on 1st epibranchial; 5) Continuous, median cartilage below frontal bones; 6) No open gill slit between 4th and 5th branchial arches; 7) Metapterygoid reduced in size, not articulating with quadrate; 8) Parahypural separated from urostylar centrum; 9) Hypurals 1+2+3+4 fused together and to centrum. Zeiformes (*sensu stricto*) and Caproidae share a neural spine closely adpressed to skull; lack of palatine teeth; 1st dorsal pterygiophore inserting into 1st interneural space; several neural spines oriented vertically (or anterovertically), and a few other osteological characters. To date, ontogenetic characters have not been utilized in phylogenetic studies.

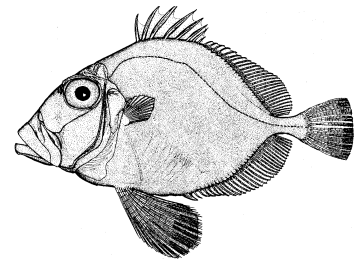
Early stages of the Zeiformes are very poorly known. Of the 10 species known (or suspected) to occur in deep waters of the study area, larvae are described for 3 and juveniles are known for another 2. Early stages are undescribed in the following five species (adult examples):



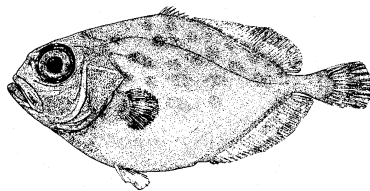
A. *Parazen pacificus* Kamohara



B. *Zenion hololepis* Goode and Bean

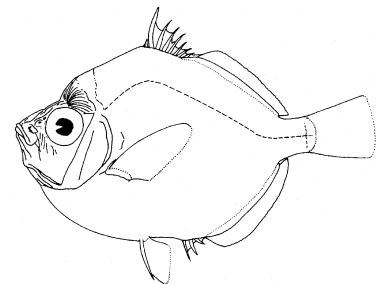


C. *Cyttopsis rosea* (Lowe)

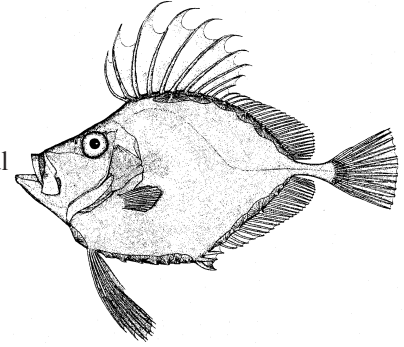


D. *Pseudocyttus maculatus* Gilchrist

Larvae of *Zenion* have row of small, supraorbital spines, laterally projecting spines on pterotic and opercle, and a large spine at preopercle angle (Johnson and Patterson, 1993)



E. *Antigonia combatia* Berry and Rathjen

Zenopsis conchifera* (Lowe, 1852)*Zeidae****Buckler dory**

Range: North Atlantic Ocean; in the western North Atlantic from vicinity of several banks on Scotian Shelf and Gulf of Maine to Brazil; fairly common off North Carolina and slope of Georges Bank

Habitat: Meso- to benthopelagic in depths of 65–400 m, mostly 200–300 m; occurs in schools

Spawning: Undescribed; ovaries with well-developed eggs during winter

Eggs: – Ovarian eggs 1.2–1.4 mm in diameter, orange-colored

Larvae:

- Body initially moderately elongate, becomes deep at level of pectoral fin base; preflexion larvae are rather deep anteriorly, tapering to narrow tail
- Preanus length increases from about 50% SL to about 70% SL
- Mouth large, oblique, reaching to level of mid-eye in early stages, more anterior as snout elongates in later stages
- Flexion occurs at sizes between 6 and 7 mmSL
- Pelvic fin rays early forming; fins become voluminous and elongate
- Anterior dorsal fin spines form first, become elongate
- Few spines form on head during development: posttemporal, supraorbital ridge, sphenotic and upper angle of preopercle; none is very large
- Pigmentation includes dense covering of melanophores over most of body, with the exception of the terminus of caudal peduncle; anterior dorsal and pelvic fins densely pigmented

Meristic Characters

| | |
|--------------------|---------------|
| Myomeres: | 34–36 |
| Vertebrae: | 34–36 |
| Dorsal fin rays: | VIII–X, 24–27 |
| Anal fin rays: | III, 24–26 |
| Pectoral fin rays: | 12–13 |
| Pelvic fin rays: | 0,6 |
| Caudal fin rays: | 1+13+1 |

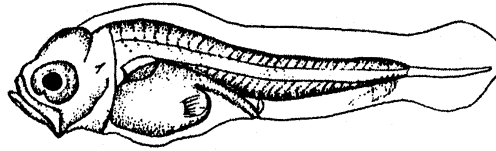
Note: 1. Distinguished from other zeiforms by lack of scales, low counts of dorsal, anal and pectoral fin rays, higher counts of dorsal fin spines, and lack of spines in pectoral or pelvic fins

Figures: Adult: Heemstra, 2003c; **A–D:** Weiss *et al.*, 1987

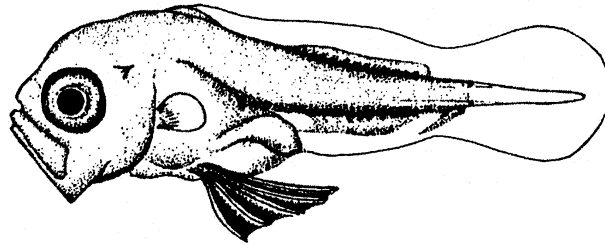
References: Weiss *et al.*, 1987; Scott and Scott, 1988; Moore and DeWitt, 2002a; Tyler *et al.*, 2003

Zenopsis conchifera

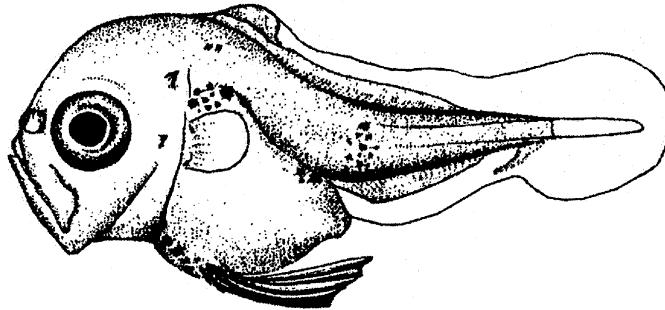
A. 4.2 mmSL



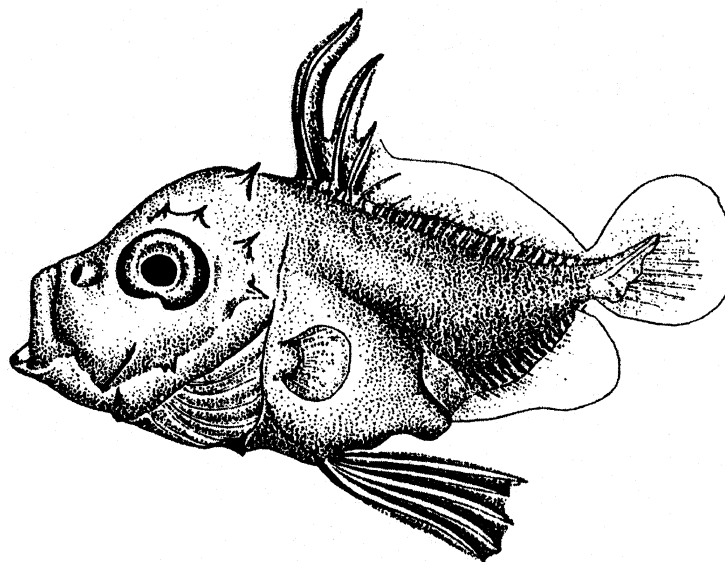
B. 4.6 mmSL



C. 4.8 mmSL



D. 6.6 mmSL



Neocyttus helgae* (Holt and Byrne, 1908)*Oreosomatidae****False boarfish**

Range: Several places worldwide; in the North Atlantic as far north as 67°N; off Ireland, Madeira; also collected from Mid-Atlantic Ridge

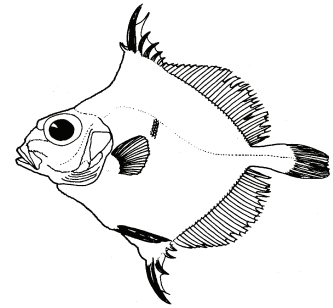
Habitat: Benthopelagic in depths of 988–1,210 m

Spawning: Undescribed

Eggs: – Undescribed

Larvae: – Undescribed

Juvenile: – Pelagic "*Oreosoma*" stage: body very deep, laterally compressed, tapers to narrow caudal peduncle
 – Note enlarged, bulges on body under dorsal fin origin and between pelvic fins and anus
 – Warty protuberances on body bulge areas
 – Dark pigment over most of body
 – Small, terminal mouth
 – Dorsal and anal fin spines initially short, become elongate after transformation

**Meristic Characters**

| | |
|--------------------|------------|
| Myomeres: | – |
| Vertebrae: | – |
| Dorsal fin rays: | VII, 34–36 |
| Anal fin rays: | IV, 30–32 |
| Pectoral fin rays: | – |
| Pelvic fin rays: | I, 6 |
| Caudal fin rays: | 2+13+2 |

Grammicolepis brachiusculus* Poey, 1873*Grammicolepididae****Thorny tinselfish**

Range: Worldwide; in the western North Atlantic from Georges Bank to Suriname, including Bahamas and Cuba

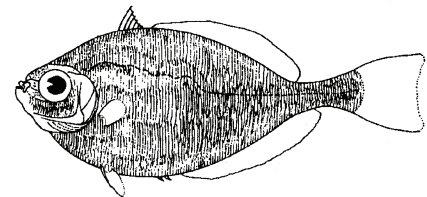
Habitat: Benthopelagic in depths of 300–900 m

Spawning: Undescribed

Eggs: – Undescribed

Larvae: – Undescribed; reportedly have rows of head spines (see note box on figure page)

Juvenile: – Body depth 1.4–1.6 in SL; head length 3.2–3.8 in SL
 – Dorsal and pelvic fin spines elongate
 – Conspicuous, horizontally flattened spiny scutes on body
 – Body color silvery with irregular black blotches
 – Caudal fin with black spots; anal fin crossed by 4–5 black bars
 – Transformation occurs at 25–30 cm, when body becomes elongate, spiny scutes are lost and scales become slender, vertically elongate

*Grammicolepis brachiusculus***Meristic Characters**

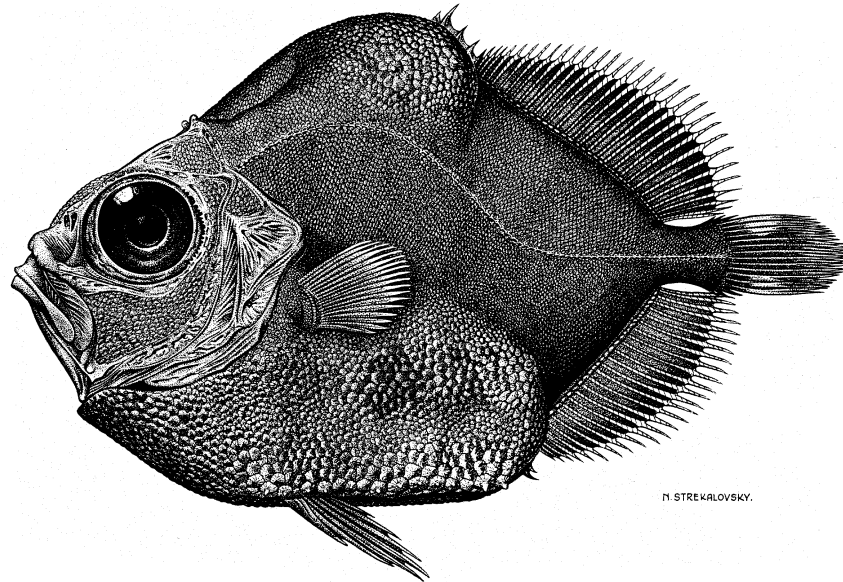
| | |
|--------------------|------------------|
| Myomeres: | 43–46 |
| Vertebrae: | 11+32–35 = 43–46 |
| Dorsal fin rays: | VI–VII, 28–35 |
| Anal fin rays: | II–III, 28–36 |
| Pectoral fin rays: | 14–15 |
| Pelvic fin rays: | I, 6–7 |
| Caudal fin rays: | 1+15+1 |

Figures: Adult *N. helgae*: Karrer, 1986; **A**: N. Strekalovsky (Backus *et al.*, 1965); Adult *G. brachiusculus* and **B**: Heemstra, 2003e

References: Karrer, 1986; Johnson and Patterson, 1993; Heemstra, 2003d, 2003e

Neocyttus helgae

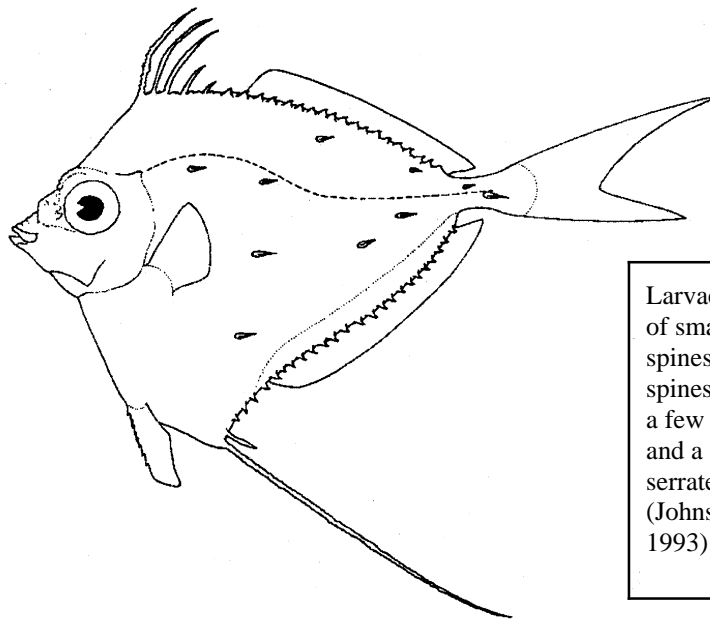
This juvenile, originally identified as *Neocyttus helgae*, has been re-identified as *Alloctytus guineensis*, an eastern Atlantic, bathypelagic species occurring between 18°N and 33°S. The figure is retained here to illustrate the "oreosoma" pelagic stage.



Anterior part
of lateral line
strongly arched

A. 72.5 mmSL (Juvenile)

Fin rays unbranched
(except caudal)



Larvae reportedly have row of small supraorbital spines, a row of small spines on the frontal bone, a few spines on preopercle, and a laterally projecting serrate ridge on pterotic (Johnson and Patterson, 1993)

B. 17 cmSL (Juvenile)

Xenolepidichthys dalgleyi* Gilchrist, 1922*Grammicolepididae****Tinselfish**

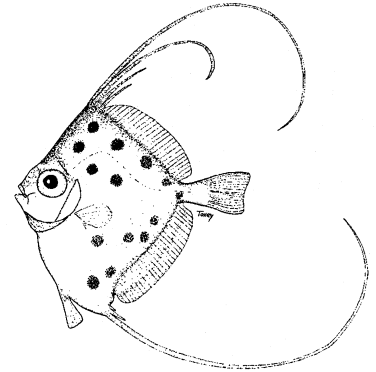
Range: Atlantic and western Pacific oceans; in the western North Atlantic from Emerald Bank, Nova Scotia, to northern South America, including Gulf of Mexico

Habitat: Benthopelagic in depths of 90–900 m

Spawning: Undescribed

Eggs: – Undescribed

- Larvae:**
- Extremely deep-bodied, laterally compressed
 - Preanus length short (about 30% SL) early in development
 - Head length about 30% SL; mouth oblique, but relatively small
 - Eye diameter very large in early larvae
 - Sequence of fin ray development undescribed; dorsal and anal fin spines presumably form before fin rays
 - Anterior dorsal and anal fin spines extremely elongate; filamentous extensions form on dorsal fin spines
 - Pelvic fin origin anterior to level of pectoral fin base
 - Head spination apparently weak, but small row of spines forms on supra-orbital region and on pterotic
 - Scales form as vertically elongate ridges
 - Members of this family may remain pelagic to large size (100 mmSL or more) before settling to bottom habitats
 - Pigmentation includes large, dark blotches on body
- Note:** 1. Juveniles form 29 spiny protuberances along base of dorsal fin (34–36 spiny protuberances in *Grammicolepis brachiusculus*)

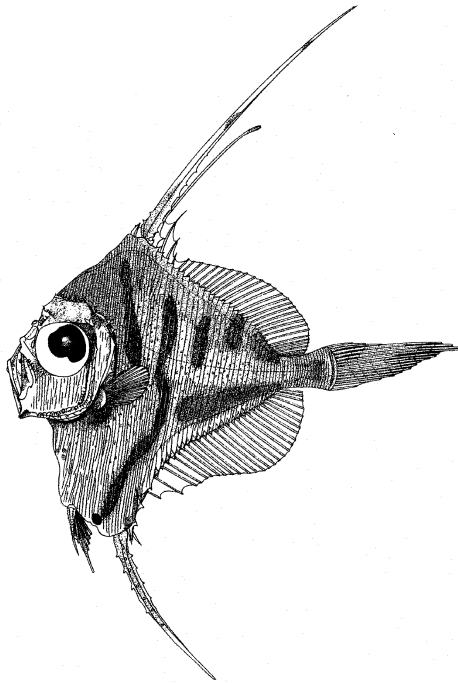
**Meristic Characters**

| | |
|--------------------|-------------|
| Myomeres: | 36–38 |
| Vertebrae: | 36–38 |
| Dorsal fin rays: | V–VI, 27–31 |
| Anal fin rays: | II, 27–29 |
| Pectoral fin rays: | 14–15 |
| Pelvic fin rays: | I, 6–7 |
| Caudal fin rays: | 1+15+1 |

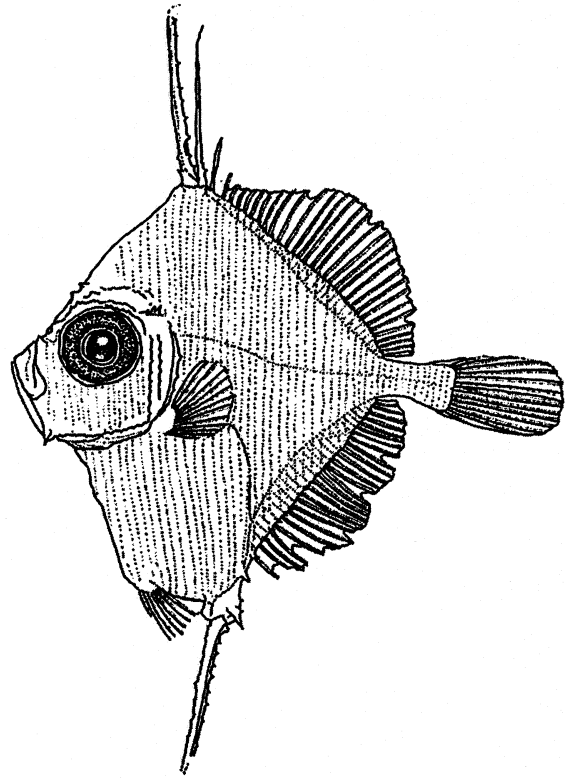
Figures: Adult: Heemstra, 2003e; A: Ditty, 2003; B: Okiyama, 1988; C: Myers, 1937

References: Karrer and Heemstra, 1986; Scott and Scott, 1988; Moore and DeWitt, 2002b; Heemstra, 2003e

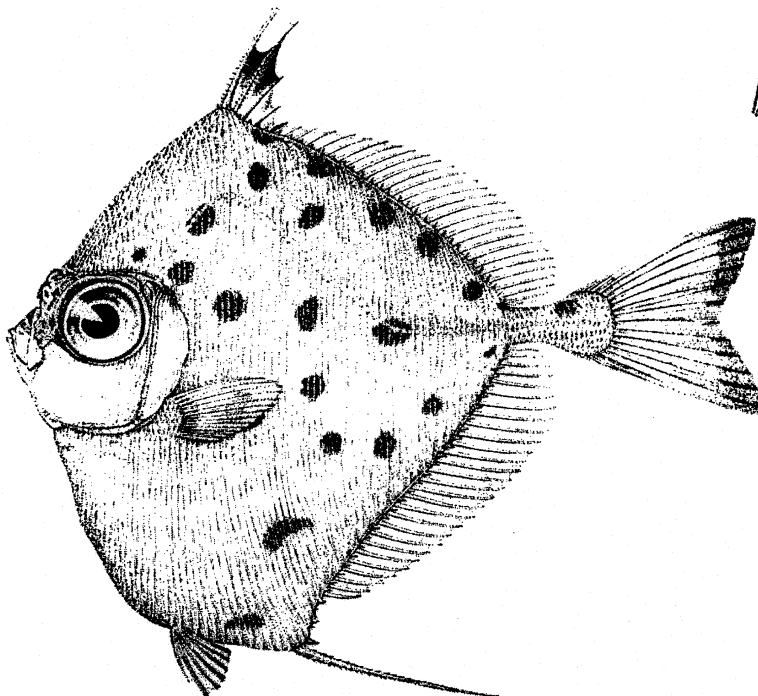
Xenolepidichthys dalglesi



A. 10.7 mmSL



B. 17.2 mmSL



C. 60.0 mmSL

***Antigonia capros* Lowe, 1843**
Caproidae
 Deepbody boarfish

Range: Atlantic, Pacific and Indian oceans; in the western North Atlantic from Gulf of Maine to Brazil, including Gulf of Mexico and Caribbean Sea

Habitat: Benthopelagic in depths of 40–600 m; associated with rocky slopes and ledges

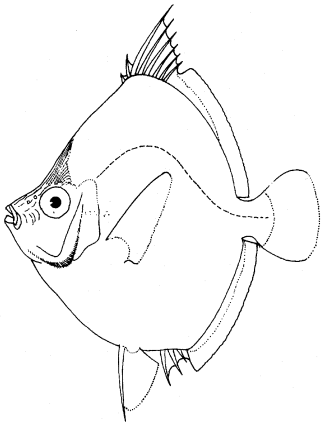
Spawning: Larvae have occurred in Apr–Jun off Brazil; otherwise undescribed

Eggs: – Undescribed; presumably pelagic

Larvae: – Body becomes deep early in development
 – Preanus length slightly <70% SL
 – Precocious and very well developed, serrated spines on mid-cranium and preopercle; these disappear at transformation
 – Supraorbital with serrate ridge
 – Radiating serrated ridges on frontal bones
 – Few spines in pterotic, sphenotic region
 – Flexion begins at about 3.0 mmSL
 – Scales begin forming on side of head at 4.5 mmSL; scales and fin rays complete by 8.0 mmSL
 – Pigmentation includes prominent melanophores over dorsal gut and top of head

Note: 1. A congener, *Antigonia combatia*, also occurs in the western North Atlantic, from Nova Scotia to Brazil; larvae are undescribed; the two species are separable based on dorsal and anal fin ray counts

2. Caproids are distinguished from other fishes by deep, compressed body, presence of a spine in the pectoral fin, and by low vertebral number



Meristic Characters

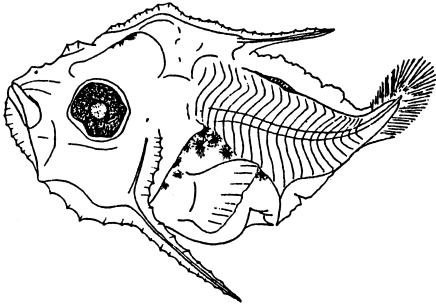
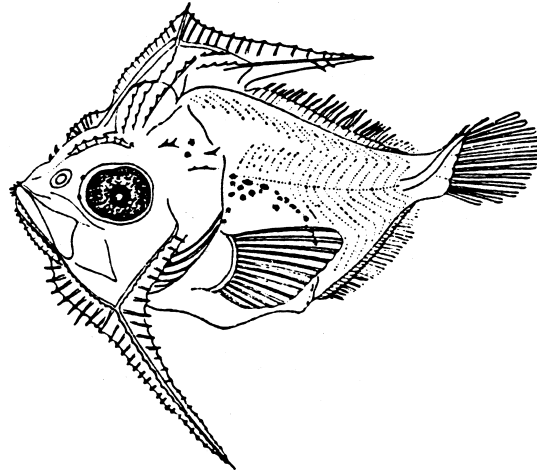
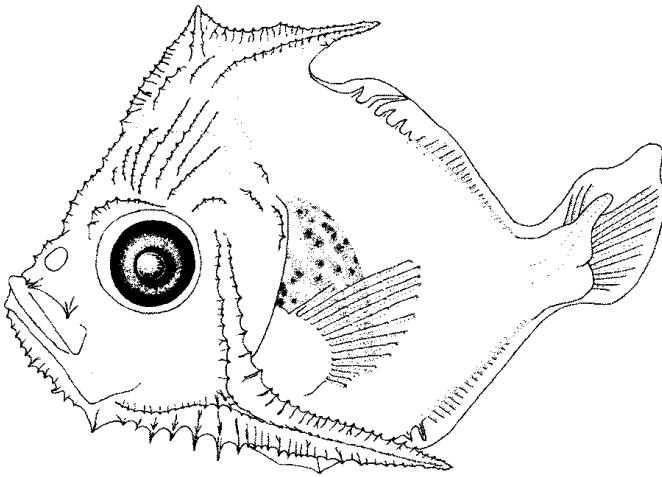
| | |
|--------------------|---------------|
| Myomeres: | 22 |
| Vertebrae: | 22 |
| Dorsal fin rays: | VII–IX, 31–38 |
| Anal fin rays: | III, 29–34 |
| Pectoral fin rays: | I, 12–14 |
| Pelvic fin rays: | I, 5 |
| Caudal fin rays: | 4+6+6+3 |

Larvae of certain other families have serrated ridges on mid-cranium, but differ as shown in table: × = present

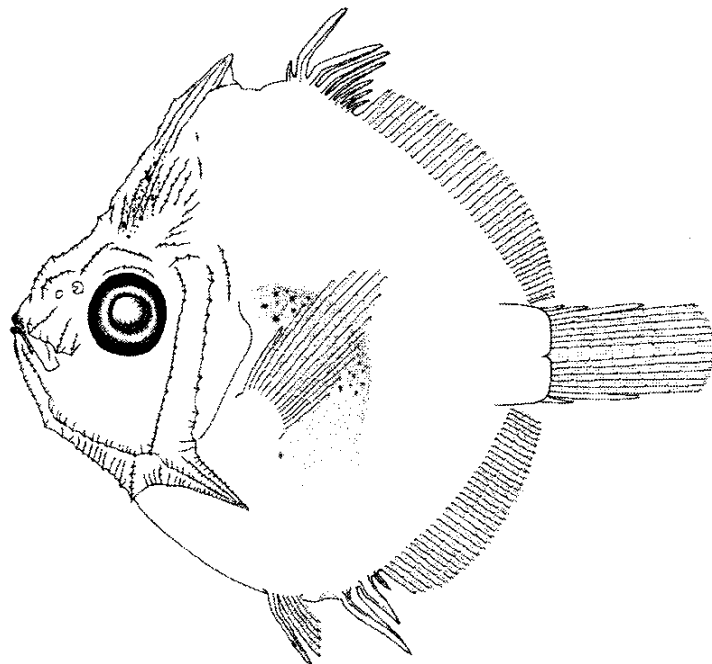
| Family | Preopercle angle spine | Large pelvic dorsal, and anal fin spines | Serrated cranial ridges | Rostral spine | Pterotic/Parietal spine |
|---------------------------------|----------------------------|--|-------------------------|------------------|-------------------------|
| Caproidae | × (lost at transformation) | no | × | no | × |
| Acanthuridae | no | × | × | no | small |
| Beryciformes (some families) | × | no | × | × | × |
| Scorpaeniformes (some families) | × | no | × | no | × |
| Dactylopteridae | × | no | no | no | × |
| Priacanthidae | × | × | × | no | × |
| Istiophoridae | × | no | no | elongate maxilla | × |

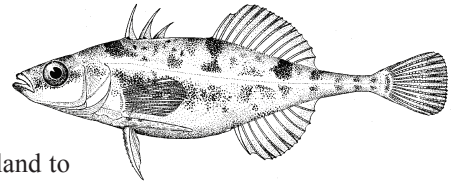
Figures: Adult: Parin, 2002b; **A–B:** Nakahara, 1962; **C–D:** M. D. Greene (Greene and Powell, 2006)

References: Berry, 1959b; Nakahara, 1962; Johnson and Patterson, 1993; Greene and Powell, 2006; Moore and Klein-MacPhee, 2003; Parin, 2002b

Antigonia capros**A. 3.0 mmSL****B. 4.7 mmSL****C. 4.8 mmSL**

Cranial and preopercle
spines become
reduced in size
by about 8.0 mmSL
and disappear at
transformation

**D. 8.0 mmSL**

Apeltes quadracus* (Mitchill, 1815)*Gasterosteidae****Fourspine stickleback**

Range: Coastal western North Atlantic Ocean from Labrador and Newfoundland to Virginia

Habitat: Shallow, calm, vegetated areas in freshwater, brackish estuaries, lagoons, coves, bays, salt marshes and tidal creeks; remain in estuarine areas, in deeper water, through the winter

Spawning: Spring; mostly Apr–May; later farther north

Eggs:

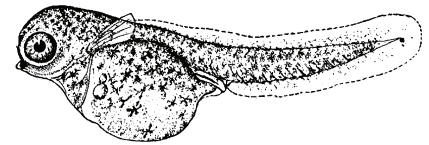
- Spherical, adhesive, amber-colored
- Diameter: 1.3–1.6 mm
- Oil globules: few, about 0.1 mm in diameter
- Protected in nests built of vegetation fragment
- Males guard eggs and early larvae

**Meristic Characters**

| | |
|--------------------|-------------|
| Myomeres: | 29–34 |
| Vertebrae: | 29–34 |
| Dorsal fin rays: | II–IV, 9–14 |
| Anal fin rays: | I, 7–11 |
| Pectoral fin rays: | 11–12 |
| Pelvic fin rays: | I, 2 |
| Caudal fin rays: | 13 |

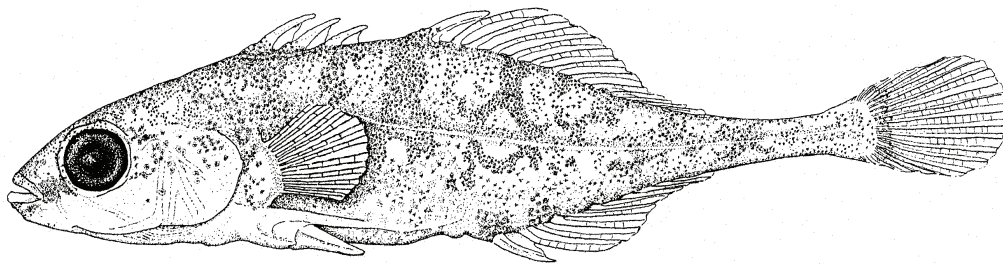
Larvae:

- Hatching occurs at 4.2–4.5 mmTL; mouth functional, eyes pigmented
- Body moderately elongate, with small head
- Preanus length >50% SL
- Very narrow caudal peduncle becomes emphasized with development
- Snout moderately pointy, with small mouth not reaching level of anterior eye
- Flexion occurs at about 7.0 mmTL
- Sequence of fin ray formation C, D, A – P₁ – P₂ (late); fin rays (except pelvic) complete by 16.0 mm
- Pigmentation includes dense scattering of melanophores over much of head and body; relatively clear, unpigmented, circular areas develop along dorsum of body



Yolk-sac larva, 4.3 mmTL

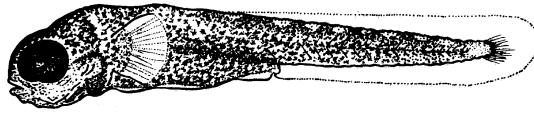
Note: 1. Larvae are generally more heavily pigmented than those of *Gasterosteus aculeatus*

Early Juvenile:**G. 17.9 mmSL**

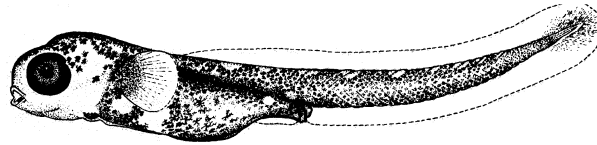
Figures: Adult: A. H. Baldwin (Krueger, 2002); Egg and yolk-sac larva: Kuntz and Radcliffe, 1917; **A–F:** William L. Dovel (Hardy, 1978a); **G:** Susan Kaiser (Able and Fahay, 1998)

References: Kuntz and Radcliffe, 1917; Scott and Scott, 1988; Able and Fahay, 1998; Krueger, 2002

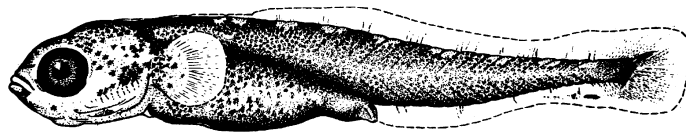
Apeltes quadracus



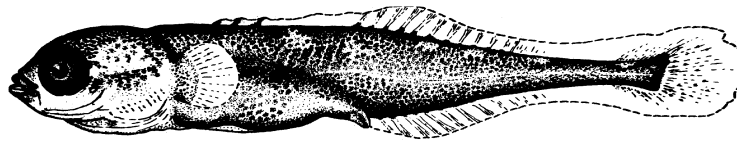
A. 5.2 mmTL



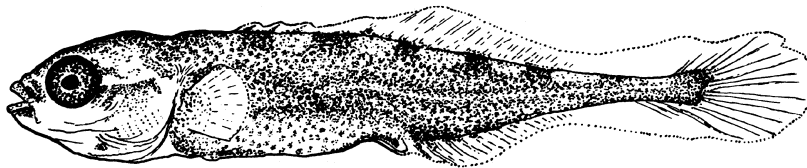
B. 5.6 mmTL



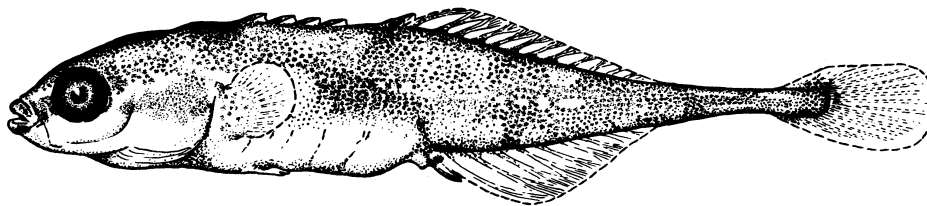
C. 8.4 mmTL



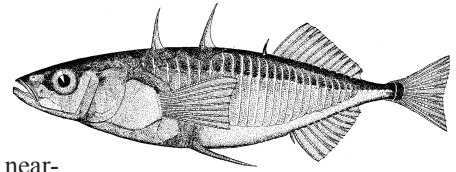
D. 10.1 mmTL



E. 10.5 mmTL



F. 16.0 mmTL

Gasterosteus aculeatus* Linnaeus, 1758*Gasterosteidae****Threespine stickleback**

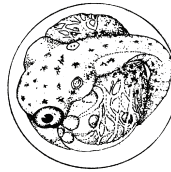
Range: Northern hemisphere, temperate zone in coastal waters and near-coastal freshwaters; in the western North Atlantic from Baffin Island to North Carolina

Habitat: Pelagic in oceanic waters to a variety of shallow estuarine and freshwater habitats, including tidal creeks and marsh surface pools

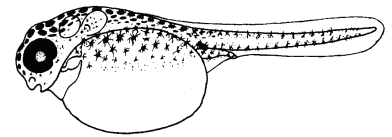
Spawning: "Anadromous" pattern: adults move from ocean into estuaries in late winter or early spring, spawn Mar–May (New Jersey), then move back offshore

Eggs:

- Demersal, spherical, adhere to each other
- Diameter: 1.0–2.0 mm
- Oil globules: numerous (5–25+), various sizes
- Perivitelline space: narrow
- Protected in nests built of vegetation fragments
- Male guards and aerates (by fanning) the eggs during incubation

**Meristic Characters**

| | |
|--------------------|------------|
| Myomeres: | 29–33 |
| Vertebrae: | 29–33 |
| Dorsal fin rays: | II–V, 6–13 |
| Anal fin rays: | I, 6–13 |
| Pectoral fin rays: | 9–11 |
| Pelvic fin rays: | I |
| Caudal fin rays: | 5–7 + 6–7 |

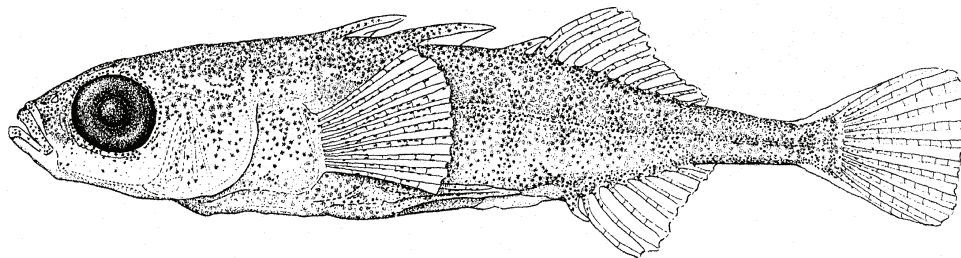


Yolk-sac larva, 3.0 mmTL

Larvae:

- Hatching occurs at 3.0–7.0 mm (mostly 4.2–4.5 mmTL); mouth functional, eyes pigmented; melanophores scattered over dorsum of head and body, and upper surfaces of yolk mass
- Body moderately elongate, with bulging yolk mass
- Preanus length 40–60% SL
- Later larvae more slender, with pointy snout, small mouth not reaching level of anterior eye
- Flexion occurs at about 6.0–11.0 mmTL
- Sequence of fin ray formation: C, D, A – P₁ – P₂ (late); all fin rays complete by 15.0 mmTL
- Caudal peduncle becomes very slender by about 10 mm; lateral keels develop on sides of caudal peduncle
- Pigmentation includes dense scattering of melanophores over dorsum of head and body; vague barred pattern may be visible at about 12–30 mmTL; some juveniles may develop silvery flanks

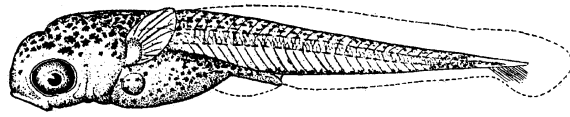
Note: 1. A congener, *Gasterosteus wheatlandi*, occurs from Newfoundland to New Jersey. Its reproductive behavior and habitat preferences are similar to those of *G. aculeatus* (McInerney, 1969); eggs and larvae are undescribed.

Early Juvenile:**E. 18.6 mmTL**

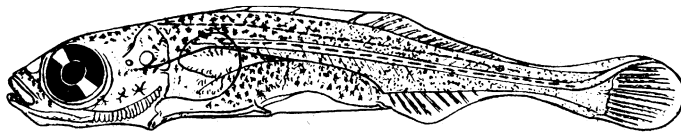
Figures: Adult: H. L. Todd (Krueger, 2002); Egg: Kuntz and Radcliffe, 1917; yolk-sac larva and A: Swarup, 1958; B: Ehrenbaum, 1905; C: Agassiz, 1882; D: Y. Shojima, 1958; E: Susan Kaiser (Able and Fahay, 1998)

References: Kuntz and Radcliffe, 1917; Cowen *et al.*, 1991; Able and Fahay, 1998; Krueger, 2002

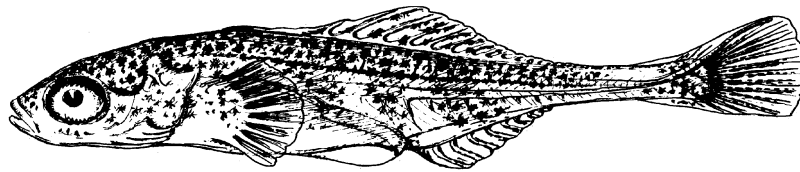
Gasterosteus aculeatus



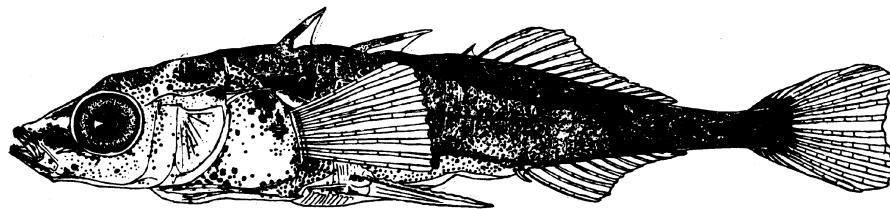
A. 6.3 mmTL



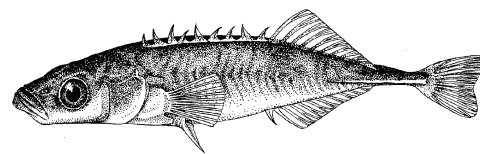
B. 9.4 mmTL



C. 12.0 mmTL



D. 19.8 mmTL

Pungitius pungitius* (Linnaeus, 1758)*Gasterosteidae****Ninespine stickleback**

Range: Circumpolar; in salt and freshwater of northern hemisphere; in the western North Atlantic, a coastal form occurs from Baffin Island and southern Greenland to New Jersey

Habitat: Saltwater or brackish waters along shorelines; also freshwater

Spawning: "Catadromous" pattern: adults migrate from freshwater to brackish habitats during spring and early summer, spawn, then return to freshwater habitats during fall; spawn in tidal, heavily vegetated, marsh-surface pools

Eggs:

- Spherical, various shades of yellow
- Diameter: 1.10–1.22 mm
- Yolk: homogeneous
- Oil globules: many, 0.02–0.20 mm in diameter
- Protected in cylindrical "nurseries" built of vegetation fragments
- Male guards and aerates (by fanning) the eggs during incubation

Larvae:

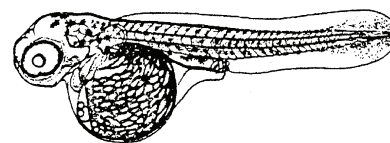
- Hatching occurs at 4.2–5.6 mm; eyes unpigmented, mouthparts unformed, pigment concentrated over dorsal surface of yolk mass and top of head
- Preanus length about 50% SL
- Body moderately elongate
- Mouth small; maxilla ends under level of anterior eye
- Flexion occurs at about 5–6 mmNL
- Caudal, dorsal and anal fin rays form first
- Dorsal fin spines form from posterior to anterior; dorsal fin rays form from anterior to posterior
- Pigmentation in early larvae concentrated over gut and dorsum of body and head; during flexion stage, dense pigment covers most of head and body

Note:

1. Some authors refer to the North American form as *Pungitius occidentalis* and regard it as separate from the European *Pungitius pungitius* and the Asian *P. sinensis* (e.g. Haglund *et al.*, 1993). The three species are reproductively isolated by breeding behavior and habitat preferences (Foster, 1977). The North American species is further separated into a coastal ("Bering") form and an inland ("Mississippian") form. The coastal form has more dorsal fin spines and anterior lateral plates, but fewer gill rakers, than congeners (McPhail, 1963). Some authors also regard these North American forms as separate species. See Krueger (2002).
2. If the previously described taxonomy is followed, the drawings and description pertain to *Pungitius pungitius* collected from the White Sea

Meristic Characters

| | |
|--------------------|----------|
| Myomeres: | 30–32 |
| Vertebrae: | 32–34 |
| Dorsal fin rays: | IX, 9–11 |
| Anal fin rays: | I, 8–10 |
| Pectoral fin rays: | 10 |
| Pelvic fin rays: | I, 1 |
| Caudal fin rays: | 12 |



Yolk-sac larva, 4.0 mmNL

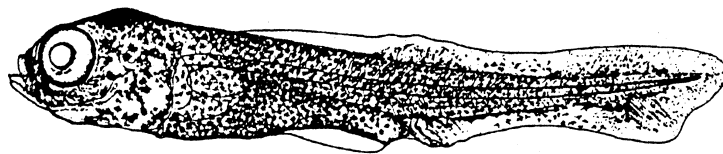
Figures: Adult: D. R. Harriott (Scott and Scott, 1988); Egg, yolk-sac larva and A–C: Shadrin, 1994

References: Griswold and Smith, 1972; Wooton, 1976; Foster, 1977; Shadrin, 1994; Scott and Scott, 1988; Krueger, 2002

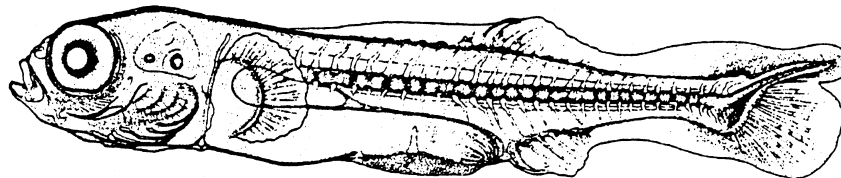
Pungitius pungitius



A. 5.5 mmNL



B. 5.4 mmNL



**C. 6.7 mmNL
(Melanophores Excluded)**

Syngnathiformes

Selected meristic characters in species belonging to the order Syngnathiformes whose adults or larvae have been collected in the study area. Classification sequence follows Eschmeyer, 1990. Caudal fin rays (if present) are 10 in most syngnathids, 9 in *Oostethus*; see species accounts for other counts. Sources: Miller and Jorgenson, 1973; Fritzsche, 1976; Dawson, 1982; Vari, 1982.

| Family Species | Vertebrae | Dorsal Fin Rays | Anal Fin Fin Rays | Pectoral Fin Rays | Trunk Rings | Tail Rings |
|--|-------------|--------------------|----------------------|----------------------|----------------|---------------|
| Fistulariidae | | | | | | |
| <i>Fistularia petimba</i> | 76–83 | 14–16 | 14–15 | 15–17 | – | – |
| <i>Fistularia tabacaria</i> | 84–87 | 13–18 | 13–17 | 15–16 | – | – |
| Centriscidae² | | | | | | |
| <i>Macroramphosus scolopax</i> | 23 | IV–VIII, 10–14 | 19–21 | 18–21 | – | – |
| Syngnathidae | | | | | | |
| <i>Amphelikturus dendriticus</i> | (See Rings) | 15–18 | 2–3 | 12–15 | 13–15 | 37–41 |
| <i>Bryx dunckeri</i> | 50–53 | 21–27 | 0 | 9–13 | 15–18 | 30–36 |
| <i>Cosmocampus elucens</i> ³ | 49–50 | 21–25 | 3 | 11–15 | 15–18 | 29–34 |
| <i>Hippocampus erectus</i> | 49–51 | 16–20 | 3–4 | 14–17 | (10) 11 | 33–38 |
| <i>Hippocampus reidi</i> | (See Rings) | 16–19 | (3) 4 | 15–17 | 11 | 33–37 |
| <i>Oostethus brachyuros</i> ¹ | (See Rings) | 33–54 | 4 | 17–23 | 16–21 | 20–26 |
| <i>Syngnathus floridae</i> | 51–52 | 26–35 | 3 | 12–16 | 16–19 | 29–39 |
| <i>Syngnathus fuscus</i> | 55–60 | 33–49 | 3 | 12–15 | 18–21 | 34–39 |
| <i>Syngnathus louisianae</i> | 51–52 | 29–42 | 3 | 12–16 | 19–21 | 33–38 |
| <i>Syngnathus pelagicus</i> | 49–52 | 25–34 | 3 | 12–16 | 15–18 | 30–34 |
| <i>Syngnathus springeri</i> | 61–62 | 32–38 | 3 | 12–14 | 22–24 | 34–37 |

¹ Treated here as the subspecies *O. brachyuros lineatus*

² Macroramphosidae of some authors

³ *Cosmocampus hildebrandi* occurs as far north as just south of 35°N; it differs from *C. elucens* in having a shorter snout, more tail rings (31–35), and fewer pectoral fin rays (10–13)

Characters in 5 species of *Syngnathus* that occur in the study area. (* = counts from North Carolina and north only.)

| Species | | Trunk Rings Under Dorsal Fin | Total Rings Under Dorsal Fin | Tail Rings | Dorsal Fin Rays |
|----------------------|--------|---------------------------------|---------------------------------|------------|--------------------|
| <i>S. fuscus</i> | 18–21 | 3.0–6.5* | 7.75–9.0 | 34–39 | 34–49* |
| <i>S. floridae</i> | 17–18* | 0.25–2.00* | 6.25–7.75* | 29–35* | 26–35* |
| <i>S. louisianae</i> | 19–21 | 3.75–6.0 | 6.50–9.00 | 35–38* | 33–42* |
| <i>S. pelagicus</i> | 15–18 | 1.0–3.0 | 5.75–8.50 | 30–34 | 25–34 |
| <i>S. springeri</i> | 22–24 | 3.0–4.75 | 7.5–8.75 | 34–37 | 34–48* |

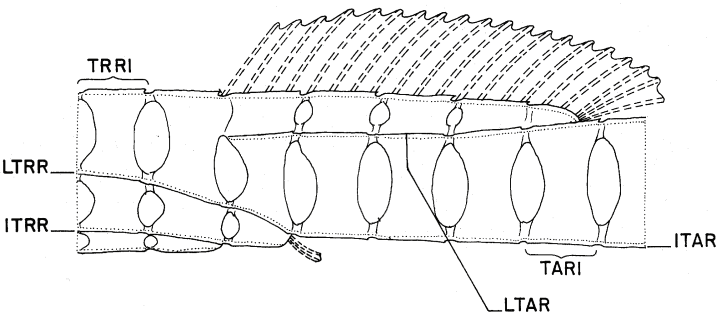
Syngnathiformes

When syngnathids are released from the male’s brood pouch (or are "born"), they are essentially small adults. Therefore, there is no transformation, *per se*, from larva to juvenile in these fishes, and adult characters are useful, or essential, for identification. Characters of the exoskeleton (body rings separated by ridges encircling the body and tail) are more useful than vertebrae (or myomeres) for identifying genera and species of syngnathids (pipefishes). The first trunk ring bears the pectoral fin base, the last bears the anus. Tail rings follow, encircling the tail between the anus and base of caudal fin. Longitudinal body ridges are also located on the body (below) and are important characters for separating genera. (Figures and table after Dawson, 1982.)

Characters of syngnathid genera (pipefishes) with species occurring in the present study area.

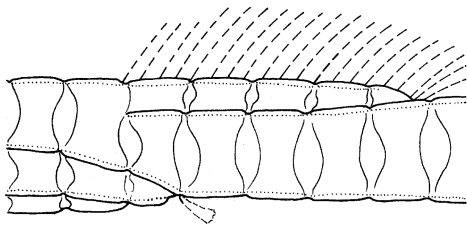
ITRR = Inferior Trunk Ridge
ITAR = Inferior Tail Ridge
LTRR = Lateral Trunk Ridge
LTAR = Lateral Tail Ridge

TRRI = Trunk Ring
TARI = Tail Ring

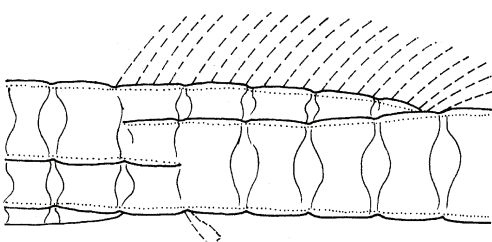


| Genus | ITRR–ITAR | LTRR–LTAR | Lateral Snout Ridge | Pectoral Fin Rays | Caudal Fin Rays | Anal Fin |
|-----------------------------------|-------------|-------------|---------------------|-------------------|-----------------|----------|
| <i>Amphelikturus</i> ¹ | Interrupted | Interrupted | Absent | 12–15 | 9–10 | Present |
| <i>Oostethus</i> | Interrupted | Interrupted | Absent | 17–23 | 9 | Present |
| <i>Bryx</i> | Confluent | Interrupted | Present | <16 | 10 | Absent |
| <i>Cosmocampus</i> | Confluent | Interrupted | Present | <16 | 10 | Present |
| <i>Syngnathus</i> | Confluent | Interrupted | Absent | <16 | 10 | Present |

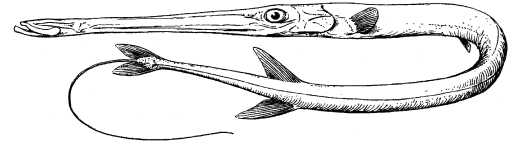
¹ Tail is curled (prehensile) and dorsal fin base is elevated in *Amphelikturus*; not curled and not elevated in others



Condition of body ridges in *Oostethus* and *Amphelikturus*



Condition of body ridges in *Bryx*, *Cosmocampus* and *Syngnathus*

Fistularia tabacaria* Linnaeus, 1758*Fistulariidae****Bluespotted cornetfish**

Range: Western and eastern tropical Atlantic Ocean; in the western North Atlantic as far north as Nova Scotia and Newfoundland, south to Brazil, including Gulf of Mexico and Caribbean Sea

Habitat: Mostly over grass flats and reefs to a depth of 36 m

Spawning: Small larvae collected in Feb; otherwise undescribed

Eggs:

- Pelagic, spherical
- Diameter: 1.5–2.1 mm
- Oil globules: absent
- Perivitelline space: very narrow

**Meristic Characters**

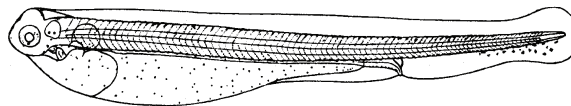
| | |
|--------------------|-------|
| Myomeres: | 75–88 |
| Vertebrae: | 84–87 |
| Dorsal fin rays: | 13–18 |
| Anal fin rays: | 13–17 |
| Pectoral fin rays: | 15–16 |
| Pelvic fin rays: | 6 |
| Caudal fin rays: | 7+7 |

Larvae:

- Size at hatching undescribed; *Fistularia petimba* hatches at 7.1 mmTL (Fig. E)
- Body extremely elongate, oval in cross-section; gut moderately convoluted
- Preanus length about 75% SL; small air bladder above gut at about 33% of gut length
- Head small, snout elongate with small, terminal mouth; teeth begin to form at about 30+ mm
- Note development of a filament growing from middle 2 rays in caudal fin; spines form on this filament at about 110 mm
- Note short-based dorsal and anal fins located opposite each other; fin rays form during flexion stage
- Pelvic fin rays late-forming
- Head spines: small spines first visible over eye and at cleithral symphysis in preflexion stage; later larvae have 5 serrate ridges on snout (dorsal, dorso-lateral, ventro-lateral); spines or spiny ridges also form on supraoccipital, supracleithral, posttemporal, and parietal; spines disappear at settlement size (about 150 mm)
- Body spinules form shortly after hatching, in 4 rows (along dorso- and ventro-lateral body edges) along almost entire length of body; spines spread to cover entire body surface at about 40+ mm; these begin to disappear on anterior part of body, then posterior part, at settlement size (about 150 mm)
- Pigment includes stripe of melanophores along dorsum of gut, ventral surface of tail, scattering on lower jaw and on caudal finfold; larger larvae and juveniles develop encircling vertical bands on snout, trunk and tail

Note:

1. A congener, *Fistularia petimba*, has also occurred in the study area; the egg figure and characters above pertain to eggs of this species collected in Japanese waters; the yolk-sac larva is illustrated below; see meristic characters in Syngnathiformes introductory table

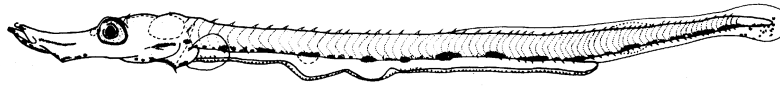
E. 7.1 mmTL***Fistularia petimba*
(Yolk-sac larva)**

2. The juvenile stage, characterized by a covering of small spines over the body, has been referred to as the "villosa" stage (Lütken, 1880)

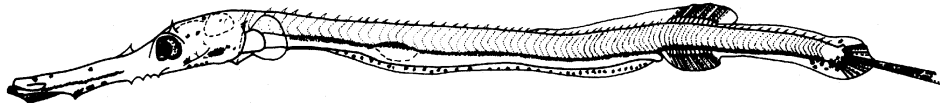
Figures: Adult: Bigelow and Schroeder, 1953; Egg: Mito, 1961a; **A–B:** Leis and Rennis, 1983; **C:** Jungerson, 1910; **D:** Böhlke and Chaplin, 1968; **E:** Mito, 1961a

References: Fritzsche, 1976; Hardy, 1978a; Leis and Rennis, 1983; Klein-MacPhee, 2002f

Fistularia tabacaria

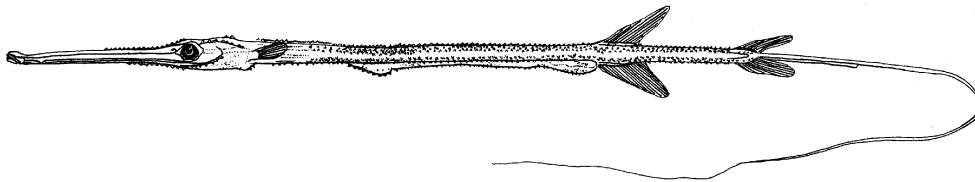


A. 9.4 mm (*Fistularia* sp.)

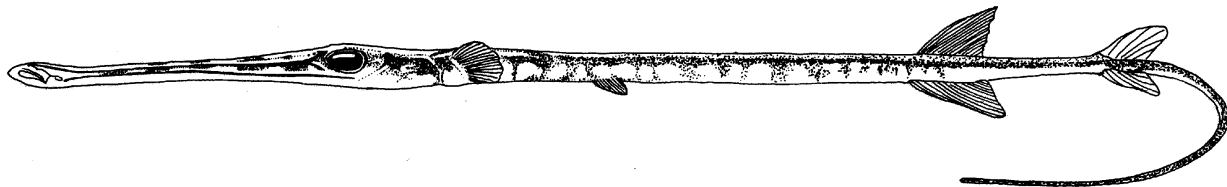


B. 15.6 mm (*Fistularia commersoni*)

Larvae depicted in Figs. A and B
were collected from the Great
Barrier Reef (SW Pacific Ocean)



**C. 43.0 mm TL (not including 42-mm caudal filament)
(*Fistularia tabacaria*)**



**D. 306 mm (including caudal filament)
(*Fistularia tabacaria*)**

Macroramphosus scolopax* (Linnaeus, 1758)*Centriscidae****Longspine snipefish**

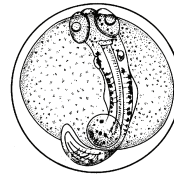
Range: Worldwide in temperate waters, mostly between 20° and 40°N; in the western North Atlantic from Slope Water off Nova Scotia to Caribbean Sea

Habitat: Benthopelagic in depths of 50–500 m

Spawning: Oct–Mar (eastern Atlantic) on continental shelf, over seamounts, or near islands

Eggs:

- Pelagic, Spherical, amber-colored
- Diameter: 1.0 mm
- Chorion: smooth
- Yolk: rose-violet in color
- Oil globule: single, 0.2 mm

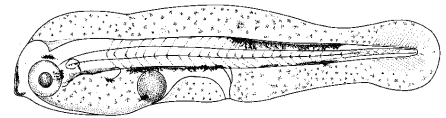


Larvae:

- Hatching occurs at 3.0 mmTL
- Body moderately elongate; preanus length about 50% SL
- Note 'duck-billed' profile throughout larval stage
- Flexion begins at about 4.0 mmTL
- Sequence of fin ray formation: C, D, A–P₁–P₂
- Head spines: supraorbital and occipital crests develop in larvae as small as 4.0–6.0 mm; preopercle edge develops series of spines; spines become less obvious by about 10.0 mm
- Body spines: spinous scales develop along lateral line at about 4.2 mm, cover entire body by 6.2 mm
- Pigmentation: early larvae have saddle of melanophores on dorsum of tail and a line of pigment along ventral surface of body from near eye to beginning of caudal peduncle; spots on top of head; later stages have increased pigment spreading onto flanks until much of body is densely pigmented except for small clear space on caudal peduncle

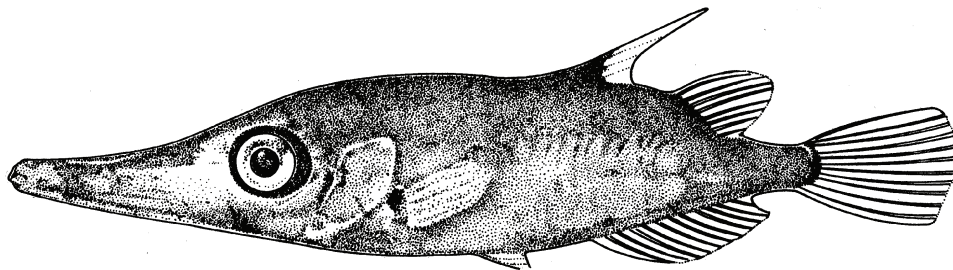
Meristic Characters

| | |
|--------------------|----------------|
| Myomeres: | 23 |
| Vertebrae: | 23 |
| Dorsal fin rays: | IV–VIII, 10–14 |
| Anal fin rays: | 19–21 |
| Pectoral fin rays: | 18–21 |
| Pelvic fin rays: | 4–6 |
| Caudal fin rays: | 6–7+4+5+6–7 |



Yolk-sac larva, 3.0 mmTL

Note: 1. Larvae and juveniles up to 50–100 mm live near surface or in midwaters; larger individuals descend to near bottom habitats

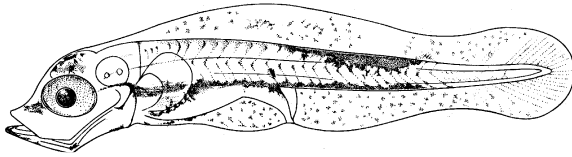
Early Juvenile:

G. 20.0 mmTL Pelagic-juveniles develop pelagic coloration (blue dorsum, silvery sides) at sizes between 13.0 mm and size at descent

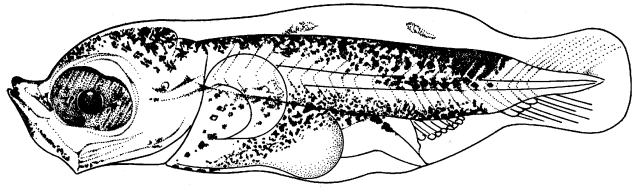
Figures: Adult: K. H. Moore (Collette, 2002c); Egg, yolk-sac larva, and A–C, E: Elizabeth Ray Peters (redrawn from Sparta, 1936); D, F: Uchida, 1958; G: D'Ancona, 1933

References: Fage, 1918; Sparta, 1933; D'Ancona, 1933; Ehrich and John, 1973; Collette, 2002c

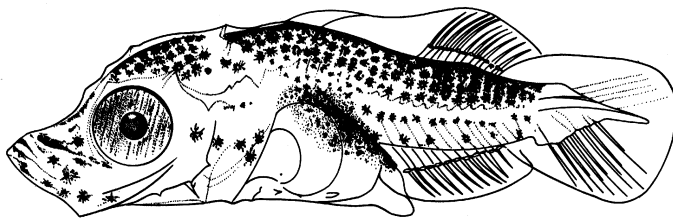
Macroramphosus scolopax



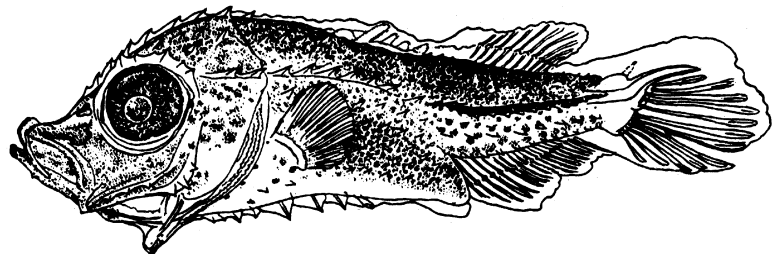
A. 2.8 mmTL



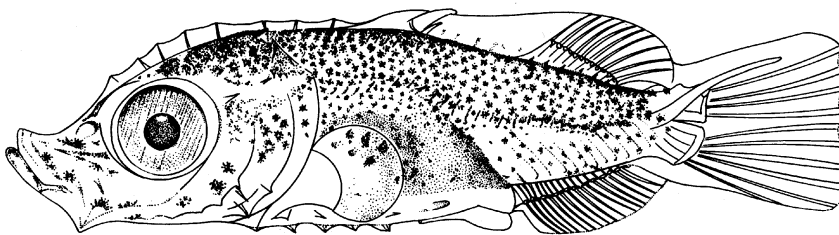
B. 3.6 mmTL



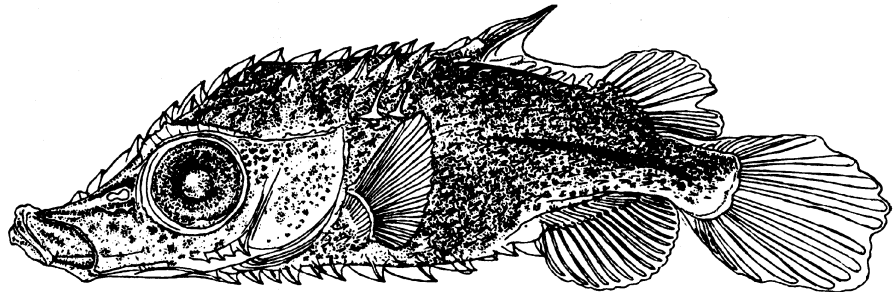
C. 4.8 mmTL



D. 5.6 mmTL



E. 6.2 mmTL



F. 8.0 mmTL

Hippocampus erectus* Perry, 1810*Syngnathidae****Lined seahorse**

Range: Atlantic coast of the Americas from Nova Scotia to Uruguay, including Gulf Stream, Bermuda, Gulf of Mexico and Caribbean Sea

Habitat: Estuaries and inner continental shelf, in depths to 73 m; typically associated with vegetation (e.g. eelgrass); most move into ocean for winter

Spawning: Spring through summer (New Jersey); possibly year-round in Florida; female deposits fertilized eggs in male's brood pouch where embryonic development and hatching occur. Brood size as large as 1,515 embryos in small adult male; brood size increases with size of male

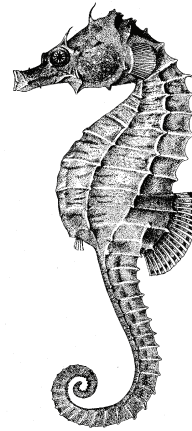
Eggs:

- Pear-shaped, 3.1–3.6 mm long
- Yolk: light orange
- Oil globules: numerous, deep orange

Larvae:

- Hatching occurs (in brood pouch) at 3.3–4.8 mm; size at release from pouch as small as 6.0 mm
- Body shape distinctive, but snout shorter than in juveniles or adults
- Fin rays fully developed at hatching
- Cirri develop on body as small as 7.0 mm
- Pigmentation at hatching includes alternating dark and light bands on body; later stages develop dark pigment on top of head that spreads over gut; juveniles become dark over-all with light colored blotches surrounding bases of dermal spines

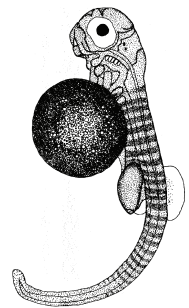
Note: 1. Young-of-the-year and adults have been observed on inner continental shelf off Long Island during the winter, lying motionless on bottom substrates, in water temperatures of 10.6°C (Wicklund *et al.*, 1968); in Chesapeake Bay, they may overwinter in deep channels (Musick, 1972)

**Meristic Characters**

| | |
|--------------------|-------|
| Myomeres: | 49–51 |
| Vertebrae: | 49–51 |
| Dorsal fin rays: | 16–20 |
| Anal fin rays: | 3–4 |
| Pectoral fin rays: | 14–17 |
| Pelvic fin rays: | 4 |
| Caudal fin rays: | none |



Egg and
Yolk-sac larva
3.6 mmTL



**E. 91 mmTL
(Juvenile)**

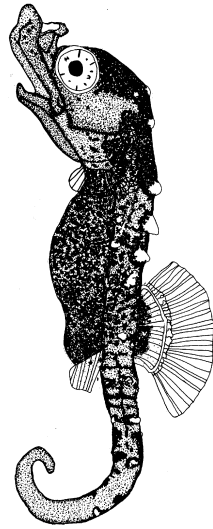


Branched, dermal flaps may be present over body, especially associated with tubercles of the superior trunk ridges or tail ridges

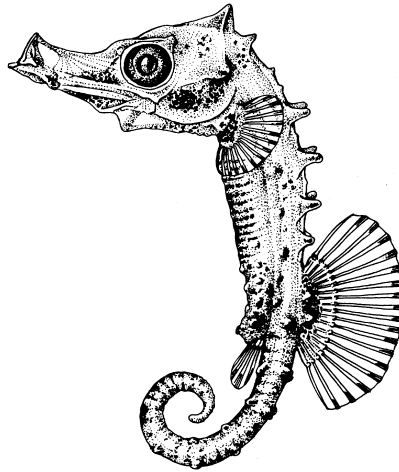
Figures: Adult: H. L. Todd (Collette, 2002c); Egg, yolk-sac larva, and **A:** Linda L. Hudson (Hardy, 1978a); **B:** Alice J. Lippson (Lippson and Moran, 1974); **C–D:** Ginsburg, 1937; **E:** Vari, 1982 (after Ginsburg, 1937)

References: Hardy, 1978a; Vari, 1982; Able and Fahay, 1998; Collette, 2002c

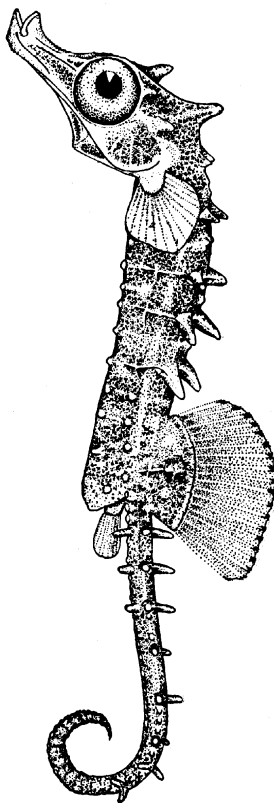
Hippocampus erectus



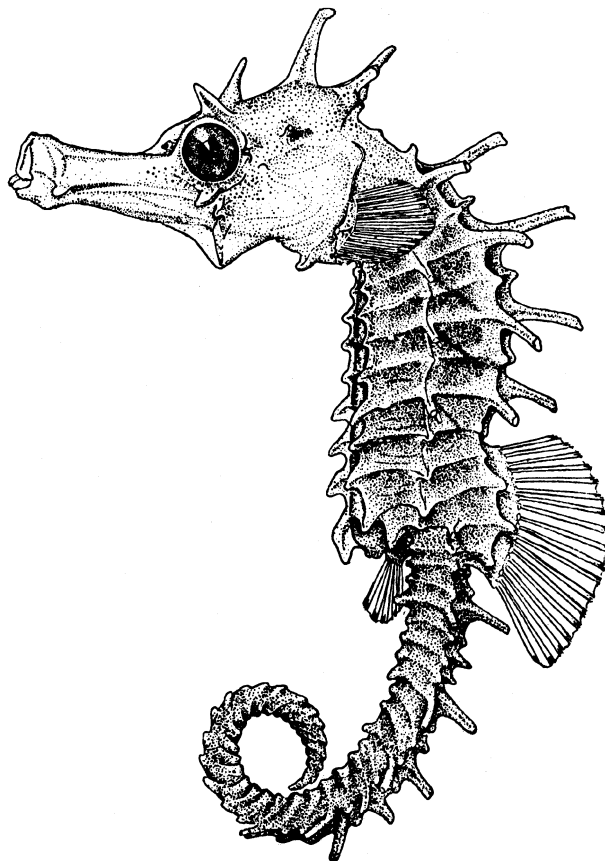
A. 4.8 mmTL



B. 3.3 mmTL



C. 7.0 mmTL



D. 17.0 mmTL

Syngnathus fuscus* Storer, 1839*Syngnathidae****Northern pipefish**

Range: Western North Atlantic Ocean from Gulf of St. Lawrence to Florida

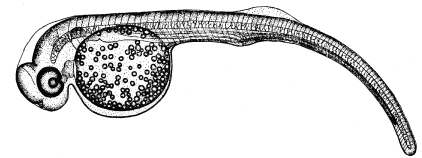
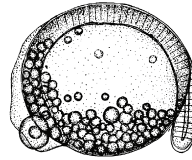
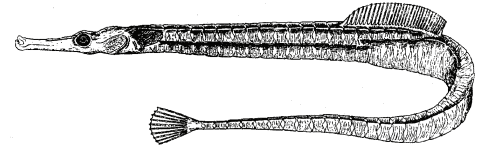
Habitat: Shallow bays, harbors, rivers, creeks, salt marshes, usually associated with submerged vegetation; spends the winter in coastal ocean

Spawning: Spring through summer; female deposits fertilized eggs in male's brood pouch where embryonic development and hatching occur; brood size varies from 45 to 1,380 embryos; larvae are released from pouch after hatching

Eggs: – Diameter: 0.75–1.0 mm
– Oil globules: multiple

Larvae: – Release from the brood pouch occurs at sizes up to 10–12 mmTL, after yolk is absorbed
– Body shape distinctive from earliest stages
– Preanus length about 50% SL initially, decreases to about 40% SL
– Air bladder forms over midsection of gut
– Mouth small and terminal at end of elongate snout
– Dorsal and caudal fin rays early forming
– Dorsal fin relatively long-based
– Anal fin rays form late; pelvic fin rays lacking
– Body rings form early; 18–21 trunk rings present between pectoral fin base and anus; 34–39 tail rings present
– Earliest larvae lack pigment; at about 8.5 mm, vague bands form across body, pigment spreads to involve dorsal and ventral edges of body, then entire body becomes darkly pigmented

Note: 1. Juveniles remain planktonic until about 40 mmTL, when settlement to shallow, vegetated habitats occurs.
2. In New Jersey estuaries, young-of-the-year occur from May to October or November, when they begin to migrate to oceanic habitats. Size at the end of this estuarine stage is variable, from 5 to 20 cmTL. Reproduction begins the following spring, when young-of-the-year reach an age of one year and lengths of 8 to 24 cmTL, and begin returning to estuaries. It is unknown whether older individuals (e.g. two years old) participate in this spawning.



Excised embryo, 3.0 mmTL

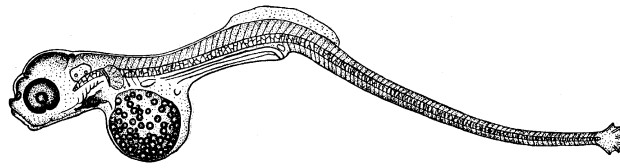
Meristic Characters

| | |
|--------------------|-------|
| Myomeres: | 55–60 |
| Vertebrae: | 55–60 |
| Dorsal fin rays: | 33–49 |
| Anal fin rays: | 3 |
| Pectoral fin rays: | 12–15 |
| Pelvic fin rays: | none |
| Caudal fin rays: | 10 |

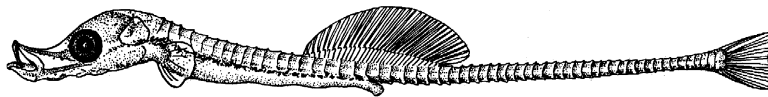
Figures: Adult: Bigelow and Welsh, 1925; Egg, embryo and A: Ryder, 1887; **B, D–E:** A. J. Lippson (Hardy, 1978a); **C:** R. Lynn Moran (Lippson and Moran, 1974)

References: Lippson and Moran, 1974; Hardy, 1978a; Fritzsche, 1984; Lazzari and Able, 1990; Able and Fahay, 1998

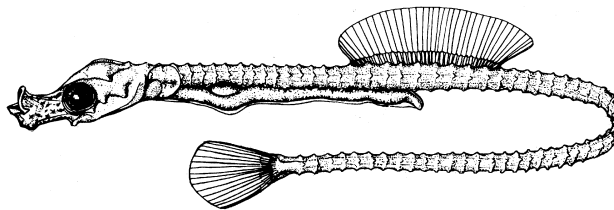
Syngnathus fuscus



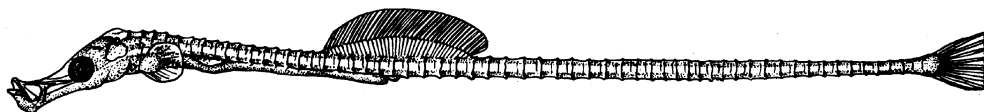
A. 3.5 mmTL (Embryo)



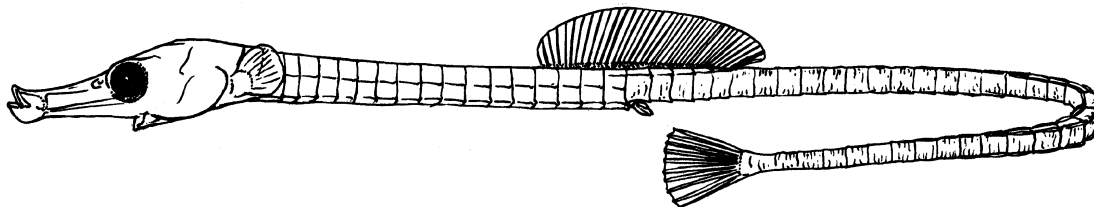
B. 7.8 mmTL



C. 13.2 mmTL



D. 14.7 mmTL



E. 37.0 mmTL