Beryciformes and Polymixiiformes

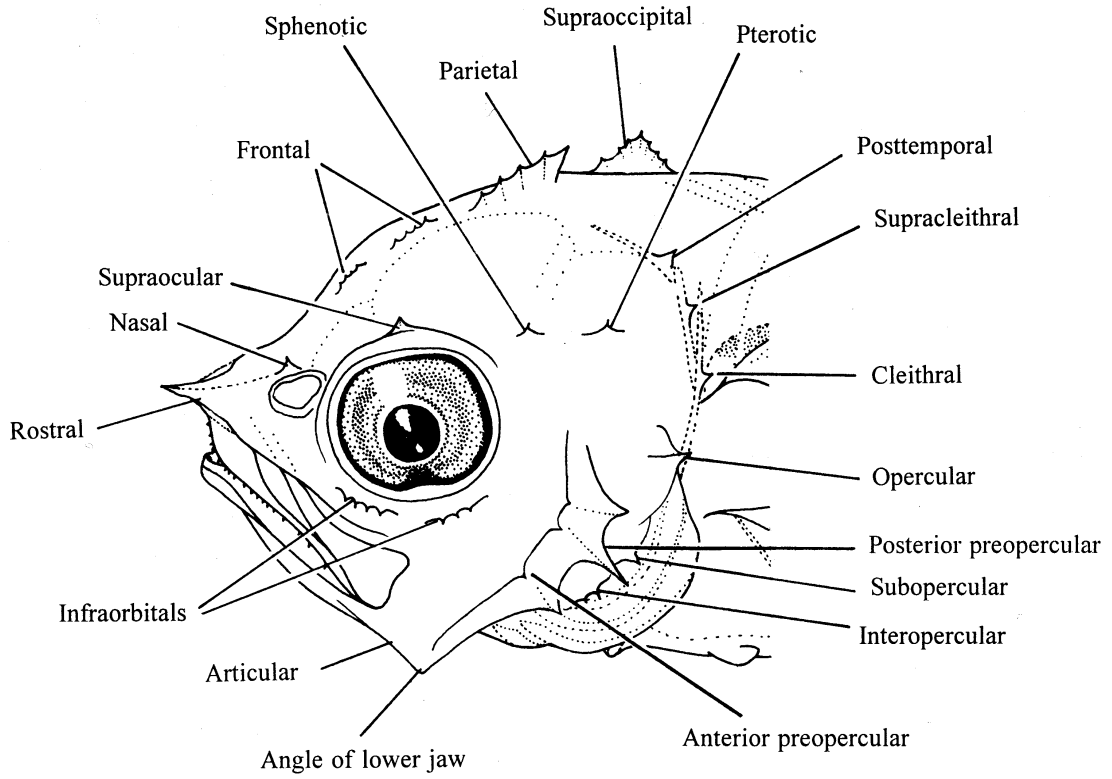
Selected meristic characters in species belonging to the orders Beryciformes or Polymixiiformes whose adults or larvae have been collected in the study area. Classification sequence follows Johnson and Patterson (1993); Moore (2002a; 2002b). Polymixiidae is often included in the Beryciformes, but recent classifications and revisions place it in its own order. The sequential placement of the Polymixiiformes is sometimes near the Ophidiiformes or Gadiformes, although a close relationship to those groups is not implied. It is included here (as a separate order) because of its past association with Beryciformes or Stephanoberyciformes (see next chapter), but no close phylogenetic relationship with those taxa is suggested. Sources: Kotlyar, 1986; Johnson and Patterson, 1993; Moore, 2002a; 2002e; 2002g; Greenfield, 2003; Richards *et al*., 2003.

Order Family *Species*	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Pelvic Fin Fin Rays
Beryciformes					
Trachichthyidae					
Gephyroberyx darwini	26	VII–IX, 12–15	III, 10–12	13–16	I, 6
Hoplostethus atlanticus	29	V–VI, 15–19	II–III, 10–12	16–20	I, 6
Hoplostethus mediterraneus	26	VI–VII, 12–14	III, 9–11	14–16	I, 6
Hoplostethus occidentalis	26	IV–VIII, 12–14	II–III, 8–10	14–18	I, 6
Diretmidae					
Diretmichthys parini	29–32	26–30	20–23	17–19	I, 6
Diretmus argenteus	15–17	25–29	20–24	16–20	I, 6
Anoplogastridae					
Anoplogaster cornuta	25–27	17–19	7–9	13–16	I, 6
Berycidae					
Beryx decadactylus	24	III–IV, 16–21	III–IV, 25–30	14–18	I, 9–10
Beryx splendens	24	III–IV, 12–15	IV, 25–30	15–19	I, 10–13
Holocentridae					
Holocentrus adscensionis	27	XI, 14–16	IV, 10	15–17	I, 7
Sargocentron bullisi	27	XI, 11–12	IV, 8	13–15	I, 7
Sargocentron vexillarium	27	XI, 12–14	IV, 8–10	14–15	I, 7
Ostichthys trachypoma	26	XI,I,13–14	IV, 10–12	14–16	I, 7
Polymixiiformes					
Polymixiidae					
Polymixia lowei	29–30	IV–VI, 26–32	III–IV, 15–18	14–18	I, 6
Polymixia nobilis	29	IV–VI, 34–38	III–IV, 15–18	14–18	I, 6

Beryciformes and Polymixiiformes

Until recently, the order Beryciformes was considered to include the suborders Bercoidei (sic) or Berycoidei, Stephanoberycoidei and Polymixioidei (e.g. Nelson, 1984; Eschmeyer, 1990; Watson, 1996l). However, several recent analyses (Johnson and Patterson, 1993; Baldwin and Johnson, 1995), based partly on ontogenetic characters, have proposed the classification followed here. The position of the monotypic Polymixiiformes is enigmatic, but it is probably not closely related to either of the other two orders. Instead, evidence (including ontogenetic) suggests it is more likely a relatively primitive member of a proposed Acanthomorpha (Johnson and Patterson, 1993). It is included in this section, primarily based on the extensive spinous ornamentation of the head of larvae, unusual for most primitive acanthomorphs. The larvae of Beryciformes and Stephanoberyciformes are separable, primarily based on the extent of spination on the heads of larvae, as described in the tables on the following two pages, (modified after Baldwin and Johnson, 1995; table 1).

The nature of head spination is important both for the identification of larvae and for contributing to an understanding of relationships between higher-level groups. "Maps" of head spination are included in several of the species-treatments because of this importance. The figure below describes the terminology of head-spines, which are usually named after the bone on which they originate. In some cases, these occur as isolated spines, in other cases they appear in the form of ridges, either rugose, spiny, or smooth-edged.



Hypothetical larva demonstrating distribution and terminology of head spines. Illustration by William Watson (Moser, 1996). See individual species treatments for specific distributions and characteristics of head spines in *Gephyroberyx*, *Hoplostethus*, *Beryx*, and *Polymixia*.

Beryciformes and Polymixiiformes (Stephanoberyciformes)

Characteristics of head spination in larvae that occur in the present study area. *Polymixia* and Stephanoberyciformes are below dashed line. See individual species treatments for more detail. Larvae of Stephanoberyciformes are covered in next chapter. Table modified after Baldwin and Johnson (1995) which also includes information on spinous scales and spines originating from other bones. Abbreviations: 0 = Absent; **Pr** = Present; **Rug** = Rugose; **Serr** = Serrate; **Ridge** = Non-serrate ridge.

FAMILY Genus	Supra-maxilla	Angulo-articular	Dentary	Infra-oribitals	Nasal	Frontal	Supra-ocular	Parietal	Pterotic
ANOPLOGASTERIDAE									
Anoplogaster	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	**Rug**	**Pr**	**Large, Rug**	**Serr**
DIRETMIDAE									
Diretmus	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	**Serr**	**Pr**	**Large, Rug**	**Serr**
TRACHICHTHYIDAE									
Gephyroberyx	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	**Serr**	**Pr**	**Serr Spine**	**Serr**
Hoplostethus	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	**Serr**	**Pr**	**Serr**	**Serr**
BERYCIDAE									
Beryx	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	**Spine**	**Pr**	**0**	**Serr**
HOLOCENTRIDAE									
Holocentrus	0	**Pr**	**Pr**	**Pr**	**Large**	**Serr**	**Pr**	**Serr**	**Ridge**
Sargocentron	0	**Pr**	**Pr**	**Pr**	**Large**	**Serr**	**Pr**	**Serr**	**Serr?**
POLYMIXIIDAE									
Polymixia	0	**Pr**	0	**Pr**	0	**Serr or Ridge**	**Pr**	**Serr**	**Serr**
MIRAPINNIDAE									
Parataeniophorus	0	0	0	0	0	0	0	0	0
BARBOURISIIDAE									
Barbourisia	0	0	**Pr**	**Pr**	**Pr**	**Serr**	**Pr**	0	0
RONDELETIIDAE									
Rondeletia	0	0	0	0	0	0	0	0	0
GIBBERICHTHYIDAE									
Gibberichthys	0	0	0	0	0	0	0	0	0
MELAMPHAIDAE					0 or	0 or	0 or	0 or	
Poromitra	0	0	0	0	**Pr**	**Spine**	**Pr**	**Pr**	0
Scopeloberyx	0	0	0	0	0	0	0	0	0
Scopelogadus	0	0	0	0	0	0	0	0	0
Melamphaes	0	0	0	0	0	0	0	0	0
STEPHANOBERYCIDAE									
Acanthochaenus	0	0	0	0	0	0	0	0	0?

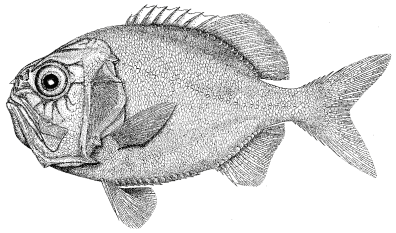
(Table continues on next page)

Beryciformes and Polymixiiformes (Also Stephanoberyciformes)

Characteristics of head spination in larvae that occur in the present study area (cont.).
Abbreviations: 0 = Absent; **Pr** = Present; **Rug** = Rugose; **Serr** = Serrate; **Ridge** = Non-serrate ridge.

FAMILY *Genus*	Supra-occipital	Post-temporal	Supra-cleithral	Opercular	Pre-opercle Anterior	Pre-opercle Posterior	Sub-opercular	Inter-opercular
ANOPLOGASTERIDAE								
Anoplogaster	0	**Pr**	0	**Ridge**	**Pr**	**Large**	0	0
DIRETMIDAE								
Diretmus	0	**Pr**	0	**Ridge**	**Pr**	**Large**	0	0
TRACHICHTHYIDAE								
Gephyroberyx	0	**Pr**	**Pr**	**Serr**	**Pr**	**Pr**	**Pr**	**Pr**
Hoplostethus	0	**Pr**	**Pr**	**Serr**	**Pr**	**Pr**	**Pr**	**Pr**
BERYCIDAE								
Beryx	0	**Pr**	0	0	**Pr**	**Pr**	**Pr**	**Pr**
HOLOCENTRIDAE								
Holocentrus	**Large**	**Pr**	0	**Large**	**Pr**	**Large**	**Pr**	**Pr**
Sargocentron	**Large**	**Pr**	0	**Large**	**Pr**	**Large**	**Pr**	**Pr**
POLYMIXIIDAE								
Polymixia	0	**Pr**	**Pr**	0	**Pr**	**Pr**	**Pr**	**Pr**
MIRAPINNIDAE								
Parataeniophorus	0	0	0	0	0	0	0	0
BARBOURISIIDAE								
Barbourisia	0	0	0	0	**Pr**	0	0	**Pr**
RONDELETIIDAE								
Rondeletia	0	0	0	0 or **Pr**	0	0	0	0
GIBBERICHTHYIDAE								
Gibberichthys	0	0	0	0	0	0	0	0
MELAMPHAIDAE		0 or	0 or	0 or				
Poromitra	0	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	0	0
Scopeloberyx	0	0	0	0	0	0	0	0
Scopelogadus	0	0	0	0	0	0 or **Pr**	0	0
Melamphaes	0	0	0	0 or **Pr**	0	0 or **Pr**	0	0
STEPHANOBERYCIDAE								
Acanthochaenus	0	0	0	0	0	0	0	0

Gephyroberyx darwini (Johnson, 1866)
Trachichthyidae
Big roughy



Range: Atlantic and Indian oceans to southern Australia; in the western North Atlantic from Browns Bank to Gulf of Mexico and Caribbean Sea

Habitat: Benthopelagic in depths of 9–1,210 m (mostly 200–500 m)

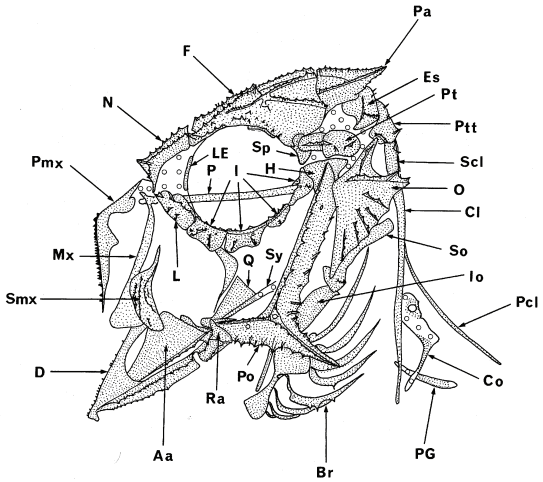
Spawning: Undescribed

Eggs: – Undescribed

Meristic Characters

Myomeres:	about 26
Vertebrae:	26
Dorsal fin rays:	VII–IX, 12–15
Anal fin rays:	III, 10–12
Pectoral fin rays:	13–16
Pelvic fin rays:	I, 6
Caudal fin rays:	VI, I, 9+8, I, VI

Larvae:
- Undescribed; the following description based on *G. japonicus*
- Body and head deep, laterally compressed; body depth 50–60% SL
- Preanus length about 70% SL
- Head robust; head length about 40% SL; teeth early forming
- Mouth large and oblique; maxilla reaches level of posterior eye
- Head spines obvious; spines occur on almost all bones of the head (except maxilla, retroarticular, supraoccipital); see distribution of head spines below
- Frontal, parietal and preopercle spines particularly large, well-developed
- Sequence of fin ray development: D, A, C – P_1 – P_2 (compare to early pelvic fin rays in *Hoplostethus*)
- Larvae are covered with tack-like scales, composed of a single spine projecting from the center of a circular scale plate; these will be replaced by adult scales at transformation
- Spinules lacking on pelvic fin rays, present on rays of other fins; compare to *Hoplostethus* larvae
- Larger larvae develop a series of scutes along the abdominal keel, between pelvic fins and anus (not present in *Hoplostethus* larvae); each scute includes 3 hook-like spines along midline, plus 2–3 spines on lateral surface
- Pigmentation dense, beginning with melanophores over peritoneum, dorsolateral portion of body, spreading to include much of head and body; caudal peduncle and mouth region unpigmented



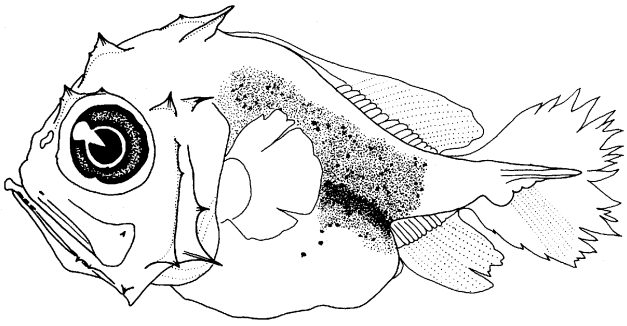
Aa - Anguloarticular
Br - Branchiostegal
Cl - Cleithrum
Co - Coracoid
D - Dentary
Es - Extrascapular
F - Frontal
H - Hyomandibular
I - Infraorbitals
Io - Interopercle
L - Lachrymal
LE - Lateral ethmoid
Mx - Maxilla
N -Nasal
O - Opercle
P - Parasphenoid
Pa - Parietal
Pcl - Postcleithrum
Pmx - Premaxilla
Po - Preopercle
Pt - Pterotic
Ptt - Posttemporal
Q - Quadrate
Ra - Retroarticular
S - Supraoccipital (not labeled)
Scl - Supracleithrum
Smx - Supramaxilla
So - Subopercle
Sp - Sphenotic
Sy - Symplectic

D: *Gephyroberyx japonicus* 11.0 mmSL

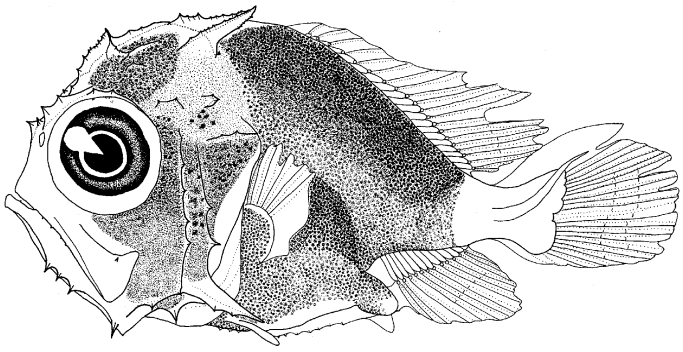
Figures: Adult: Mary Ann Holloway (Woods and Sonoda, 1973); **A–D**: Konishi and Okiyama, 1997

References: Woods and Sonoda, 1973; Johnson and Patterson, 1993; Baldwin and Johnson, 1995; Konishi and Okiyama, 1997

Gephyroberyx japonicus

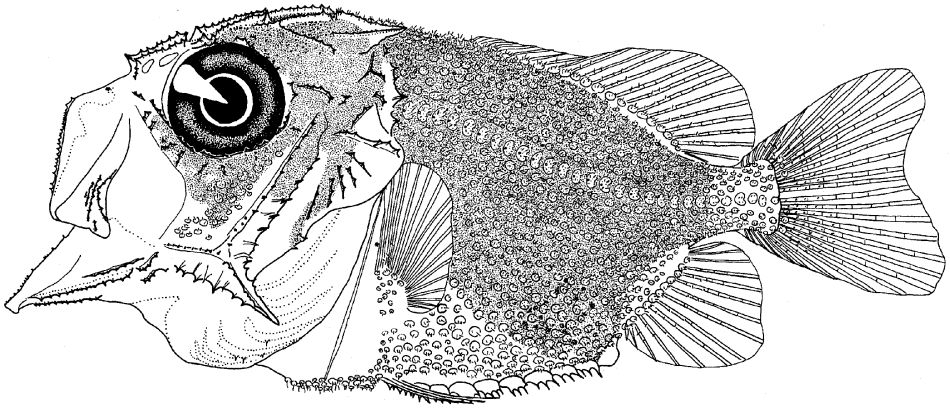


A. 4.5 mmNL



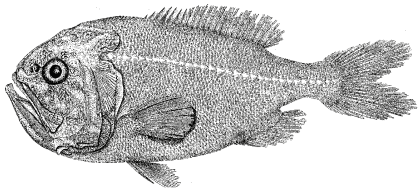
B. 4.6 mmSL

Larvae of *Gephyroberyx darwini* are undescribed. Larvae of a closely related species from the Pacific Ocean are included here based on the assumption that they are similar to those of *G. darwini*.



C. 11.0 mmSL

Hoplostethus atlanticus Collett, 1889
Trachichthyidae
Orange roughy



Range: Atlantic and Pacific oceans; in the western North Atlantic from Davis Strait off Baffin Island, to Scotian Shelf and Corner Rise seamounts

Habitat: Benthopelagic in depths of 300–1,550 m

Spawning: Undescribed; may not occur in study area

Eggs:
- Spherical, presumably buoyant; may only occur in deep water
- Diameter: 2.12–2.45 mm
- Oil globule: single, conspicuously orange

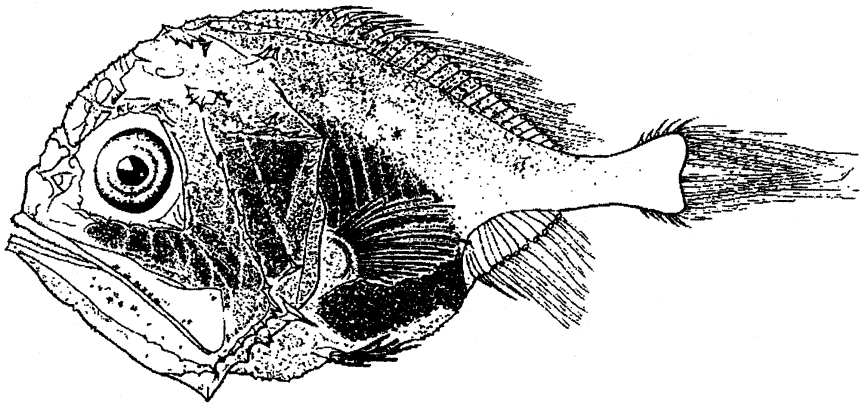
Meristic Characters

Myomeres:	about 29
Vertebrae:	29
Dorsal fin rays:	V–VI, 15–19
Anal fin rays:	II–III, 10–12
Pectoral fin rays:	16–20
Pelvic fin rays:	I, 6
Caudal fin rays:	VI–VIII, I, 9+8, I,VI

Larvae:
- Undescribed; the following description based on *Hoplostethus* sp.
- Body and head deep, laterally compressed; body depth 37% to 46% SL
- Anus situated immediately anterior to anal fin; preanus length 63% to 77% SL
- Head robust; head length about 33% SL, increases proportionately with growth
- Mouth large and oblique; maxilla reaches level of posterior eye
- Head spines obvious; early-forming spines occur on the frontal, otic, parietal and dentary bones; see distribution of head spines in Fig. E
- Frontal, parietal and preopercle spines not as well-developed as in *Gephyroberyx* larvae
- Sequence of fin ray development: D, A, C – P_1, P_2; (pelvic fin rays earlier forming than in *Gephyroberyx*)
- Larvae are covered with tack-like scales, composed of a single spine projecting from the center of a circular scale plate; these will be replaced by adult scales at transformation
- Spinules occur on rays of all fins; compare to *Gephyroberyx* larvae
- Venter in all larvae smooth; no scutes develop along abdominal ridge as in *Gephyroberyx* larvae
- Pigmentation light; no other information because of length of preservation time in larvae depicted in Figs. B–D; pigment in 26.0-mm juvenile (Fig. E) includes densely black peritoneum, melanophores sprinkled over much of body, leaving caudal peduncle clear

Note: Larvae have proven to be difficult to collect in Australian waters, and they are unreported from the present study area. MCZ collections include a few larvae identified only as "*Hoplostethus*".

Early Juvenile:



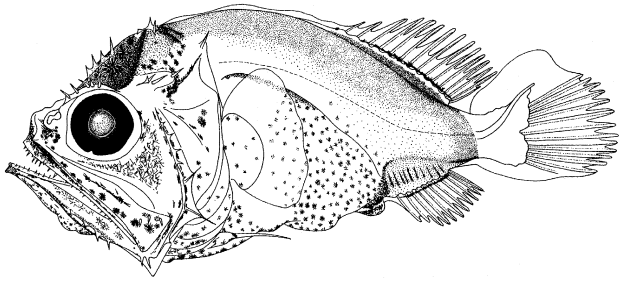
F. 26.0 mmSL
(Hoplostethus atlanticus)

Figures: Adult: Mary Ann Holloway (Woods and Sonoda, 1973); **A**: Richards *et al*., 2003; **B–E**: Konishi and Okiyama, 1997; **F**: Jordan and Bruce, 1993

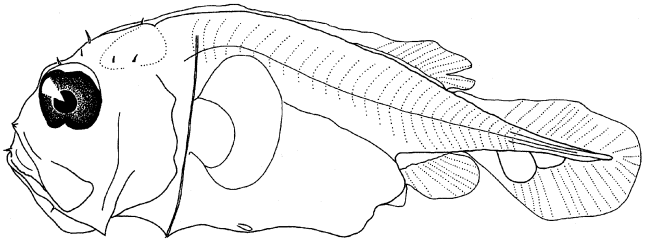
References: Johnson and Patterson, 1993; Jordan and Bruce, 1993; Baldwin and Johnson, 1995; Konishi and Okiyama, 1997; Moore, 2002d; Kulka *et al*., 2003

Hoplostethus atlanticus

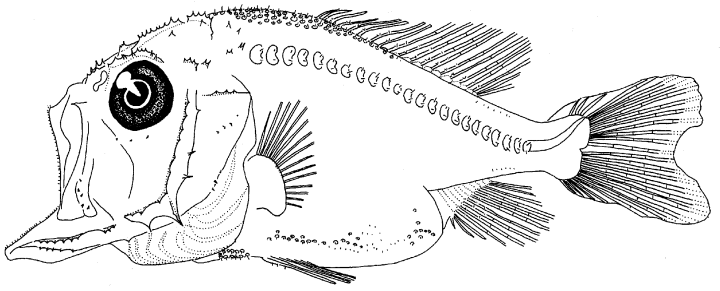
Larvae of *Hoplostethus atlanticus* are undescribed. Larvae of unidentified species of *Hoplostethus* from the Straits of Florida (Fig. A) and North Pacific (B-D) are included here based on the assumption that they are similar to those of *H. atlanticus*.



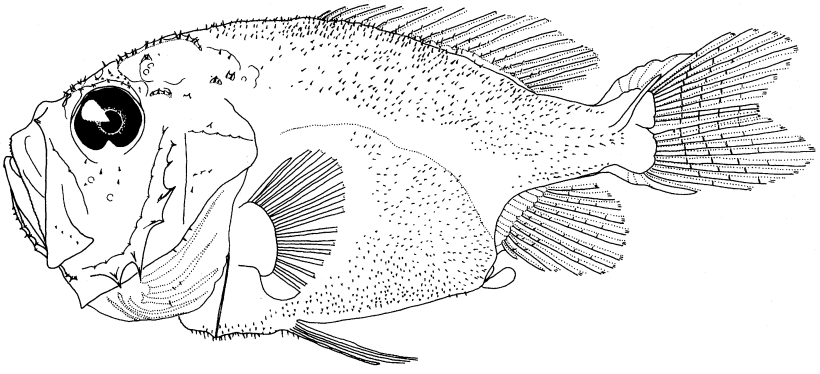
A. 5.3 mmSL (Trachichthyiidae unident.)



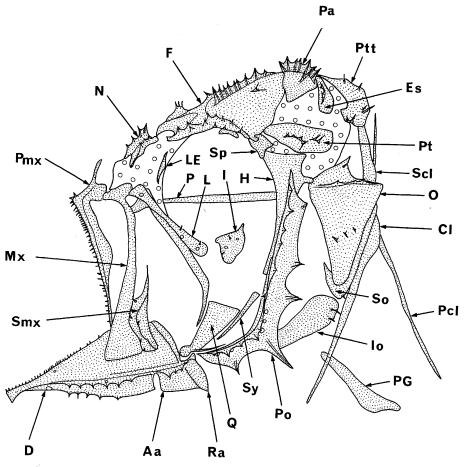
B. 5.4 mmNL (*Hoplostethus* sp.)



C. 9.6 mmSL (*Hoplostethus* sp.)



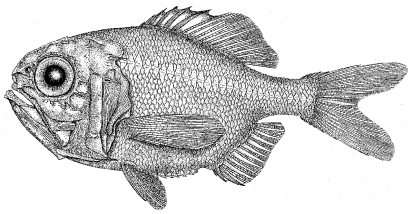
D. 10.7 mmSL (*Hoplostethus* sp.)



E. 10.7 mmSL
Head Spines
(see *Gephyroberyx japonicus* for abbreviations)

Note: a remnant preanal finfold may persist in larvae as large as 11.0 mmSL

Hoplostethus mediterraneus Kotlyar, 1986
Trachichthyidae
Silver roughy



Range: The subspecies *Hoplostethus m. sonodae* Kotlyar, 1986, is restricted to the western North Atlantic Ocean from Browns Bank to southern Brazil, including the Gulf of Mexico and Caribbean Sea.

Habitat: Benthopelagic, in depths of 183–1,466 m, primarily between 200 and 500 m

Spawning: Undescribed

Eggs: – Undescribed

Larvae:
- Undescribed; description below pertains to juveniles (Figs. A and B); see discussion box on figure page
- Body very deep, laterally compressed; head deep and short (44% SL)
- Anus situated immediately anterior to anal fin origin; preanus length about 70% SL
- Mouth large, oblique; maxilla reaches beyond level of posterior eye
- Head spines obvious, especially in series following ridges (e.g. frontal, parietal, nasal, infraorbital)
- Sequence of fin ray development unknown for this form
- Larvae are covered with tack-like scales, composed of one to several spines projecting from the center of a circular scale plate; these will be replaced by adult scales at transformation
- No enlarged scales along lateral line, although Parr (1933) reports "... swollen papillae are particularly conspicuous in the lateral line region ..."
- Spinules present on rays of dorsal, anal and pelvic fins; compare to other *Hoplostethus* larvae
- Venter in both juvenile specimens smooth; no scutes develop along abdominal ridge as in *Gephyroberyx* larvae
- Pigmentation light; body peppered with fine melanophores, larger ones on caudal peduncle; peritoneum darkly pigmented; pectoral and pelvic fin membranes densely black

Meristic Characters

Myomeres:	about 26
Vertebrae:	26
Dorsal fin rays:	VI–VII, 12–14
Anal fin rays:	III, 9–11
Pectoral fin rays:	14–16
Pelvic fin rays:	I, 6
Caudal fin rays:	?+I+9+8+I+?

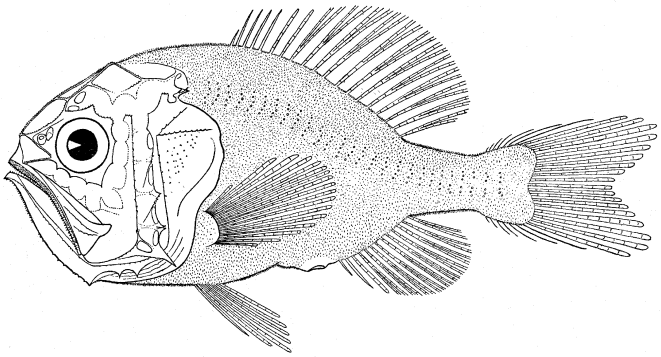
Note: 1. The juveniles portrayed in Figs. A and B do not refer to *Hoplostethus mediterraneus*, but probably to some other species of *Hoplostethus*, possibly an undescribed species. See discussion box.

Figures: Adult: Mary Ann Holloway (Woods and Sonoda, 1973); **A**: Parr, 1933; **B**: Johnson, 1970

References: Parr, 1933; Woods and Sonoda, 1973; Keene and Tighe, 1984; Johnson and Patterson, 1993; Baldwin and Johnson, 1995

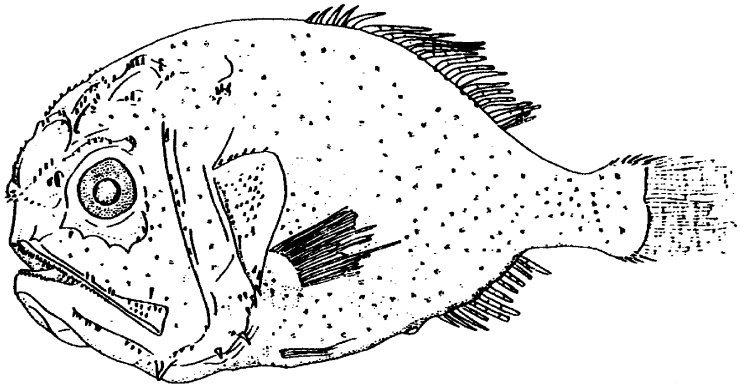
Hoplostethus sp. (*Korsogaster nanus*)

Fin ray counts reported for this specimen:
Anal: II, 11(total 13)
Pectoral: 17
Collected in the Atlantic (Bahamas) (Parr, 1933)



A. 18.0 mmSL

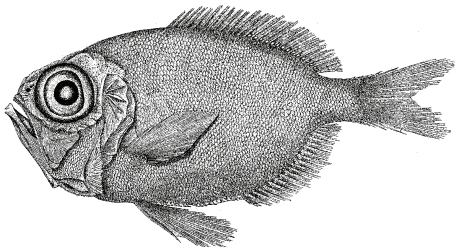
Fin ray counts reported for this specimen:
Anal: III, 8 (total 11)
Pectoral: 19
Collected in the Equatorial Pacific (Johnson, 1970)



B. 21.5 mmSL

The specimen depicted in Fig. A was described as *Korsogaster nanus* (Parr, 1933). That specimen, and a second (Fig. B), also described as *Korsogaster nanus* (Johnson, 1970), have been ascribed to the juvenile stage of *Hoplostethus mediterraneus* (Woods and Sonoda, 1973) or to some other trachichthyid (Keene and Tighe, 1984). However, the two specimens probably do not refer to the same species (compare head spination, body and snout shape, anal and pectoral fin ray counts), nor does either refer to *H. mediterraneus*, largely because their meristic counts are beyond the ranges in that species. It seems more likely that these larvae refer to young stages of *Hoplostethus*, but possibly to one or more undescribed species. Also see discussion in Baldwin and Johnson (1995).

Diretmichthys parini (Post and Quero, 1981)
Diretmidae
Black discfish



Range: Worldwide in temperate and tropical waters; in the western North Atlantic from south of Grand Bank to northern South America, including Gulf of Mexico and Caribbean Sea

Habitat: Meso- to bathypelagic in depths of 240–2,100 m

Spawning: Undescribed

Eggs: – Undescribed

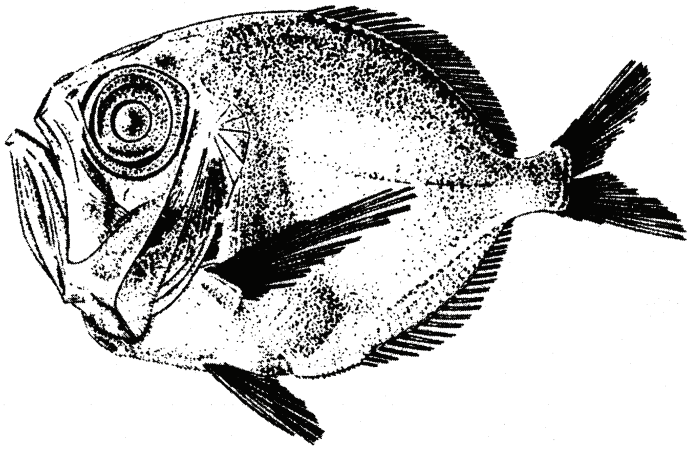
Meristic Characters	
Myomeres:	about 29–32
Vertebrae:	29–32
Dorsal fin rays:	26–30
Anal fin rays:	20–23
Pectoral fin rays:	17–19
Pelvic fin rays:	I, 6
Caudal fin rays:	4+10+9+4

Larvae:
- Body is initially elongate, soon becomes very deep, compressed
- Anus located midway between pelvic and anal fins
- Head very deep with large eye (although larger in *Anoplogaster*)
- Spines lacking in dorsal fin
- Pelvic fin origin below or ahead of pectoral fin origin (cf. behind pectoral fin origin in *Diretmus argenteus*)
- Series of spiny, keeled scutes forms on ventral midline, anterior to anal fin
- Important head spines include a short, stout, rugose spine on the frontal bone over each eye; a long, rugose parietal spine on each side of head, directed posteriorly; a long preopercle spine, directed ventrally
- Parietal and preopercle spines smaller than in larvae of *Diretmus argenteus*
- Spines are lacking on maxilla, retroarticular, branchiostegals, supraoccipital, supracleithrum, subopercle, interopercle, opercle, although the latter has a non-serrate ridge
- Pigmentation in larger larvae includes a horseshoe shaped patch on the flank

Note:
1. Diretmid larvae are somewhat similar to those of Anoplogasteridae (both lack dorsal fin spines), but diretmids have more dorsal fin rays and at least twice the number of anal fin rays
2. Other families whose larvae have long head spines (e.g. Scorpaenidae, Triglidae, Dactylopteridae, Istiophoridae) differ in the lack of certain spines, orientation of these spines, and meristic characters

Juvenile:

Note minute spines located along the bases of the dorsal and anal fin rays

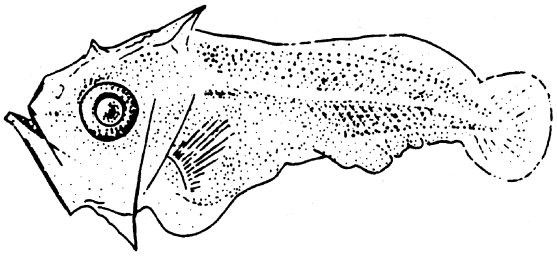


E. 60.0 mmSL

Figures: Adult: Woods and Sonoda, 1973 (as *Diretmus argenteus*); **A–E**: Post and Quero, 1981

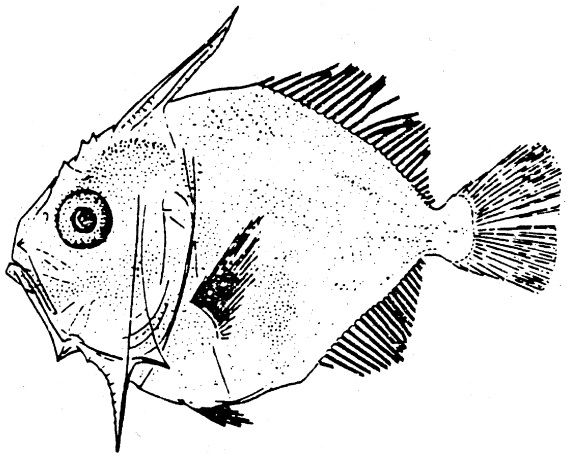
References: Post and Quero, 1981; Kotlyar, 1990; Watson, 1996m; Lyczkowski-Shultz *et al*., 2000; Moore, 2002c; Richards *et al*., 2003

Diretmichthys parini

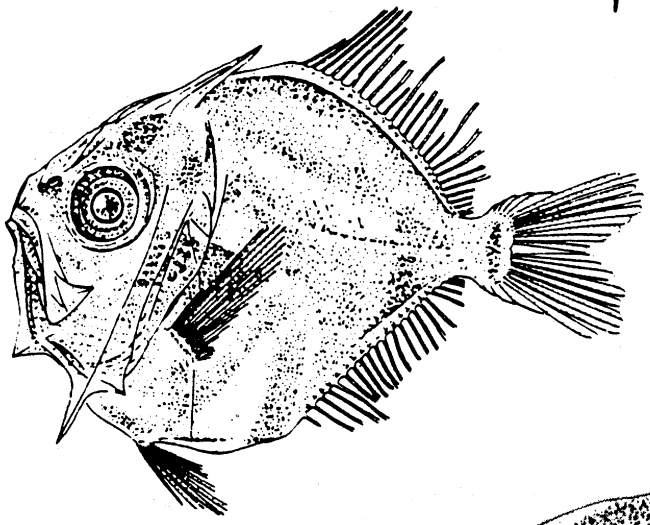


A. 4.7 mmSL

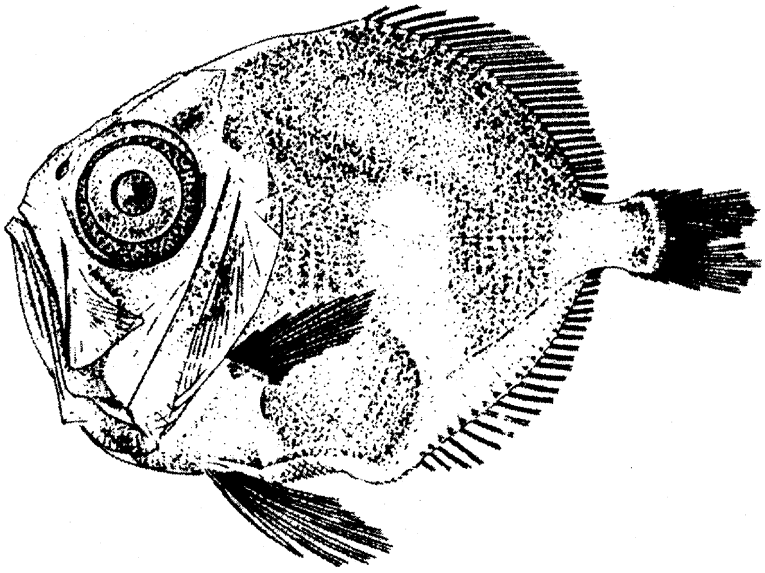
Note ventral or antero-ventral orientation of preopercle spine (compare to *Diretmus argenteus*)



B. 5.8 mmSL

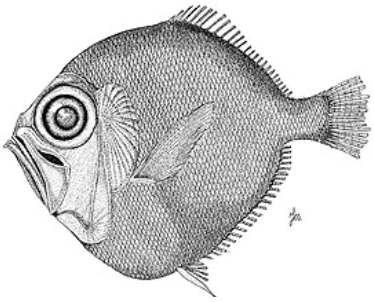


C. 10.9 mmSL



D. 28.0 mmSL

Diretmus argenteus Johnson, 1863
Diretmidae
Spinyfin



Range: Worldwide in tropical and temperate waters; in the western North Atlantic from east of Flemish Cap to northern South America including Gulf of Mexico and Caribbean Sea

Habitat: Meso- to bathypelagic in depths of 280–2,000 m

Spawning: Undescribed

Eggs: – Undescribed

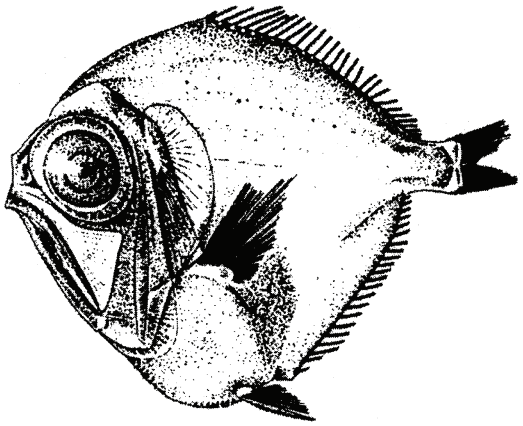
Meristic Characters	
Myomeres:	about 15–17
Vertebrae:	15–17
Dorsal fin rays:	25–29
Anal fin rays:	20–24
Pectoral fin rays:	16–20
Pelvic fin rays:	I, 6
Caudal fin rays:	4+10+9+4

Larvae:
- Body is initially elongate, soon becomes very deep, compressed
- Anus located immediately anterior to anal fin origin
- Head very deep with large eye (although larger in *Anoplogaster*)
- Spines lacking in dorsal fin
- Pelvic fin origin behind pectoral fin origin (cf. below or ahead of pectoral fin origin in *Diretmichthys parini*)
- Series of spiny, keeled scutes forms on ventral midline, anterior to anal fin and extending anterior to pelvic fins
- Important head spines include a short, stout, rugose spine on the frontal bone over each eye; a long, rugose parietal spine on each side of head, directed posteriorly; a long preopercle spine, directed postero-ventrally
- Parietal and preopercle spines larger than in larvae of *Diretmichchtys parini*
- Spines are lacking on maxilla, retroarticular, branchiostegals, supraoccipital, supracleithrum, subopercle, interopercle, opercle, although the latter has a non-serrate ridge
- Pigmentation in small larvae includes discrete blotches along the dorsum with a linear blotch along the anal fin base; larger larvae (6.8 mm) have densely pigmented body with unpigmented caudal peduncle and a clear, unpigmented space extending from the mid-dorsal fin to mid-anal fin

Note:
1. Diretmid larvae are somewhat similar to those of Anoplogasteridae (both lack dorsal fin spines), but diretmids have more dorsal fin rays and at least twice the number of anal fin rays
2. Other families whose larvae have long head spines (e.g. Scorpaenidae, Triglidae, Dactylopteridae, Istiophoridae) differ in the lack of certain spines, orientation of these spines, and meristic characters

Juvenile:

Note minute spines located along the bases of the dorsal and anal fin rays

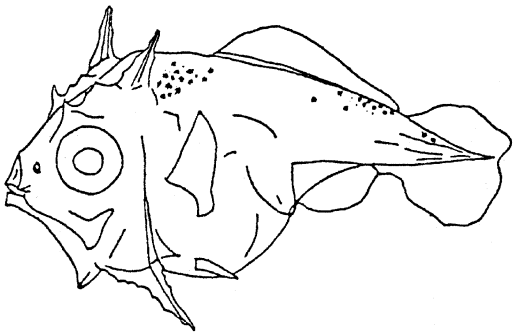


D. 48.0 mmSL

Figures: Adult: Les Gallagher, ImagDOP; Centro do IMAR da Universidade dos Açores ; **A**: Post, 1976; **B**: Watson, 1996m; **C–D**: Post and Quero, 1981

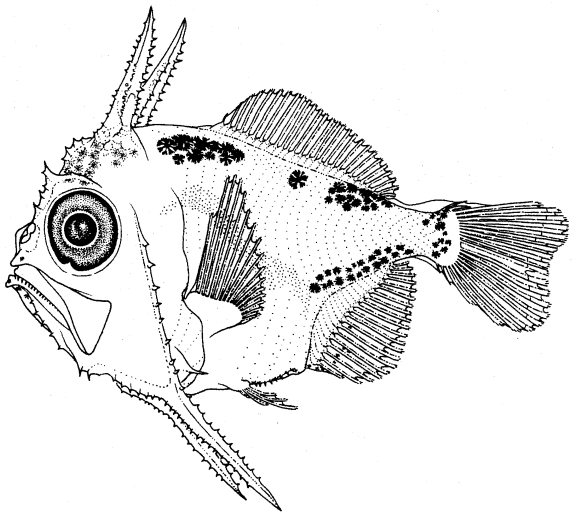
References: Post and Quero, 1981; Kotlyar, 1987; 1990; Watson, 1996; Lyczkowski-Shultz *et al*., 2000; Moore, 2002c; Richards *et al*., 2003

Diretmus argenteus

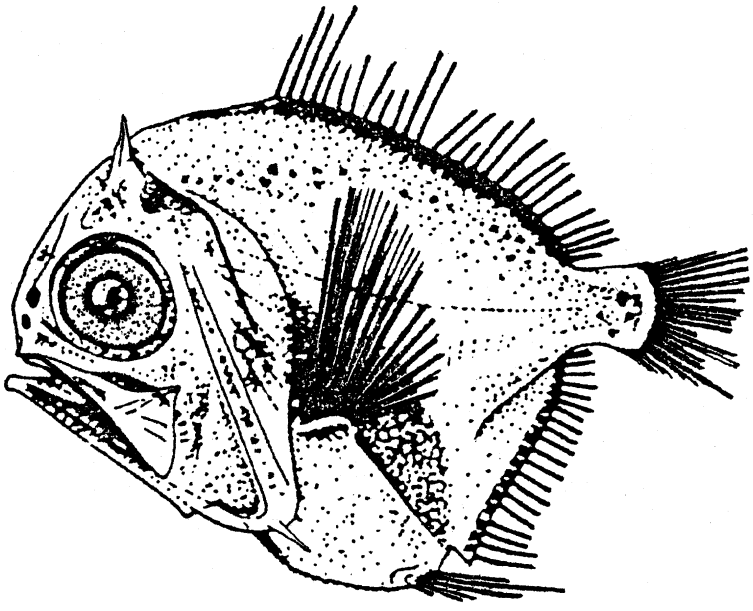


A. 5.8 mmSL

Note posteroventral orientation of preopercle spine (compare to *Diretmichthys parini*)

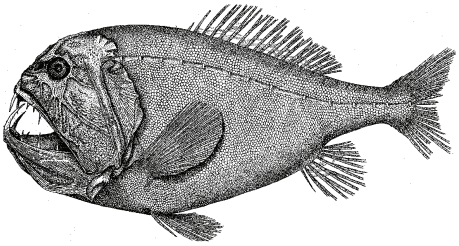


B. 6.2 mmSL



C. 16.1 mmSL

Anoplogaster cornuta (Valenciennes, 1833)
Anoplogastridae
Fangtooth



Range: Worldwide in temperate to tropical waters; in the western North Atlantic from Greenland to Gulf of Mexico and Caribbean Sea

Habitat: Meso- to bathypelagic in depths of 640–4,900 m; young stages shallower

Spawning: Summer in eastern Pacific Ocean; undescribed in Atlantic Ocean

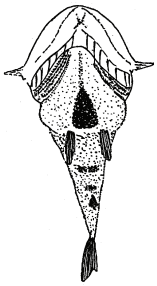
Eggs:
- Undescribed

Larvae:
- Body and head very deep; eye very large; preanus length 70–80% SL
- Spines lacking in dorsal fin
- Sequence of fin ray development: D, A – P_1, C – P_2
- Important head spines include very large parietal and preopercle, with secondarily spiny frontal spine over eye
- Flexion occurs between 4.3 and 5.1 mm
- Much of the mid-body densely pigmented; preopercle region also densely pigmented

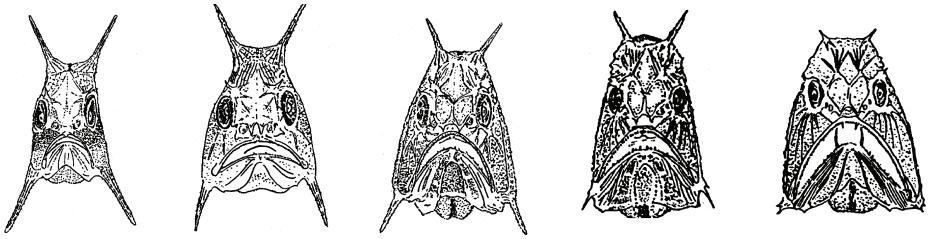
Meristic Characters

Myomeres:	about 25–27
Vertebrae:	25–27
Dorsal fin rays:	17–19
Anal fin rays:	7–9
Pectoral fin rays:	13–16
Pelvic fin rays:	I, 6
Caudal fin rays:	5–7+10+9+5–9

Development of ventral pigment:

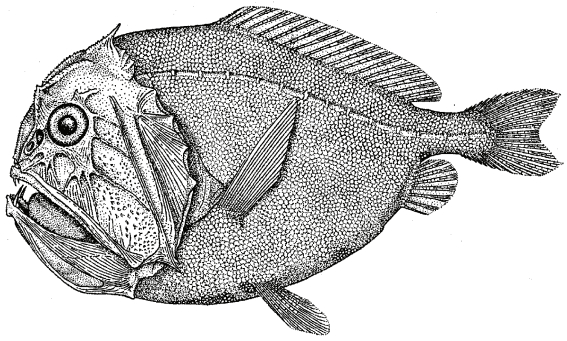


Note:
1. The young stages of *Anoplogaster brachycera* (no records in present study area) have much shorter parietal, frontal and preopercle spines. See illustrations in Moore (2002e)
2. Anterior views demonstrating ontogenetic reduction in parietal and preopercular spines



13 mm **19 mm** **31 mm** **57 mm** **74 mm**

Juvenile:

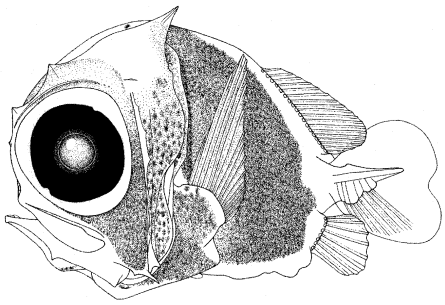


G. 75.0 mmSL

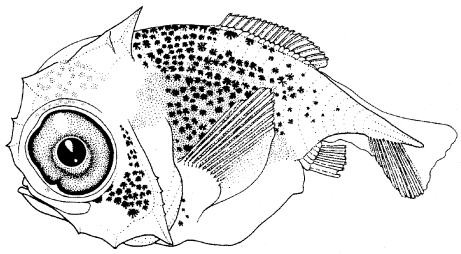
Figures: Adult and **G**: Mary Ann Holloway (Woods and Sonoda, 1973); **A**: Richards *et al.*, 2003; **B–C**: Watson, 1996m; **D**: Betsy Washington (Keene and Tighe, 1984); **E–F**: Okiyama, 1988; anterior head and ventral pigment views: Kotlyar, 1986

References: Keene and Tighe, 1984; Kotlyar, 1986; Watson, 1996m; Moore, 2002e; Richards *et al.*, 2003

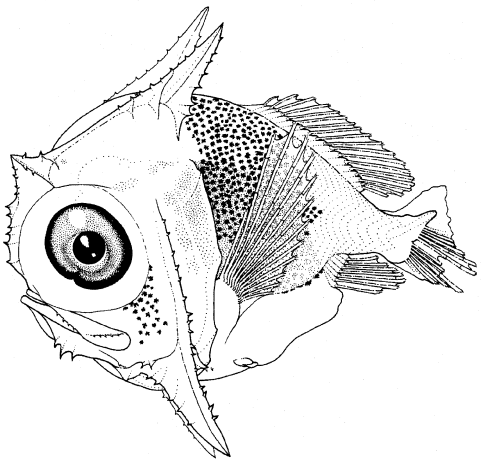
Anoplogaster cornuta



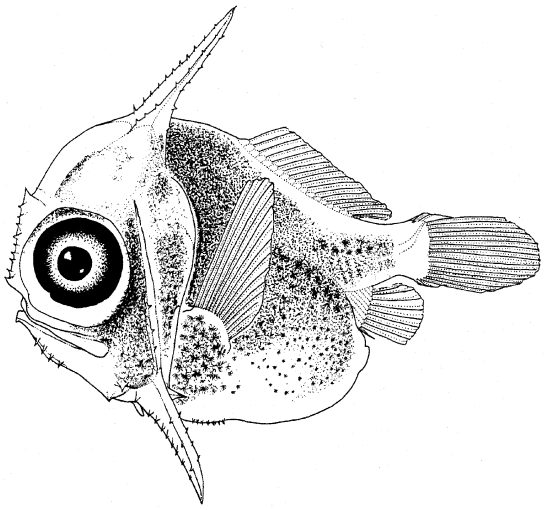
A. 4.0 mmNL



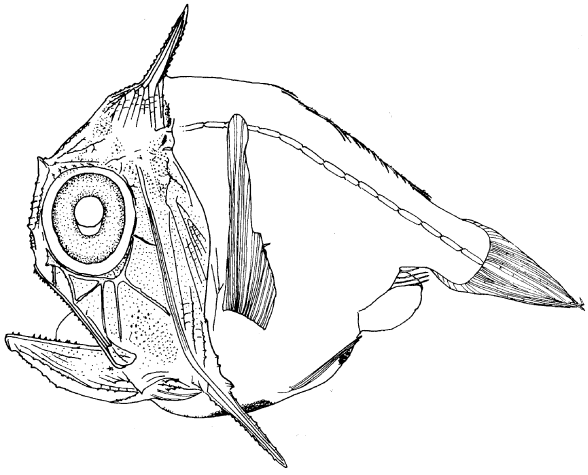
B. 4.0 mmSL



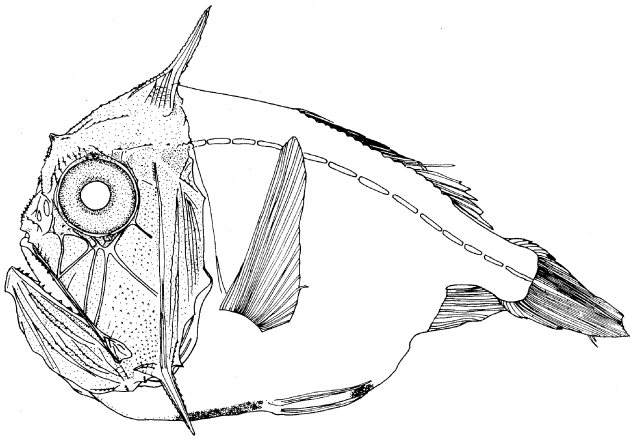
C. 4.3 mmSL



D. 6.0 mmSL

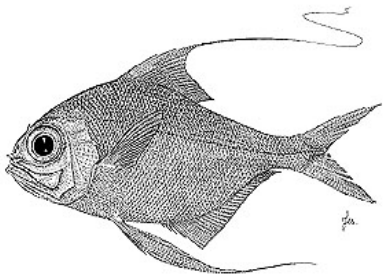


E. 15.7 mmSL



F. 26.6 mmSL

Beryx decadactylus Cuvier, 1829
Berycidae
Alfonsino



Range: Widespread in Atlantic, Pacific and Indian oceans in tropical to subtropical waters; in the western North Atlantic from southern Nova Scotia and Gulf of Maine to Caribbean Sea

Habitat: Benthopelagic in depths of 100–972 m (primarily 400–600 m)

Spawning: Undescribed

Meristic Characters

Myomeres:	23
Vertebrae:	24
Dorsal fin rays:	III–IV, 16–21
Anal fin rays:	III–IV, 25–30
Pectoral fin rays:	14–18
Pelvic fin rays:	I, 9–10
Caudal fin rays:	10+9 (PrC)

Eggs:
- Undescribed

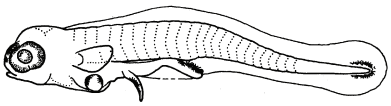
Larvae:
- Larvae of *Beryx* spp. are unidentifiable to species until dorsal fin rays are formed. The following description pertains to larvae smaller than 15 mm (Figs. A–D) identified as *Beryx* sp.
- Hatching occurs at <2.0 mm; eyes unpigmented, mouth unformed
- Body elongate with small head; gut uncoiled, preanus length about 50% SL
- Concave dorsal head profile with pointy snout characteristic of early larvae
- Flexion occurs between 3.7 and 6.0 mm; body deepens during this process
- Preanal and dorsal finfolds persist into postflexion stage; dorsal finfold resembles developing adipose fin; both finfolds disappear by 9.2 mm
- Anterior dorsal fin spines early forming (at about 2.8 mm), elongate and filamentous
- Pelvic fin rays form early (at about 1.5–3.0 mm); fin rays become elongate, filamentous
- Parietal spines lacking; pterotic bears a serrated ridge; 1st lower infraorbital spine (large) forms at about 3.8–4.5 mm, persists into adult stage
- See Beryciformes Introduction for table describing distribution of other head spines; see figure opposite explaining position of pertinent spines
- Fin rays complete (and scales fully formed) by 15 mm; scales not modified with spines
- Pigment in early larvae is sparse on the body, but includes distinct melanophore clusters on the fore- and midbrains, anterior end of oil globule, over intestine above anus, and at tip of notochord; light pigment on filamentous portion of dorsal and pelvic fin rays
- Internal branchial pigment present in larger *B. decadactylus* larvae and juveniles; absent in *Beryx splendens*

Note:
1. Larvae are superficially similar to those of Melamphaidae in body shape, gut shape, gut length, and sequence of fin ray development. Differences include pigment patterns, meristic characters and head spination.
2. Larvae of *Beryx decadactylus* are best distinguished from those of *B. splendens* by dorsal fin ray counts; see Mundy (1990) for descriptions of subtle differences in head spination

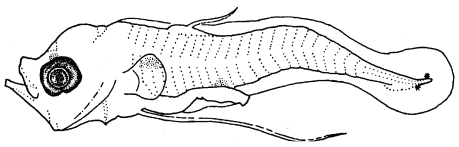
Figures: Adult: Les Gallagher, University of the Azores; **A–E**: Mundy, 1990; head spination: Mundy, 1990

References: Woods and Sonoda, 1973; Busakhin, 1982; Mundy, 1990; Johnson and Patterson, 1993; Baldwin and Johnson, 1995; Moore, 2002e; 2002g

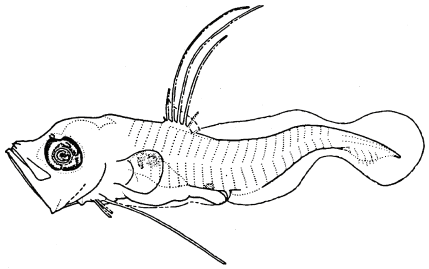
Beryx decadactylus



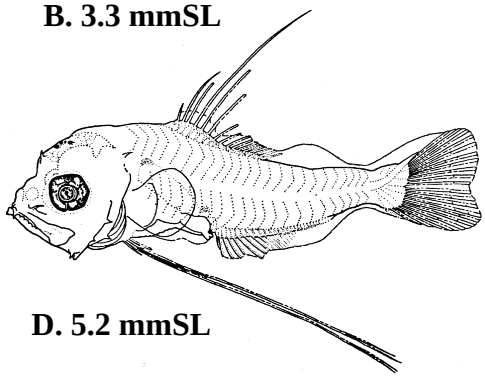
A. 2.1 mmSL



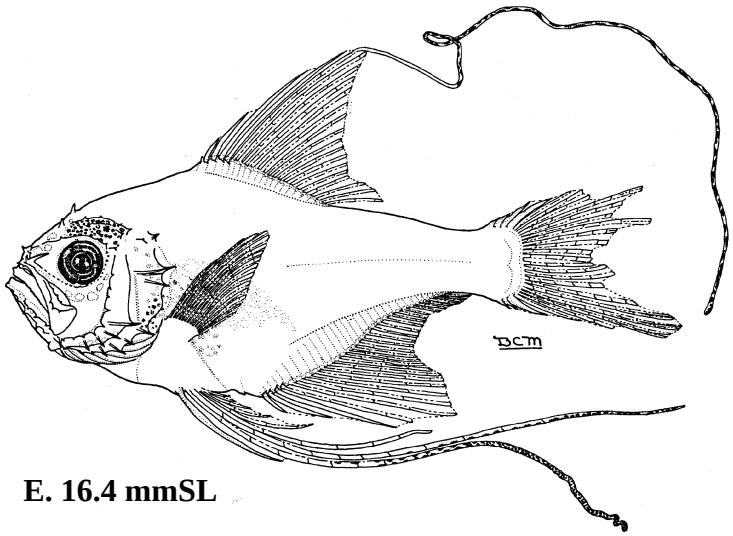
B. 3.3 mmSL



C. 4.0 mmSL



D. 5.2 mmSL

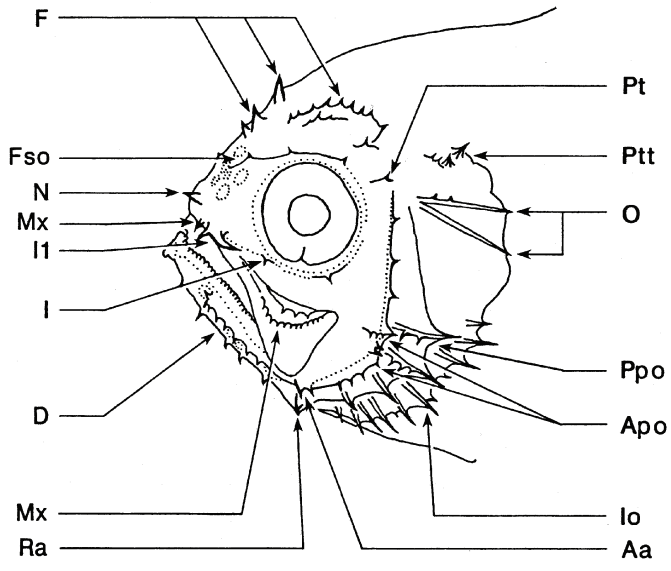


E. 16.4 mmSL

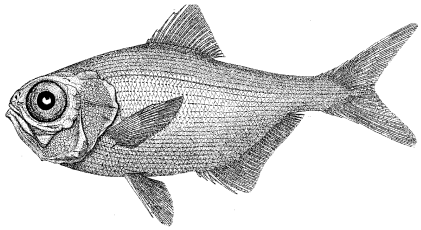
Figs. A-D identified to genus *Beryx* only

Head spination in 16.4 mm specimen:

Aa – Anguloarticular
Apo – Anterior preopercle
D – Dentary
F – Frontal
Fso – Supraorbital ridge
I – Infraorbital
II – 1st intraorbital
Io – Interopercle
Mx – Maxilla
N – Nasal
O – Opercle
Ppo – Posterior preopercle
Pt – Pterotic
Ptt – Postemporal
Ra – Retroarticular



Beryx splendens Lowe, 1834
Berycidae
Slender alfonsino



Range: Worldwide in tropical and temperate waters; in the western North Atlantic from Browns Bank and Corner Seamounts to Brazil

Habitat: Benthopelagic in depths of 200–1,000 m

Spawning: Undescribed

Meristic Characters

Myomeres:	23
Vertebrae:	24
Dorsal fin rays:	III–IV, 12–15
Anal fin rays:	IV, 25–30
Pectoral fin rays:	15–19
Pelvic fin rays:	I, 10–13
Caudal fin rays:	10+9 (PrC)

Eggs:
- Undescribed

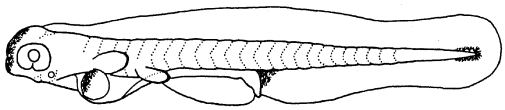
Larvae:
- Larvae of *Beryx* spp. are unidentifiable to species until dorsal fin rays are formed. The following description pertains to *Beryx* sp. larvae with the addition of notes on a reared larva (3.0 mmSL) and larvae with full complements of dorsal fin rays
- Hatching occurs at <2.0 mm; eyes unpigmented, mouth unformed
- Body elongate with small head; gut uncoiled, preanus length about 50% SL
- Concave dorsal head profile with pointy snout characteristic of early larvae
- Flexion occurs between 3.7 and 6.0 mm; body deepens during this process
- Preanal and dorsal finfolds persist into postflexion stage; dorsal finfold resembles developing adipose fin; both finfolds disappear by 9.2 mm
- Anterior dorsal fin spines early forming (at about 2.8 mm), elongate and filamentous;
- Pelvic fin rays form early (at about 1.5–3.0 mm); fin rays become elongate, filamentous
- Parietal spines lacking; pterotic bears a serrated ridge; 1st lower infraorbital spine (large) forms at about 3.8–4.5 mm, persists into adult stage
- See Beryciformes Introduction for table describing distribution of other head spines; see figure on *B. decadactylus* figure page explaining position of pertinent spines
- Fin rays complete (and scales fully formed) by 15 mm; scales not modified with spines
- Pigment in early larvae is sparse on the body, but includes distinct melanophore clusters on the fore- and midbrains, anterior end of oil globule, over intestine above anus, and at tip of notochord; light pigment on filamentous portion of dorsal and pelvic fin rays
- Internal branchial pigment absent; this pigment present in larger *B. decadactylus* larvae and juveniles

Note:
1. Larvae are superficially similar to those of Melamphaidae in body shape, gut shape, gut length, and sequence of fin ray development. Differences include pigment patterns, meristic characters and head spination.
2. Larvae of *B. splendens* are best distinguished from those of *B. decadactylus* by dorsal fin ray counts; see-Mundy (1990) for descriptions of subtle differences in head spination

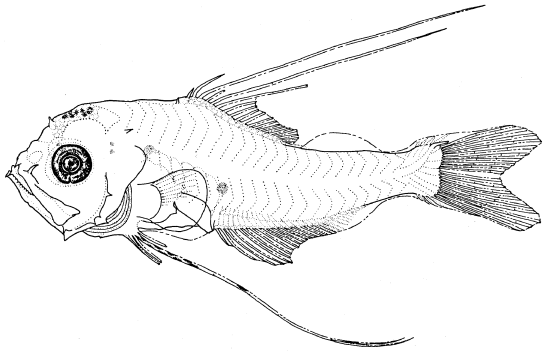
Figures: Adult: Mary Ann Holloway (Woods and Sonoda, 1973); **A–C**, **E**: Mundy, 1990; **D**: Okiyama, 1988

References: Woods and Sonoda, 1973; Busakhin, 1982; Mundy, 1990; Johnson and Patterson, 1993; Baldwin and Johnson, 1995; Moore, 2002g

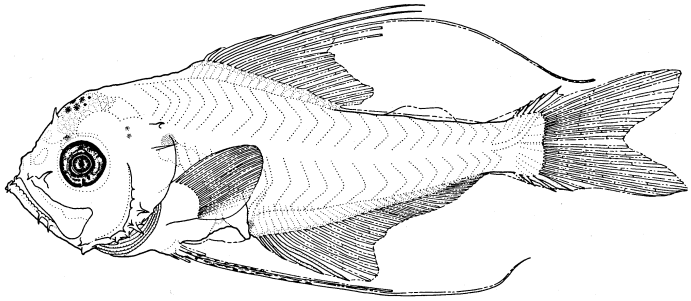
Beryx splendens



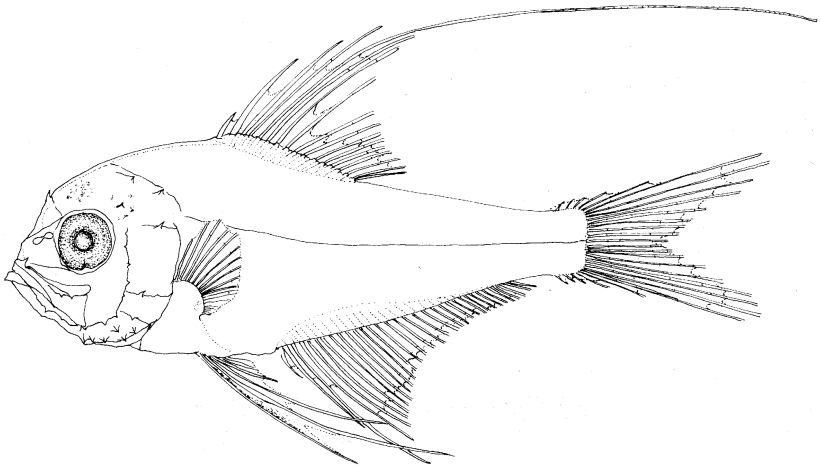
A. 3.0 mmSL (Reared)



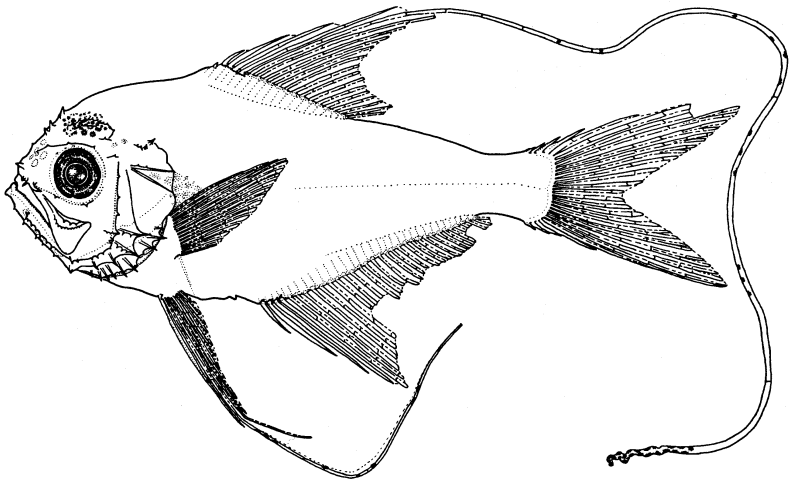
B. 6.0 mmSL



C. 7.5 mmSL



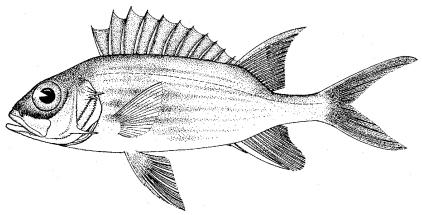
D. 10.0 mmSL



E. 15.0 mmSL

Holocentridae Early Life History

Squirrelfishes, soldierfishes



Meristic Characters

Myomeres:	about 26–27
Vertebrae:	26–27
Dorsal fin rays:	XI–XII, 11–16
Anal fin rays:	IV, 8–13
Pectoral fin rays:	13–17
Pelvic fin rays:	I, 7
Caudal fin rays:	10+9 (PrC)

Range: Most holocentrids occurring in the western Atlantic Ocean are found in tropical waters between Florida and northern South America, including the Caribbean Sea

Habitat: Most occur in relatively shallow waters near reefs or rocky substrates; a few (e.g. *Ostichthys trachypoma*) are found in deeper water (up to 460 m)

Spawning: Undescribed for most taxa

Eggs: Undescribed for most taxa

Larvae: The early life histories of holocentrids may be summarized as follows:

1. **Hatching**: occurs at quite small sizes, with eyes pigmented, mouthparts formed, and early development of preopercle spines and a crest on the head, the early expression of an elongate, serrate, supraoccipital spine

2. **Larvae**: go through a pelagic larval stage (Fig. A–B), characterized by extensive head spination, including elongate, serrate, supraoccipital, preopercle, opercle and rostral spines. In the subfamily Holocentrinae (genera *Holocentrus*, *Sargocentron* and *Neoniphon*) the rostral spine of larvae is fused along its entire length, and larvae have late-forming pelvic fin rays. In the subfamily Myripristinae (genera *Myripristis*, *Ostichthys*, *Corniger*, *Plectrypops*) the same spine in larvae is split laterally (Fig. C) and the pelvic fin rays form early.

3. **Transformation**: After scales and fin rays are complete, larvae first transform into a presettlement, pelagic "rhynchichthys" stage, where remnants of the rostral spine is retained (Fig. D–E). Transformation continues with a "meeki" stage, so-called because it was originally described as a new species, *Holocentrus meeki* (Bean, 1906). This stage is also pelagic, and is competent to settle to the bottom, but it remains pelagic and continues to grow until suitable bottom habitat is encountered. The "meeki" stage is characterized by loss of the head spination, acquisition of a streamlined body form, and growth that might continue up to a size of 75 mm. A series of 7–9 (up to 10) fleshy lobes supported by the infraorbital bones, surround the posteroventral rim of the orbit in this stage (Fig. F)

4. The young stages of some species grow more rapidly, and reach larger sizes before settlement than those of other species. Settlement usually occurs at sizes between 30 and 50 mmSL.

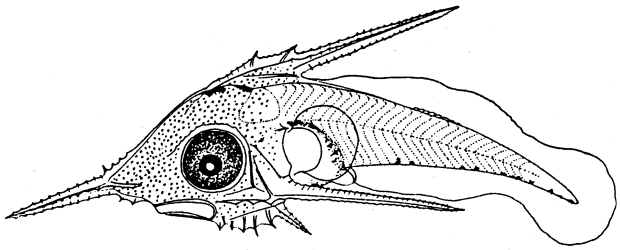
5. **Juvenile**: An early benthic, or "settled juvenile" stage then ensues, wherein the second dorsal and anal fins increase in height, body depth increases, and coloration changes, usually to some shade of rose, red, or silvery, often with a spot on the membranes between the dorsal spines (see *Sargocentron vexillarium*, Fig. J).

Note: 1. Superficially similar, spiny-headed larvae are found in the families Scorpaenidae, Triglidae, Dactylopteridae, Priacanthidae and Istiophoridae, but all of these differ in presence or absence of particular spines, orientation of these spines (if present) and meristic characters.

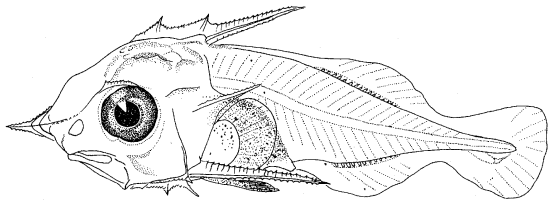
Figures: Adult (*Holocentrus adscensionis*): Greenfield, 2003; **A**, **C**, **E**: Okiyama, 1988; **B**, **D**: Jones and Kumaran, 1962; **F**: Tyler *et al*., 1993

References: McKenney, 1959; Woods and Sonoda, 1973; Leis and Rennis, 1983; Keene and Tighe, 1984; Tyler *et al*., 1993; Baldwin and Johnson, 1995; Watson, 1996l; Richards *et al*., 2003.

Holocentridae unidentified

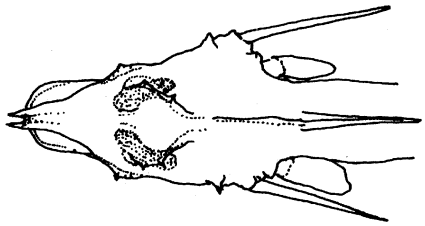


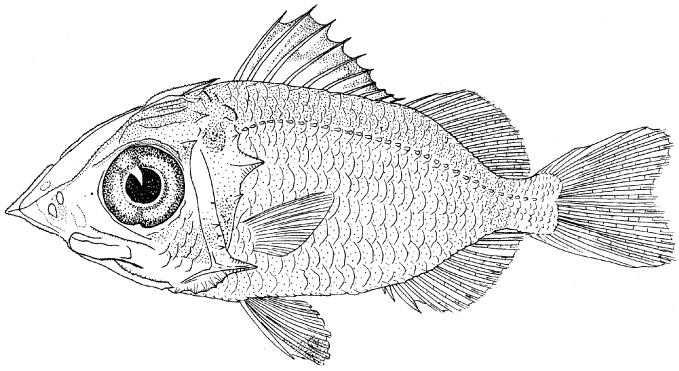
A. 4.7 mmSL Holocentrinae (Preflexion larva)



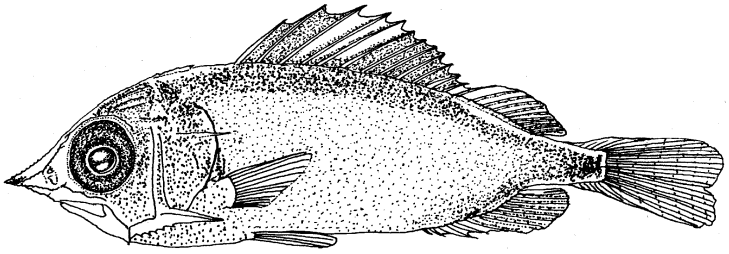
B. 4.7 mmNL Myripristinae (Preflexion larva)

C. 3.1 mmTL (Dorsal view of split rostral spine in *Myripristis* sp.)

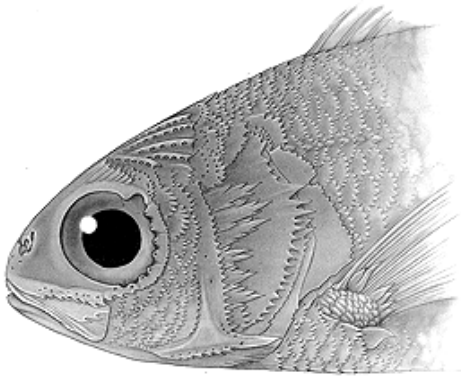




D. 16.3 mmSL Myripristinae ("Rhynchichthys" stage)

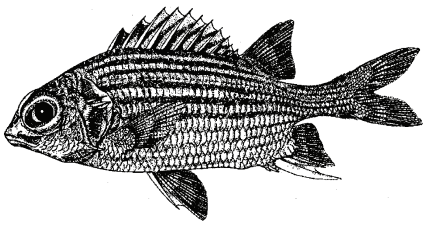


E. 23.8 mmSL Holocentrinae ("Rhynchichthys" stage)



F. 58.9 mmSL *Holocentrus rufus* (Head of "meeki" stage)

Sargocentron vexillarium (Poey, 1860)
Holocentridae
Dusky squirrelfish



Range: Western North Atlantic Ocean from Bermuda and east coast of United States from the Carolinas through Gulf of Mexico and Caribbean Sea to northern South America; young stages reported from study area, probably associated with Gulf Stream

Habitat: Inshore waters and reefs in depths of 30–110 m

Spawning: Probably year-round, with possible diminution during winter, based on ocurrences of larvae

Meristic Characters

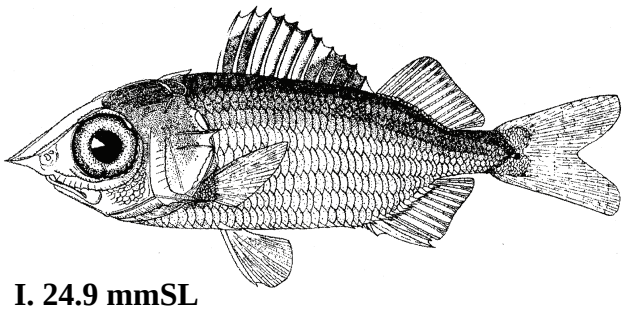
Myomeres:	about 27
Vertebrae:	27
Dorsal fin rays:	XI, 12–14
Anal fin rays:	IV, 8–10
Pectoral fin rays:	14–15
Pelvic fin rays:	I, 7
Caudal fin rays:	10+9 (PrC)

Eggs:
- Undescribed

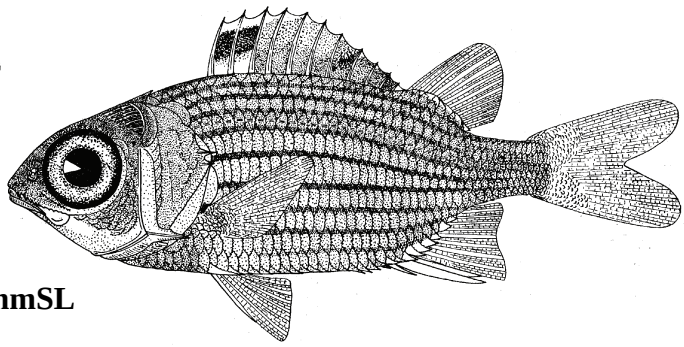
Larvae:
- Hatching occurs at sizes <2.0 mmNL, eye pigmented, mouthparts formed
- Body moderately slender with large, rounded head
- Preanus length increases from 55–70% SL (not including rostral spine)
- Flexion occurs between 6.0 and 9.0 mmSL
- Early forming head spines include supraoccipital beginning as spiny crest, preopercle angle, then rostral
- Less prominent spines also occur on many other head bones (see table in Beryciformes Introduction)
- Sequence of fin ray development: C – D, A – P_1 – P_2
- Pigmentation includes heavy scattering of melanophores over gut, few spots on top of head; early larvae have row of small spots along anal fin base; another row of pigment forms on dorsolateral flank at about 8.5 mmSL; internal pigment occurs along the vertebral column

Note: 1. Holocentrids (and their larvae) are very similar morphologically and in their meristic characters. The present series may represent a complex of several species within the subfamily Holocentrinae (Richards *et al*., 2003).

Early Juveniles: Note transformation from a pelagic, pre-settlement "Rhynchichthys" stage (fin rays and scales complete, larval head spination reduced), to a settlement-juvenile stage, at about 24–32 mmSL. (Also see Tyler *et al*., 1993)



I. 24.9 mmSL

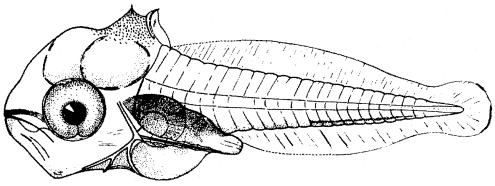


J. 32.5 mmSL

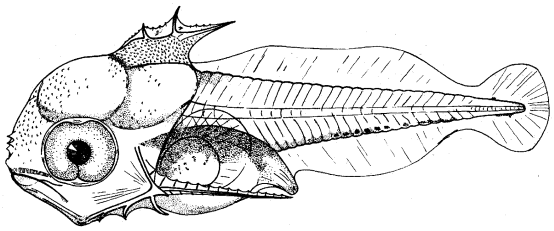
Figures: Adult: Mary Ann Holloway (Woods and Sonoda, 1973); **A–J**: McKenney, 1959

References: McKenney, 1959; Leis and Rennis, 1983; Johnson and Patterson, 1993; Tyler *et al*., 1993; Baldwin and Johnson, 1995; Richards *et al.*, 2003

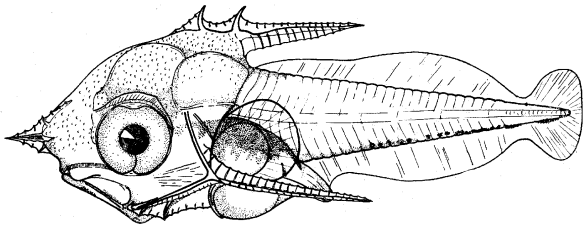
Sargocentron vexillarium



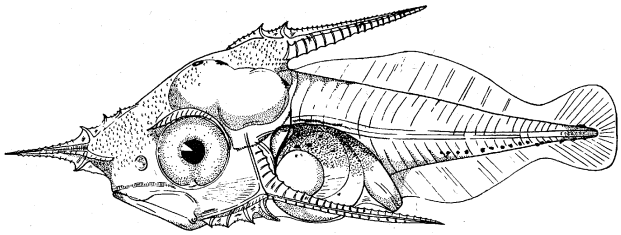
A. 1.8 mmSL



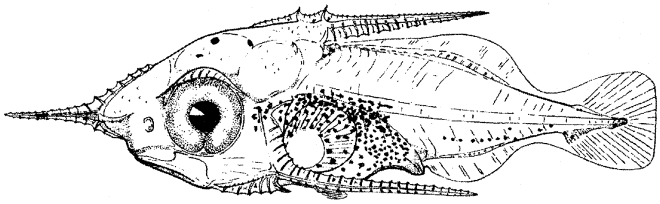
B. 2.2 mmSL



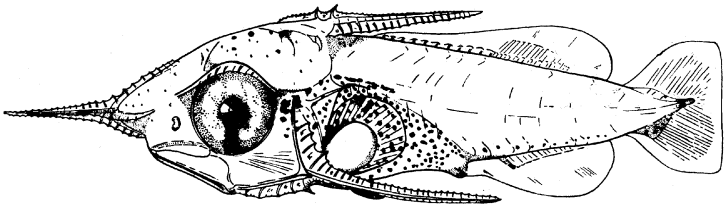
C. 2.8 mmSL



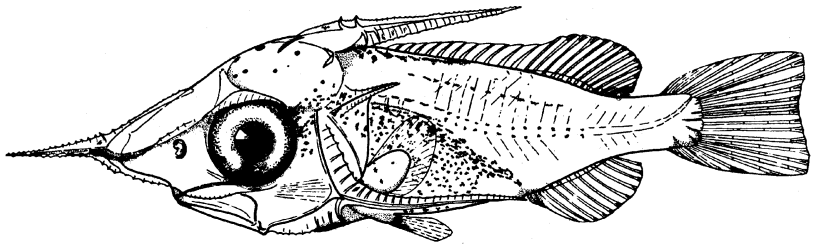
D. 4.3 mmSL



E. 5.8 mmSL



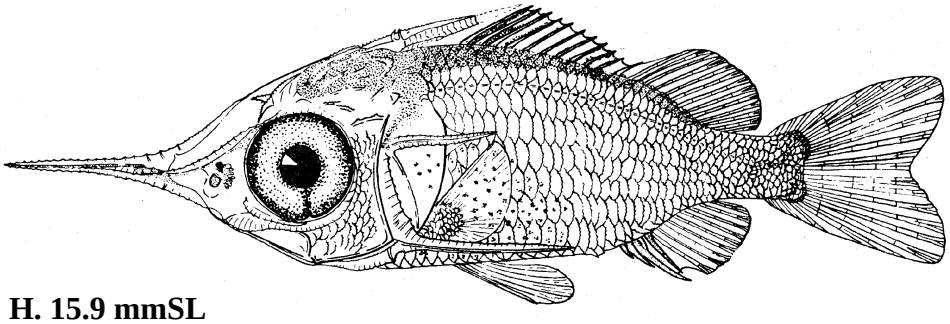
F. 7.3 mmSL



Note prominent, posteriorly directed, serrate supraoccipital, preopercle, and rostral spines

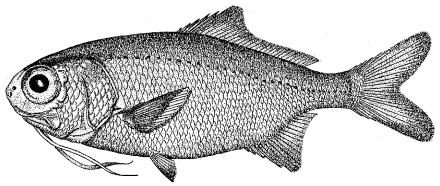
G. 8.5 mmSL

Rostral spine is the result of fusion of nasal bones



H. 15.9 mmSL

Polymixia lowei Günther, 1859
Polymixiidae
Beardfish



Range: Western North Atlantic Ocean from Grand Bank to northern South America

Habitat: Benthopelagic in depths of 82–660 m

Spawning: Undescribed

Eggs: – Undescribed

Meristic Characters

Myomeres:	about 29–30
Vertebrae:	29–30
Dorsal fin rays:	IV–VI, 26–32
Anal fin rays:	III–IV, 15–18
Pectoral fin rays:	14–18
Pelvic fin rays:	I, 6
Caudal fin rays:	10+9 (PrC)

(see meristic characters for *Polymixia nobilis* in Beryciformes Introductory table)

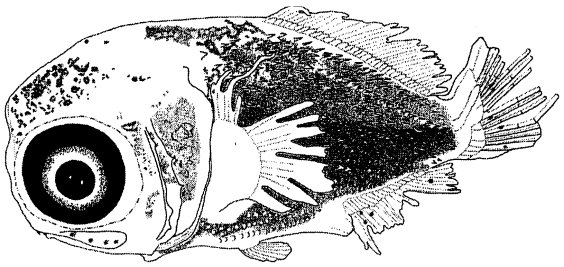
Larvae:
- Apparently not precociously developed at hatching
- Body very deep, bulky and large-headed
- Preanus length about 70% SL
- Well developed pelvic fins in early larvae
- Flexion occurs at <4.0 mmSL
- Sequence of fin ray formation undescribed
- Pectoral fin rays last to form
- Anterior dorsal fin elements not elongate
- Early-forming hyoid barbels present on gular membrane, become darkly pigmented at about 10 mm
- Spinous scales present within the pigmented area of body at 4.0 mmSL; these spread over much of head and body in later stages
- Pigmentation dense on anterior-top of head and on most of body, except caudal peduncle; snout, pectoral fin base and posterior part of head unpigmented; scattered spots on caudal and anal fin rays; venter of gut unpigmented in early larvae

Note:
1. Certain generalizations based on 10.0 mmSL larva (MCZ 58964) examined by Olney (1984)
2. Diagram of head spines is included for comparison with other taxa

Figures: Adult: Mary Ann Holloway (Woods and Sonoda, 1973); **A–B**: P. J. Bond (Lyczkowski-Shultz, 2006); **C**: Baldwin and Johnson, 1995

References: Woods and Sonoda, 1973; Olney, 1984; Johnson and Patterson, 1993; Baldwin and Johnson, 1995; Moore, 2002a; 2002f

Polymixia lowei

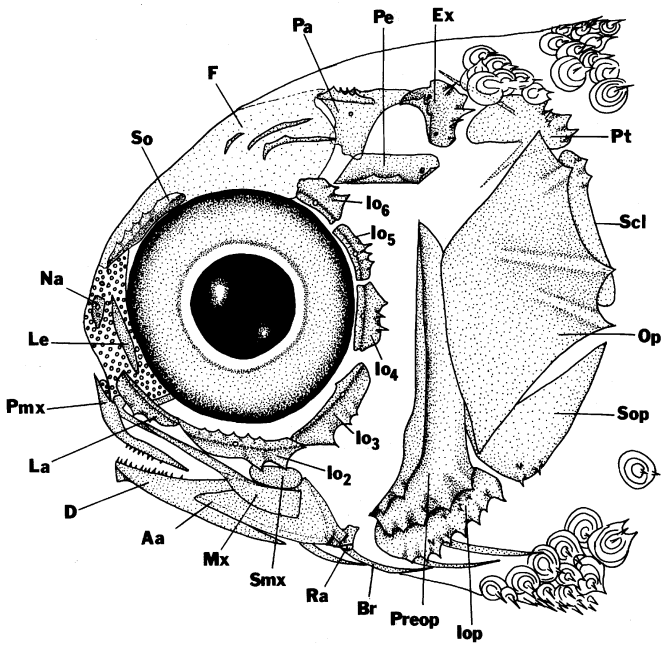


A. 4.1 mmSL

Note pair of hyoid barbels near mid-ventral line, immediately posterior to dark, gular pigment swath in the ventral view (Fig. B). A single hyoid barbel is also visible on venter below the preopercle in Fig. A.

B. 5.0 mm (Ventral View)

Note spinous scales encroaching on head in posttemporal and jugular regions.



C. 11.5 mmSL

Legend:

Aa - Anguloarticular
Br - Branchiostegal
D - Dentary
Ex - Extrascapular
F - Frontal
$Io_{\#}$ - Infraorbitals (numbered)
Iop - Interopercle
La - Lacrimal
Le - Lateral ethmoid
Mx - Maxilla
Na - Nasal
Op - Opercle
Pa - Parietal
Pe - Pterotic
Pmx - Premaxilla
Preop - Preopercle
Pt - Posttemporal
Ra - Retroarticular
Scl - Supracleithrum
Smx - Supramaxilla
So - Suprorbital ridge
Sop - Subopercle

The description of head spines was included in a comparative study of beryciform and stephanoberyciform larvae (Baldwin and Johnson, 1995) and is based on a cleared and stained specimen (MCZ 64773). Compare to head spination in beryciform larvae in the introductory pages. *Polymixia* is not closely related to beryciforms or stephanoberyciforms, but has extensive head spination, including spines on the Aa, La, F, So, Pa, Pe, Ex, Pt, Scl, Preop, Iop and Sop.