

Perciformes**Suborders Gobiesocoidei, Callionymoidei, Acanthuroidei**

Selected meristic characters in species belonging to the suborders Gobiesocoidei, Callionymoidei and Acanthuroidei whose adults or larvae have been collected in the study area. Classification sequence follows G. D. Johnson, 1993; Leis and Carson-Ewart, 2003. The inclusion of Chaetodontidae, Ehippidae and Pomacanthidae in the Acanthuroidei (sensu Tyler *et al.*, 1989) explained on next page. Sources: Davis, 1966; Miller and Jorgenson, 1973; Leis and Richards, 1984; Randall, 2002

Suborder				
Family				
<i>Species</i>	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays
Gobiesocoidei				
Gobiesocidae				
<i>Gobiesox strumosus</i>	25–26	9–12	8–10	21–23
Callionymoidei				
Callionymidae				
<i>Diplogrammus pauciradiatus</i>	18	IV, 6	4	16–19
<i>Foetorepus agassizii</i>	20–21	IV, 8	7	20–23
<i>Foetorepus goodenbeani</i>	21	IV, 8	7	21
<i>Paradiplogrammus bairdi</i>	21–22	IV, 9–10	6–9	19–20
Draconettidae				
<i>Centrodraco acanthopoma</i>	23	III, 14	13	24–26
Acanthuroidei				
Acanthuridae				
<i>Acanthurus bahianus</i>	22	IX, 23–26	III, 21–23	15–17
<i>Acanthurus chirurgis</i>	22	IX, 24–25	III, 22–23	16–17
<i>Acanthurus coeruleus</i>	22	IX, 26–28	III, 24–26	16–17
Chaetodontidae				
<i>Chaetodon capistratus</i>	24	XII–XIII, 18–20	III, 16–17	14
<i>Chaetodon ocellatus</i>	24	XII–XIV, 18–21	III, 15–18	14–15
<i>Chaetodon striatus</i>	24	XII, 19–20	III, 16–17	14
Ehippidae				
<i>Chaetodipterus faber</i>	24	IX, 21–23	III, 17–18	17–18
Luaridae				
<i>Luvarus imperialis</i>	23	II, 12–13	13–14	17–20
Pomacanthidae				
<i>Pomacanthus arcuatus</i>	24	IX, 31–33	III, 23–25	19–20

Perciformes

Suborders Gobiesocoidi, Callionymoidei, Acanthuroidei

Gobiesocoidi: Represented in the study area by a single species in the family Gobiesocidae. A previously recognized order Gobiesociformes contained the Gobiesocidae, Callionymidae and Draconettidae. These families are now considered to belong to two perciform suborders by some authors (e.g. Patterson and Rosen, 1989; Nelson, 1994; Carpenter, 2002b), a classification followed here. The pelvic fin rays are joined to form a portion of a suction disk which enables these fishes to cling to bottom substrates in high-energy habitats such as shallow areas subject to wave action. (See Allen, 1984; Watson, 1996h for more information.)

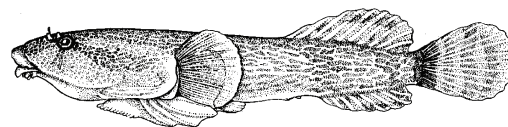
Callionymoidei: This perciform suborder contains two families with species that occur in the study area. Callionymidae is represented by 4 species, Draconettidae by one. The callionymids are small, demersal fishes, usually found on soft substrates. Their larvae hatch, develop and settle at relatively small sizes. Larvae are bulky anteriorly but taper to a very thin, long, notochord tip. Characteristic pigment patterns, especially dense ventrally, typify most of the known species. Draconettids occur in deep water, usually between 300 and 550 m. Their larvae are very poorly known.

Acanthuroidei: The monophyly of an Acanthuroidei consisting of the families Siganidae, Luvaridae, Zanclidae and Acanthuridae has been well established, based on a suite of osteological characters (Tyler *et al.*, 1989). The addition of Ehippidae, Chaetodontidae and Pomacanthidae results in a larger group, that is also monophyletic. This expanded group has been referred to as the "higher squamipinnes" (*sensu* Mok and Shen, 1983; Tyler *et al.*, 1989); here we simply refer to all of these related groups as an expanded Acanthuroidei.

Spines or serrated ridges on the head typify the larvae of all these groups. Many are also deep-bodied and have specialized, larval scales. The larvae of several families have the ability to continue growth in the competent-larval stage before suitable settlement habitat is found, but this has not been documented in all. Luvarus early stages continue to grow in body length, but remain epi- or mesopelagic. See Tyler *et al.* (1989) and Johnson and Washington (1987) for more details of ontogeny in all these families. Also see characters in table below.

Distribution of important larval characters in 5 families and a chaetodontid genus occurring in the study area

Character	Acanthuridae	<i>Chaetodon</i>	Ehippidae	Luvaridae	Pomacanthidae
Body shape	Kite-shaped, compressed	Deep compressed	Deep, disk-shaped	Kite-shaped compressed bulging forehead	Deep, very compressed
First fin elements to form	2 nd dorsal and pelvic spines	Pectoral, dorsal and anal	Caudal dorsal and anal	2 nd dorsal and pelvic spines	Caudal, dorsal and anal
Supraoccipital ridge	Low, serrate	No spines	No spines	Low, serrate	No spines
Serrate ridges on each Frontal Bone	One, low over orbit, plus short anteromedial ridge	Head encased in flat, bony plates	Few spines or none	One, low over orbit, plus short anteromedial ridge	Supraorbital only
Preopercle spines	Small	Broad, flat	Large	Large	Large (retained)
Nasal Bone	2 spiny ridges	No spines	No spines	2 spiny ridges	2 spiny ridges
Angular Bone serrate ridge	Present	None	None	Present	Present
Dentary ridges	2, serrate	None	None	2, serrate	2, serrate
Larval scale shape and orientation	Broad-based, triangular, vertical	None	None	Broad-based, fan-shaped, horizontal	Simple, spiny

Gobiesox strumosus* Cope, 1870*Gobiesocidae****Skilletfish**

Range: Western North Atlantic Ocean from New Jersey to Brazil, including Gulf of Mexico and West Indies

Habitat: Bays, estuaries and coastal ocean to maximum depth of 33 m; found near rocks, pilings, oyster reefs, sponges, eel grass beds

Spawning: Apr–Aug, with a peak in late Apr–May; eggs deposited in masses usually in high energy habitats, often attached to the underside of rocks or shells until the larvae hatch, sometimes at an advanced state of development.

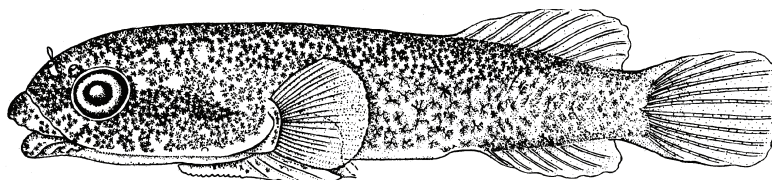
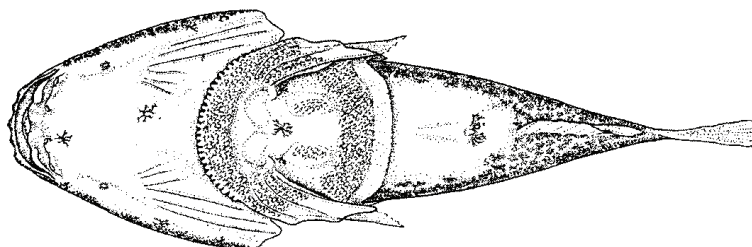
Eggs:

- Demersal, slightly oval or round, adhesive; appear yellowish
- Diameter 0.67×0.94 mm if oval; 0.75–0.94 mm if round
- Chorion finely corrugated; yolk granular, segmented
- Oil globules numerous (70–80); 0.02–0.10 mm diameter
- Perivitelline space 15–20% of diameter

Larvae:

- Hatch at about 2.4–3.4 mmTL; body moderately elongate, with thick gut; preanus length about 60% SL
- Head moderate in size, snout rounded; mouth well formed at hatching
- Flexion occurs at 4.5–7.0 mmTL; transformation occurs at 10.0–12.0 mmTL
- Sequence of fin ray formation: C – D, A – P₁ – P₂; caudal fin rays begin at about 4.5 mm, others at about 7.0 mm; all fin rays formed by 8.0–9.0 mm
- Pigment includes 2 early-forming, bold rows of melanophores, above and below notochord, from nape to level slightly posterior to anus; in larger larvae, pigment fills in between these rows; head pigment begins as scattering on top of crown and a vague bar posterior to eye; head more completely covered with pigment as transformation size approaches; in most larvae, the posterior 25% of body is unpigmented, becomes pigmented in late larval stage
- Development from larval to juvenile stage is gradual; settlement occurs after suction disk is fully formed

Note: 1. Ventral suction disk begins to form as ridges at 6.5 mmTL; well-formed, but incomplete by 8.8 mmTL; disk completely formed by 9.0 mmTL

Early Juvenile:**H. 12.0 mmTL****I. 12.0 mmTL
(Ventral View)****Meristic Characters**

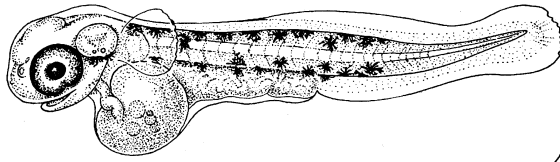
Myomeres:	25–26
Vertebrae:	25–26
Dorsal fin rays:	9–12
Anal fin rays:	8–10
Pectoral fin rays:	21–23
Pelvic fin rays:	4 (disk)
Caudal fin rays:	10+12



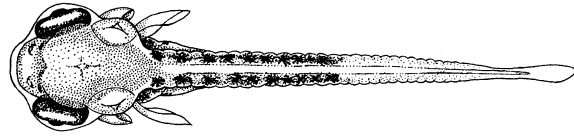
Figures: Adult: Runyan, 1961; Egg and A–C, H–I: Runyan, 1961; D–G: Dovel, 1963

References: Runyan, 1961; Dovel, 1963; Martin and Drewry, 1978; Allen, 1984; Watson, 1996h

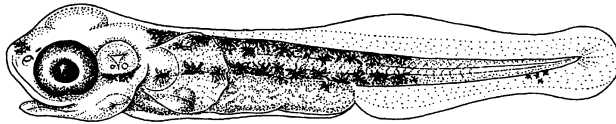
Gobiesox strumosus



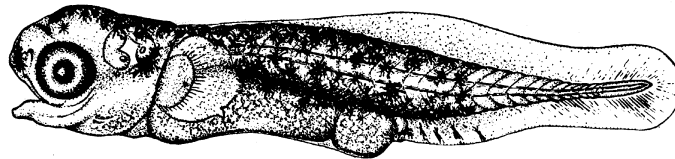
A. 3.2 mmTL



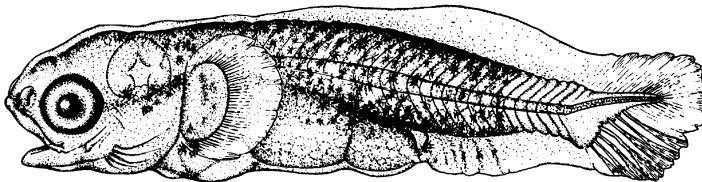
B. 3.5 mmTL
(Dorsal View)



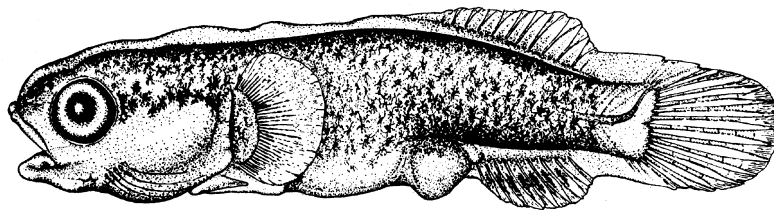
C. 3.9 mmTL



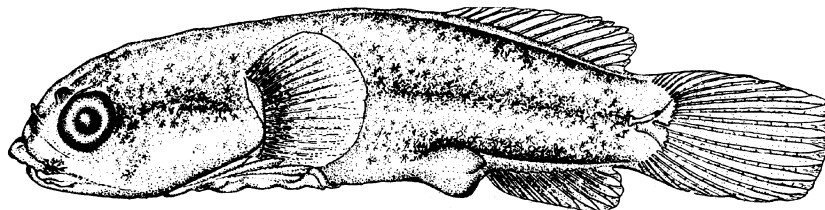
D. 4.7 mmTL



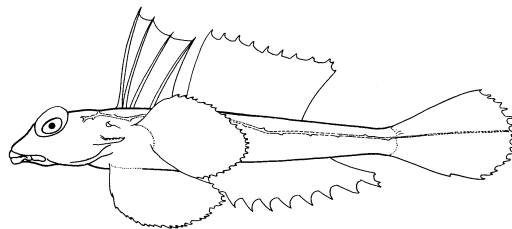
E. 6.6 mmTL



F. 8.8 mmTL



G. 11.6 mmTL

Paradiplogrammus bairdi* (Jordan, 1888)*Callionymidae****Lancer dragonet**

Range: Western North Atlantic Ocean from North Carolina to Colombia; larvae commonly collected in study area, as far north as Hudson Canyon area

Habitat: Demersal, typically in live-bottom habitats at moderate depths

Spawning: Protracted season with peak during summer-fall; larvae most common over outer continental shelf

Eggs:

- Small, spherical, pelagic
- Diameter: 0.6–0.8 mm (family character)
- Chorion: sculpted (polygonal pattern)

Larvae:

- Hatch at very small sizes (<2.0 mmNL)
- Body initially bulky anteriorly with tapering posterior parts; laterally compressed
- Head becomes broader and flatter in later larvae and eyes become dorsally oriented
- Snout initially short, then lengthens
- Small, terminal mouth becomes protrusible
- Preanus length typically >50% SL at hatching, decreases to <50% SL in later larvae
- Fin rays form early; sequence of fin ray formation: C – D, A – P₁ – P₂
- Flexion begins at small size (about 2.0 mmNL)
- Prominent, upturned notochord tip before flexion complete
- Head spines lacking (but see checklist below)
- Pigment patterns important for identifying larvae of different species; larvae are bright red when collected, but this color fades in preservative; accumulations of melanophores occur on dorsal half of body, under dorsal fin and on caudal peduncle, and on ventral half of body over anal fin base and on lower caudal peduncle; scattered spots occur on posterior head and on nape; middle parts of pelvic fin rays pigmented; base of pectoral fin pigmented

Meristic Characters

Myomeres:	21–22
Vertebrae:	21–22
Dorsal fin rays:	IV, 9–10
Anal fin rays:	6–9
Pectoral fin rays:	19–20
Pelvic fin rays:	I, 5
Caudal fin rays:	3+5+5+2

Head Spine Checklist:

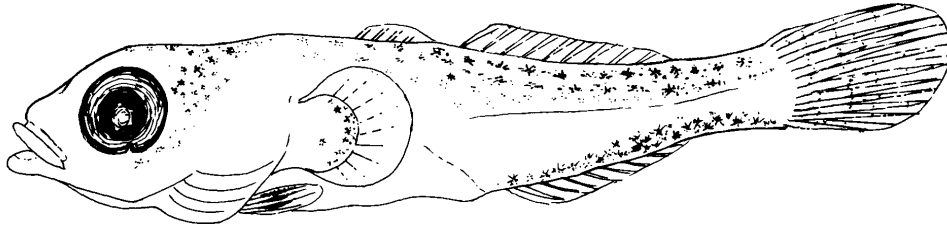
Preopercle: single, large, posteriorly directed spine, often with secondary barbs, teeth or hooks, present in later larvae; in the larvae of 5 species from the eastern Atlantic Ocean and Mediterranean Sea, these spines are specifically unique and form at sizes from 5–10 mmTL (Fage, 1918)

- Note:**
1. Tiny, spinelike structures have been reported along the margins of the dorsal and ventral finfolds in some species (e.g. Takita, 1983)
 2. The described larvae of most species have an interrupted line of pigment along midline
 3. Settlement to bottom habitats probably occurs at sizes of about 5.0 mmSL

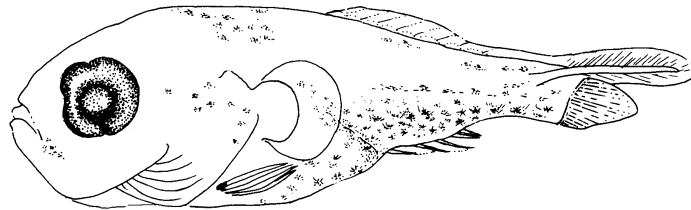
Figures: Adult: Hartel, 2002; A–C: Olney and Sedberry, 1983

References: Fage, 1918; Miller *et al.*, 1979; Nakabo, 1982; Olney and Sedberry, 1983; Takita, 1983; 1988; Houde, 1984b; Nakabo and Hartel, 1999; Hartel, 2002; Leis and Rennis, 2004e

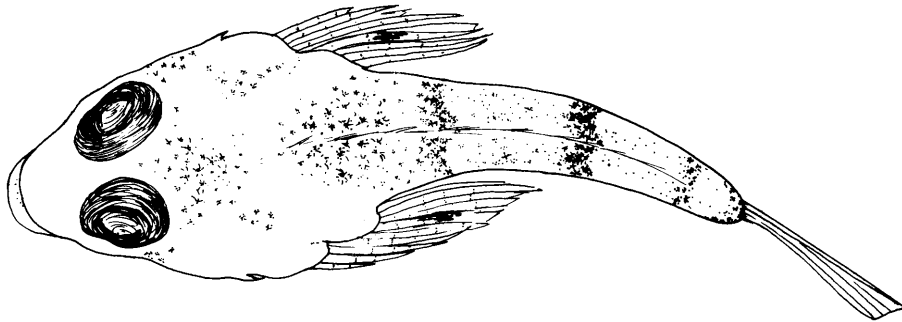
Callionymidae

Paradiplogrammus bairdi

A. 4.2 mmSL

Diplogrammus pauciradiatus

B. 2.5 mmNL

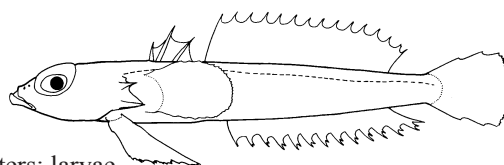


C. 4.3 mmSL (Dorsal View)

Larvae of *Diplogrammus pauciradiatus* are similar to those of *Paradiplogrammus bairdi* but have a different pigment pattern. Early larvae are most dense on the ventral part of the body and gut. A banded pattern develops in larger larvae. All stages have prominent pigment spots at the bases of the pelvic fin rays. Other pigment accumulations occur on the nape and on the opercle. Adults occur from North Carolina to Colombia, usually in seagrass beds, but also in continental shelf habitats to a depth of 55 m. Larvae may be transported into study area via the Gulf Stream.

Centrodraco acanthopoma* (Regan, 1904)*Draconettidae**

"Deepwater draconett"



Range: Atlantic and western Pacific oceans in tropical to subtropical waters; larvae widespread

Habitat: Demersal in moderately deep water, mostly in depths of 300–550 m; larvae and small juveniles mesopelagic in depths of 200–400 m over continental slope

Spawning: Undescribed

Eggs: – Undescribed

Larvae:

- Larvae only known from a single specimen (Fig. A) collected in western North Atlantic Ocean
- Body moderately elongate, laterally compressed, especially at caudal peduncle
- Preanus length about 50% SL; gut coiled
- Head moderate, slightly compressed, snout pointed
- Mouth small, protrusible, barely reaching anterior edge of eye
- Flexion complete <8.6 mmSL
- Fin rays in dorsal, anal and caudal fin complete by 8.6 mmSL
- 3 short, stout spines in D₁
- Pelvic fin base well anterior to pectoral fin base
- Head spines few; see checklist below
- Pigment lacking except for dark stripe extending through middle of caudal fin

Meristic Characters

Myomeres:	22–23
Vertebrae:	8 + 15 = 23
Dorsal fin rays:	III, 14
Anal fin rays:	13
Pectoral fin rays:	24–26
Pelvic fin rays:	I, 5
Caudal fin rays:	3+6+6+1

Head Spine Checklist:

Opercle: 1 or 2 strong spines at upper angle

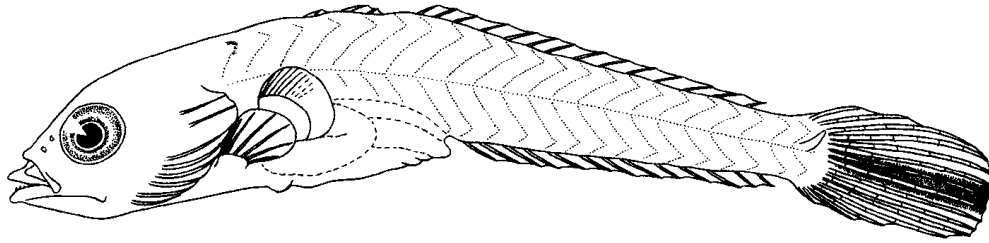
Subopercle: 1 strong spine at upper angle

Note: 1. Pelagic-juveniles up to 25 mm have been collected; probably settle to bottom habitats at about 30 mm

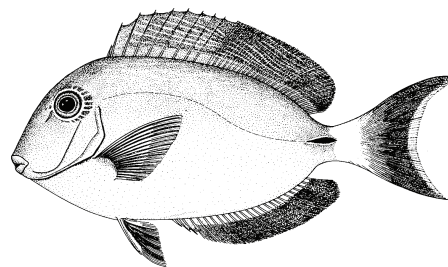
Figures: Adult: Hartel, 2002; A: Nakabo and Hartel, 2004

References: Nakabo, 1982; Fricke, 1992; Hartel, 2002; Nakabo and Hartel, 2004

Centrodraco acanthopoma



A. 8.6 mmSL

Acanthurus bahianus* Castelnau, 1855*Acanthuridae****Ocean surgeon**

Range: Western North Atlantic Ocean from Massachusetts and Bermuda to Brazil, but rare north of Florida; northern records based on young stages transported by Gulf Stream; also southeastern Atlantic Ocean at Ascension and St. Helena islands

Habitat: Coral reefs and rocky substrates, mixed with sandy bottoms

Spawning: Nov–Apr with peak Dec–Mar; employs both pair and aggregate spawning methods

Eggs:

- Pelagic, spherical
- Diameter: 0.6–0.7 mm
- Oil globule: single, 0.17 mm in diameter

Larvae:

- (Preflexion larvae not well described; larvae hatch at <2.0 mm)
- Body kite-shaped with elongate snout, small, terminal mouth
- Flexion occurs at 3.5–4.6 mm
- Elongate, early forming, serrate spines form in the sequence P₂, D₁ and A based on larvae not identified to species
- Head spines extensive (see Fig. D)
- Supraoccipital crest with 20+ spinelets forms very early (<3.0 mm)
- Small, spinulose scales arranged in vertical rows on body
- Pigment lacking except over head and gut

Meristic Characters

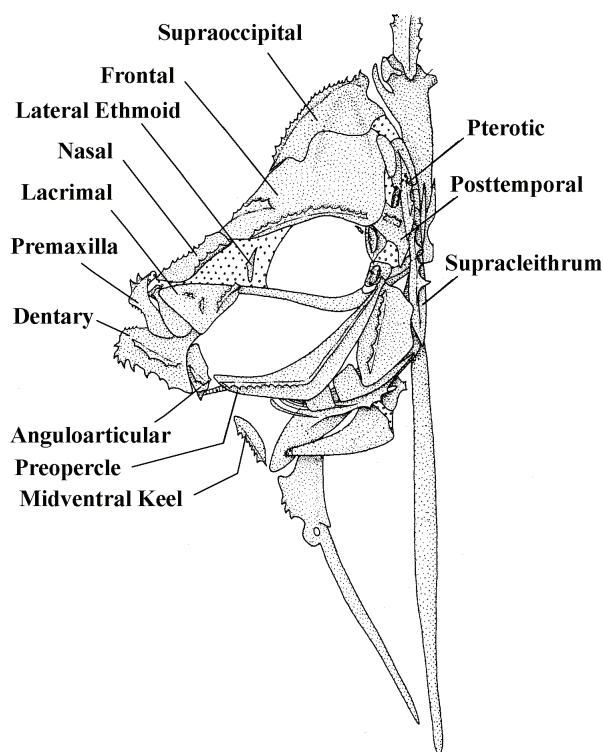
Myomeres:	22
Vertebrae:	22
Dorsal fin rays:	IX, 23–26
Anal fin rays:	III, 21–23
Pectoral fin rays:	15–17
Pelvic fin rays:	I, 3–5
Caudal fin rays:	5+8+8+5
Supraneurals:	2/1/1//

Head Spine Checklist: Extensive array of spines (see Fig. D)

Note: 1. Pacific larvae have been documented to delay transformation to juvenile stage until suitable habitat is found. This has not been documented in this species although larvae ("acronurus") larger than juveniles are often collected. In this species, transformation to juvenile stage occurs at 23–33 mm after 42–68 days as pelagic larva

Naso is closely related to *Acanthurus* and is similar in spination, except the latter have several midventral keels, not one. Bones not bearing spines unlabeled. (Compare to head spination in *Luvarus imperialis*.)

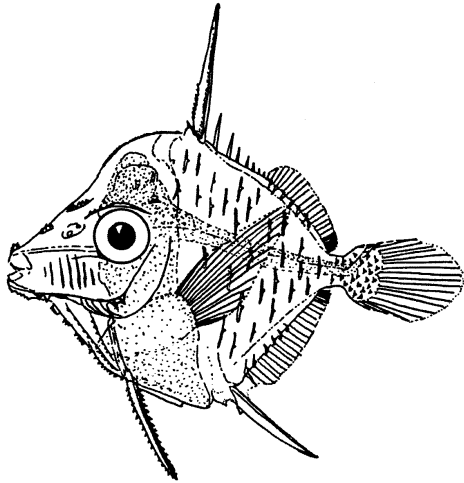
D. 9.7 mmSL *Naso* sp.



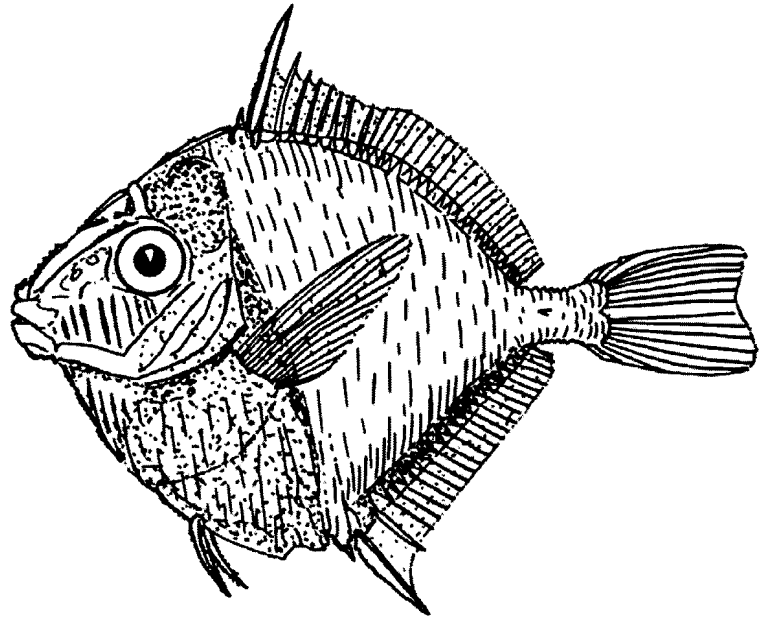
Figures: Adult: Randall, 2002a; A–B: Burgess, 1965 (B reversed); C–D: Johnson and Washington, 1987

References: Johnson and Washington, 1987; Colin and Clavijo, 1988; Randall, 2002a; Leis and Rennis, 2004f; Jackson, 2006a

Acanthurus bahianus

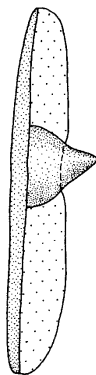


A. 5.4 mm



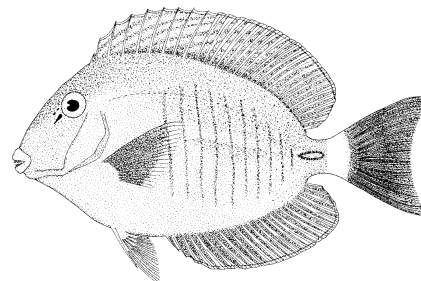
B. 13.0 mm

Retroarticular spine on side of caudal peduncle forms after transformation to juvenile



C. 10.4 mmSL (*Acanthurus* sp., larval scale, posterior view)

Note triangular projection

Acanthurus chirurgus* (Bloch, 1787)*Acanthuridae****Doctorfish**

Range: Western North Atlantic Ocean from Massachusetts and Bermuda to Brazil, including Gulf of Mexico; also eastern Atlantic Ocean off West Africa

Habitat: Coral or sponge reefs and rocky substrates, mixed with sandy bottoms; seagrass beds used as nurseries

Spawning: Undescribed; possibly similar to *Acanthurus bahianus*

Eggs:

- Pelagic, spherical
- Diameter: 0.67 mm
- Oil globule: single, 0.16 mm in diameter

Larvae:

- (Preflexion larvae not well described; larvae hatch at <2.0 mm)
- Body kite-shaped with elongate snout, small, terminal mouth
- Flexion occurs at 3.5–4.6 mm
- Elongate, early forming, serrate spines form in the sequence P₂, D₁ and A, based on larvae not identified to species
- Head spines extensive; see checklist below
- Supraoccipital crest with 20+ spinelets forms very early (<3.0 mm)
- Small, spinulose scales arranged in vertical rows on body
- Pigment lacking except over head and gut

Meristic Characters

Myomeres:	22
Vertebrae:	22
Dorsal fin rays:	IX, 24–25
Anal fin rays:	III, 22–23
Pectoral fin rays:	16–17
Pelvic fin rays:	I, 3–5
Caudal fin rays:	5+8+8+5
Supraneurals:	2/1/1//

Head Spine Checklist:

Extensive array of spines (see Fig. D on *Acanthurus bahianus* page)

Note: 1. Pacific larvae have been documented to delay transformation to juvenile stage until suitable habitat is found. This has not been documented in this species although larvae ("acronurus") larger than juveniles are often collected. In this species, transformation to juvenile stage occurs at 23–32 mm after 45–71 days as pelagic larva

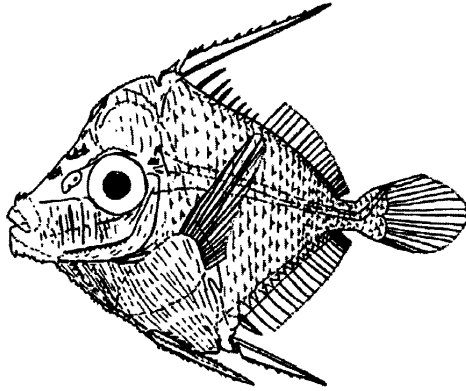
Meristic characters useful for distinguishing juveniles and adults:

<i>Species</i>	Anal Fin	Gill Rakers on First Arch
<i>Acanthurus bahianus</i>	III, 21–23	18–24
<i>Acanthurus chirurgus</i>	III, 22–23	16–19
<i>Acanthurus coeruleus</i>	III, 24–26	13–14

Figures: Adult: Randall, 2002a; A–C: Burgess, 1965 (A and C reversed)

References: Johnson and Washington, 1987; Colin and Clavijo, 1988; Randall, 2002a; Leis and Rennis, 2004f; Jackson, 2006a

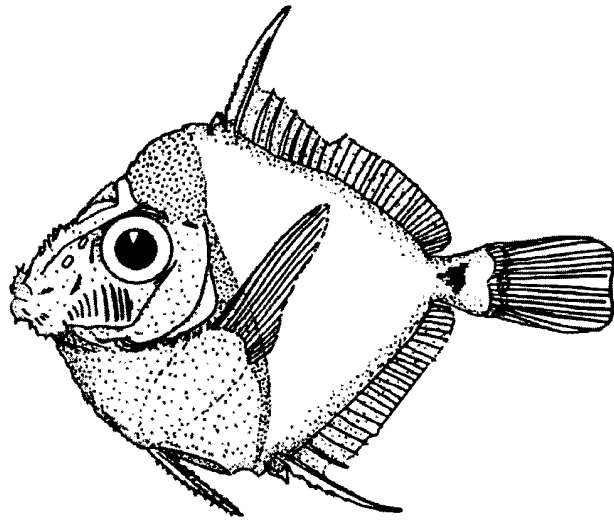
Acanthurus chirurgus



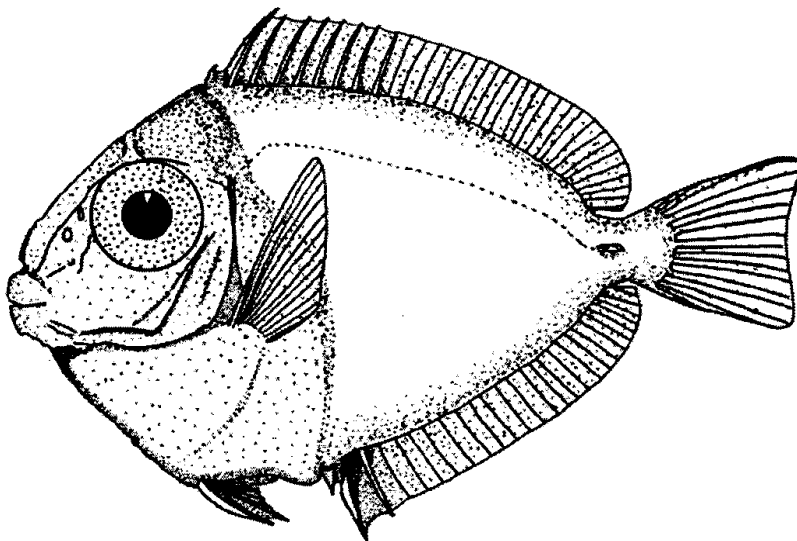
A. 5.1 mm

Scales present but omitted from Fig. B and C

Retroarticular spine on side of caudal peduncle forms after transformation to juvenile



B. 9.9 mm



C. 22.2 mm

Acanthurus coeruleus* Bloch and Schneider, 1801*Acanthuridae****Blue tang surgeonfish**

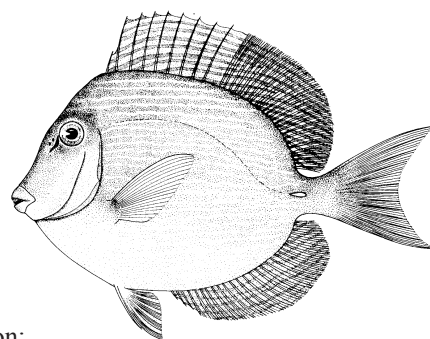
Range: Western North Atlantic Ocean from New York to Brazil; rare north of Florida and in Gulf of Mexico; also southeastern Atlantic Ocean at Ascension Island

Habitat: Coral and sponge reefs, often near seagrass beds

Spawning: 2 seasons: Apr–Nov (summer) during afternoon, 3–9 days after full moon; both pair and aggregate spawning methods employed; Dec–Mar (winter) 1 day before full moon to 5 days after full moon

Eggs: – Pelagic, spherical
– Diameter: 0.6–0.7 mm
– Oil globule: single, 0.17 mm

Larvae: – (Preflexion larvae not well described; larvae hatch at <2.0 mm)
– Body kite-shaped with elongate snout, small, terminal mouth
– Flexion occurs at 3.5–4.6 mm
– Elongate, early forming, serrate spines form in the sequence P₂, D₁ and A based on larvae not identified to species
– Head spines extensive; see checklist below
– Supraoccipital crest with 20+ spinelets forms very early (<3.0 mm)
– Small, spinulose scales arranged in vertical rows on body
– Pigment lacking except over head and gut

**Meristic Characters**

Myomeres:	22
Vertebrae:	22
Dorsal fin rays:	IX, 26–28
Anal fin rays:	III, 24–26
Pectoral fin rays:	16–17
Pelvic fin rays:	I, 3–5
Caudal fin rays:	5+8+8+5
Supraneurals:	2/1/1//

Head Spine Checklist: Extensive array of spines (see Fig. D on *Acanthurus bahianus* page)

Note: 1. Pacific larvae have been documented to delay transformation to juvenile stage until suitable habitat is found. This has not been documented in this species although larvae ("acronurus") larger than juveniles are often collected. In this species, transformation to juvenile stage occurs at 24–30 mm after 46–57 days as pelagic larva

Meristic characters useful for distinguishing juveniles and adults:

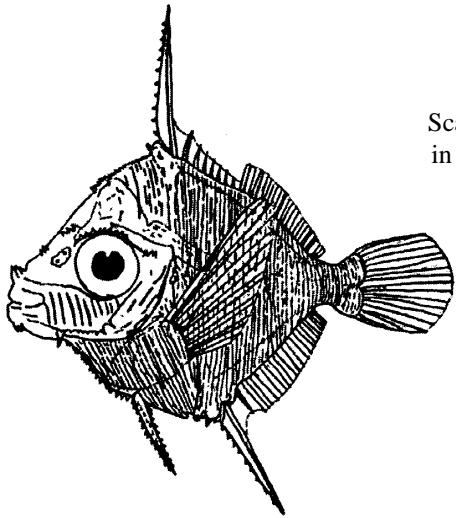
Species	Anal Fin	Gill Rakers on First Arch
<i>Acanthurus bahianus</i>	III, 21–23	18–24
<i>Acanthurus chirurgus</i>	III, 22–23	16–19
<i>Acanthurus coeruleus</i>	III, 24–26	13–14

Figures: Adult: Randall, 2002a; **A–D:** Burgess, 1965 (B, C reversed)

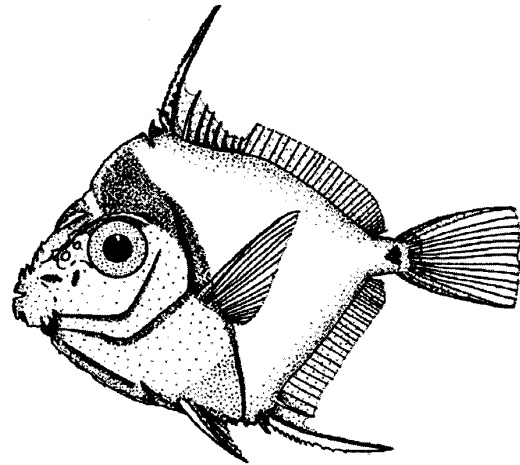
References: Johnson and Washington, 1987; Colin and Clavijo, 1988; Randall, 2002a; Leis and Rennis, 2004f; Jackson, 2006a

Acanthurus coeruleus

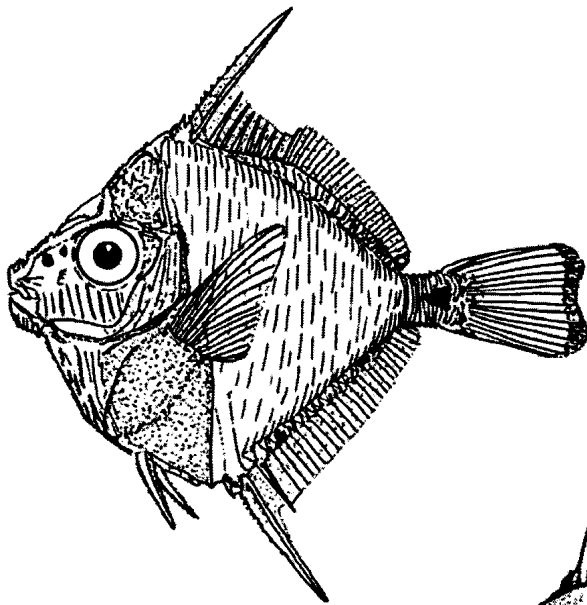
Scales, or scales and striae, omitted
in Fig. A-C



A. 5.5 mm

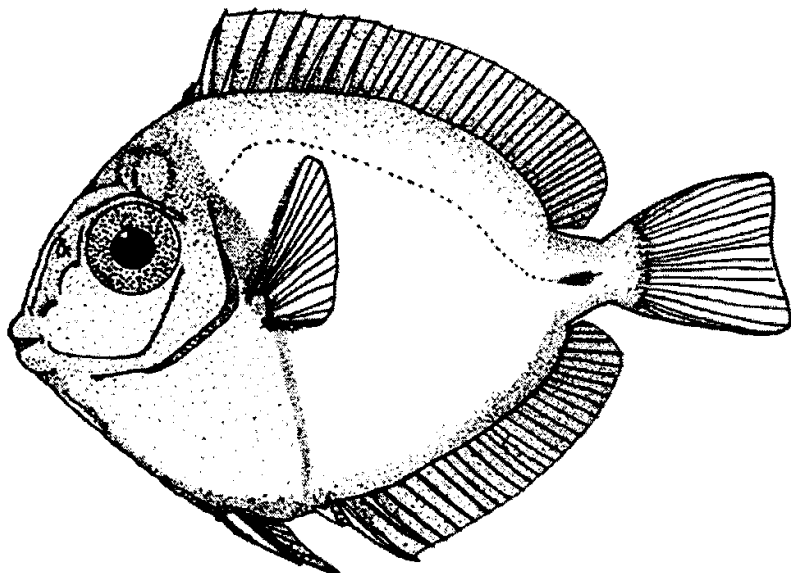


B. 9.5 mm



C. 13.0 mm

Retroarticular spine on side of caudal peduncle
forms after transformation to juvenile



D. 26.5 mm

Chaetodon capistratus* Linnaeus 1758*Chaetodontidae****Foureye butterflyfish**

Range: Western North Atlantic Ocean from Massachusetts and Bermuda to northern South America, including Gulf of Mexico; occurrences in study area composed of young-of-the-year that do not survive the winter

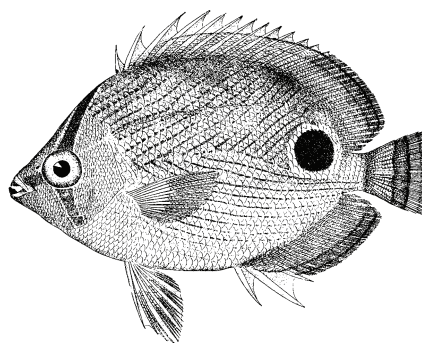
Habitat: Coral reefs, rocky substrates, pilings, seawalls; juveniles also frequent tidal creek habitats in the study area

Spawning: Feb–Apr in Bahamas and Caribbean locations

Eggs: – Undescribed

Larvae:

- Early stages undescribed in this species; general description below based on larvae of congeners
- Body initially elongate, deepens considerably by 5.5 mmSL
- Preanus length about 60% SL
- Hook-like, posterior extension of lower preopercle forms preflexion
- Flexion occurs at sizes of 4.5–5.5 mmSL
- "Tholichthys" stage (Fig. A) characterized by bony enclosure over head, with ear-like flaps extending to above pectoral fin, laterally compressed, silvery body; see checklist below
- Pigment in early stages probably includes lines of spots along dorsum, from nape to insertion of dorsal fin; a broken line of spots along midline of body; a line of spots along venter, from anus to end of anal fin; variable pigment on top of head
- Note dark smudge confined to caudal peduncle in larvae; (*Chaetodon ocellatus* has a dark bar crossing caudal peduncle from dorsal to anal fins); juvenile has 2 ocelli posteriorly (Fig. B)

**Meristic Characters**

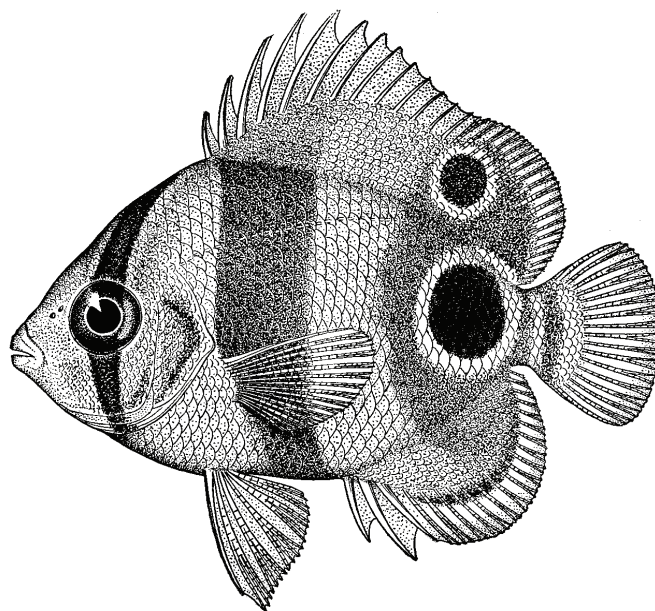
Myomeres:	24
Vertebrae:	10+14
Dorsal fin rays:	XII–XIII, 18–20
Anal fin rays:	III, 16–17
Pectoral fin rays:	14
Pelvic fin rays:	I, 5
Caudal fin rays:	9+8 PrC
Supraneurals:	0/0+2/1/

Head spine checklist:

Preopercle: early forming, broad, flat spine expanded posteriorly
 Posttemporal: expanded posteriorly
 Supracleithral: expanded posteriorly

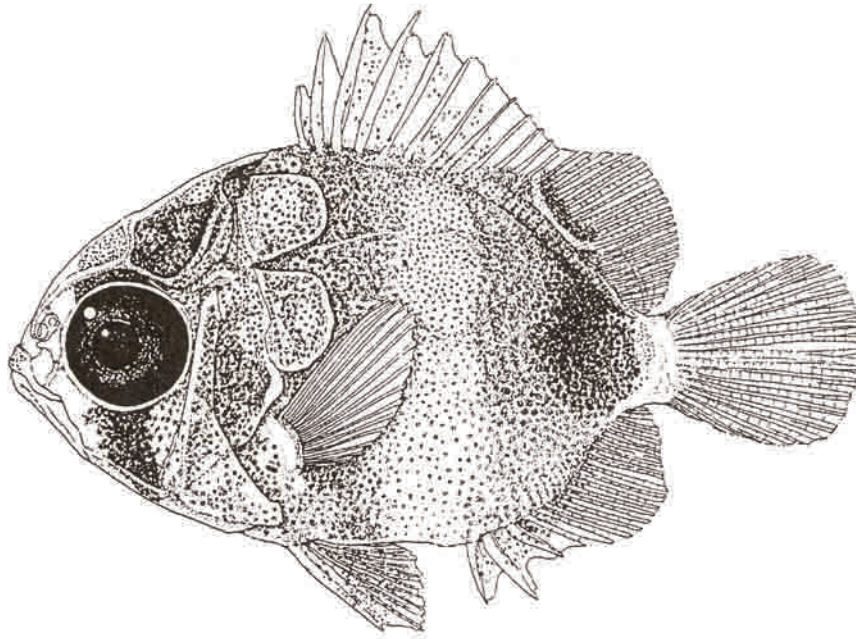
Early juvenile:

B. "less than 1.5 inches"
 (Described as *Chaetodon bricei*)



Figures: Adult: Jordan and Evermann, 1896–1900; A: Susan Kaiser (Able and Fahay, 1998); B: Smith, 1898

References: Moe, 1976; Suzuki *et al.*, 1980; Colin, 1989; M'Bride and Able, 1998; Able and Fahay, 1998; Leis and Rennis, 2004g

Chaetodon capistratus**A. 13.7 mmSL**

Note very small, terminal mouth

Earlier "tholichthys" stage larvae of *Chaetodon* sp. (5.0-6.0 mmSL) are described and illustrated in Kelly (2006). In these earlier stages, the posterior expansions on preopercle and posttemporal bones are greatly exaggerated. Most pigment in these early stages occurs as scattered melanophores on top of head and on the body, not including the posterior caudal peduncle.

Chaetodon ocellatus* Bloch 1787*Chaetodontidae****Spotfin butterflyfish**

Range: Western North Atlantic Ocean from Nova Scotia to Brazil, including Gulf of Mexico; occurrences in study area composed of young-of-the-year that do not survive the winter

Habitat: Coral reefs, rocky substrates, pilings, seawalls; juveniles also frequent tidal creek habitats in the study area

Spawning: Winter into spring (Jan–May) based on incomplete data; ripe females during May, 1 week before full moon in North Carolina

Eggs:

- Pelagic, spherical
- Diameter: 0.60–0.75 mm
- Other characters undescribed

Larvae:

- Early stages undescribed in this species; general description below based on larvae of congeners
- Body initially elongate, deepens considerably by 5.5 mmSL
- Preanus length about 60% SL
- Hook-like, posterior extension of lower preopercle forms in preflexion
- Flexion occurs at sizes of 4.5–5.5 mmSL
- "Tholichthys" stage (Fig. A) characterized by bony enclosure over head, with ear-like flaps extending to above pectoral fin, laterally compressed, silvery body
- Pigment in early stages probably includes lines of spots along dorsum, from nape to insertion of dorsal fin; a broken line of spots along midline of body; a line of spots along venter, from anus to end of anal fin; variable pigment on top of head
- Note dark bar crossing caudal peduncle from dorsal to anal fins; (*Chaetodon capistratus* has a dark smudge confined to caudal peduncle).

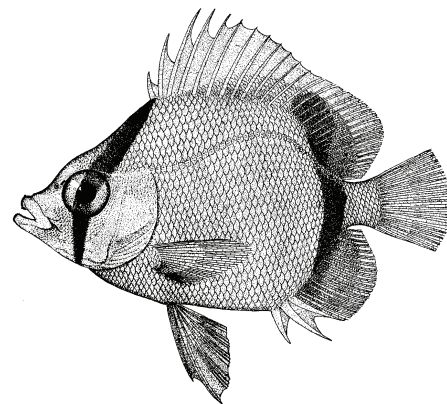
Head spine checklist:

Preopercle: early-forming, broad, flat spine expanded posteriorly

Posttemporal: expanded posteriorly

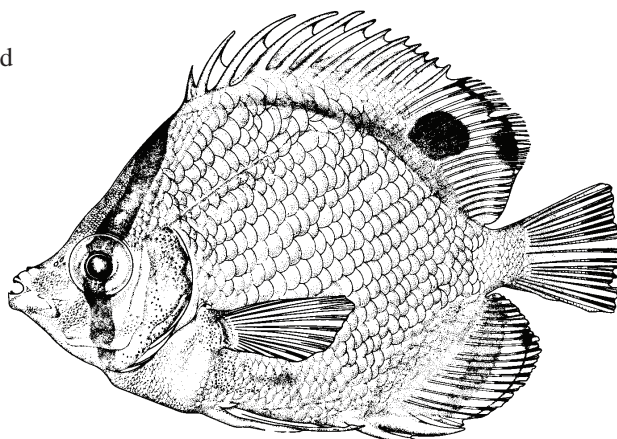
Supracleithral: expanded posteriorly

Early Juvenile: Bony enclosures over head absorbed shortly after settlement

**Meristic Characters**

Myomeres:	24
Vertebrae:	24
Dorsal fin rays:	XII–XIV, 18–21
Anal fin rays:	III, 15–18
Pectoral fin rays:	14–15
Pelvic fin rays:	I, 5
Caudal fin rays:	9+8 PrC
Supraneurals:	0/0+2/1/

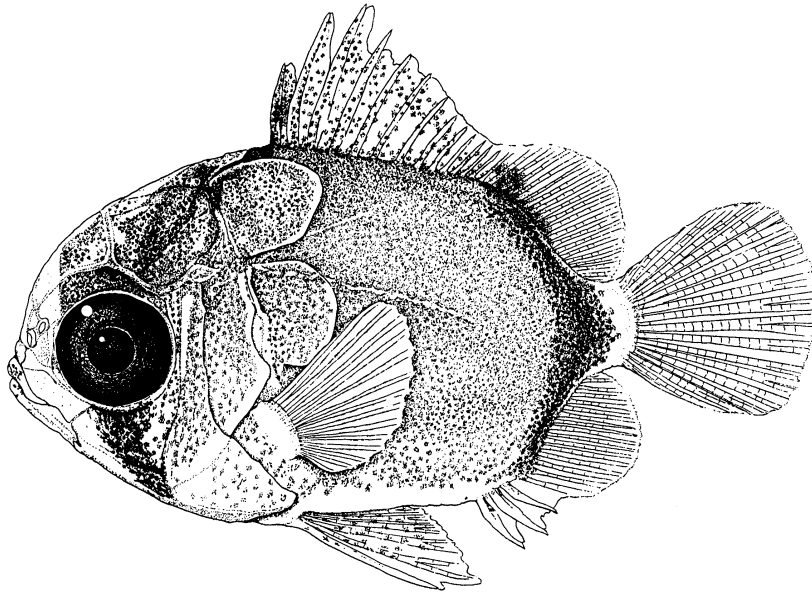
C. 50.0 mmSL



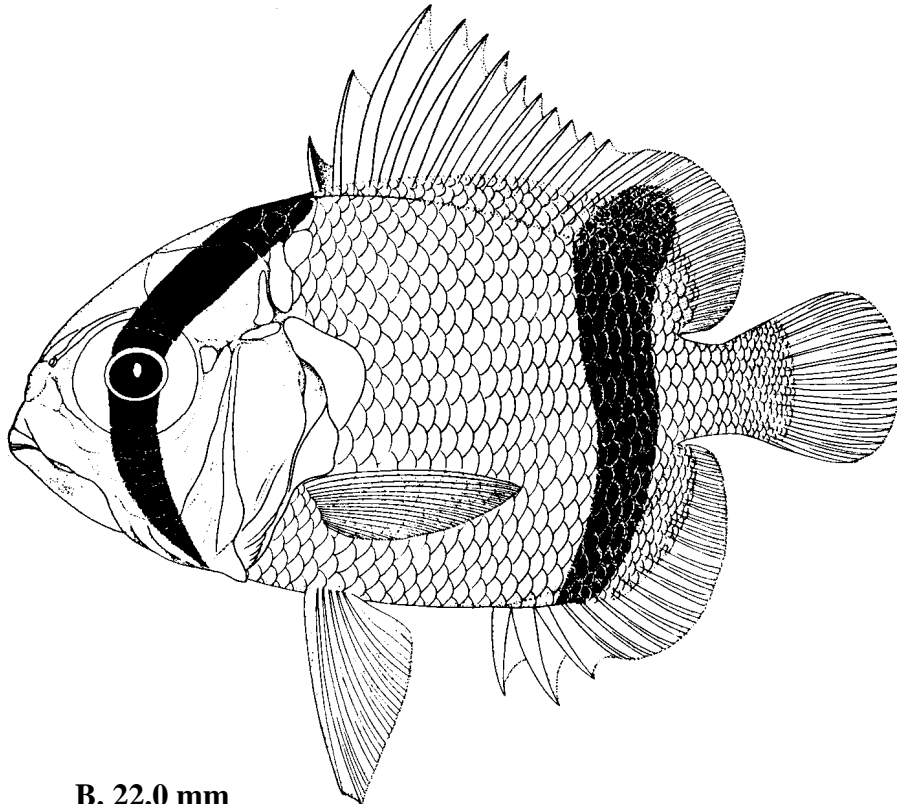
Figures: Adult: Jordan and Evermann, 1896–1900; A: Susan Kaiser (Able and Fahay, 1998); B: Fowler, 1945; C: Elizabeth Ray Peters (Fritzsche, 1978)

References: Moe, 1976; Suzuki *et al.*, 1980; Colin, 1989; M^cBride and Able, 1998; Able and Fahay, 1998; Leis and Rennis, 2004g

Chaetodon ocellatus



A. 13.8 mmSL



B. 22.0 mm

Chaetodipterus faber* (Broussonet, 1782)*Ephippidae**

Atlantic spadefish

Range: Western North Atlantic Ocean from Massachusetts to Brazil, including Gulf of Mexico; rare north of Chesapeake Bay

Habitat: Coastal waters near reefs, sandy beaches, wrecks, pilings, bridges; often in large schools; juveniles often occur in mangrove habitats

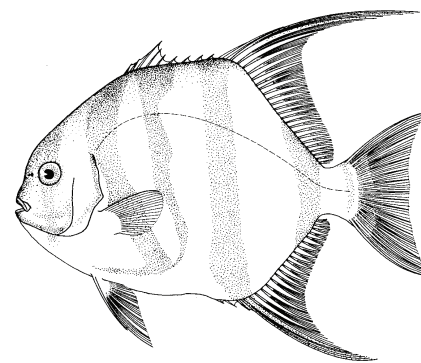
Spawning: May–Sep with peak in larval abundance Jun–Aug

Eggs:

- Pelagic, spherical
- Diameter: 1.0+ mm
- Oil globule: single

Larvae:

- Body initially elongate with bulky head and gut; body depth soon deepens considerably, anteriorly; later larvae disk-shaped
- Preanus length increases from 40% SL to 60% SL or more
- Head length about 35% SL >3.0 mm; snout blunt
- Large mouth reaches middle of eye
- Flexion occurs at 3.0–5.0 mmSL
- Sequence of fin ray formation: C – D, A – P₂ – P₁; all fin rays complete by 8.0–8.5 mmSL
- Head spines occur on many bones (see checklist below and Fig. G)
- Pigment begins anteriorly over much of body, head and opercle; becomes dense over most of body; later larvae darkly pigmented over head, body, D₁ and P₂ membranes and proximal parts of D₂ and A fins

**Meristic Characters**

Myomeres:	24
Vertebrae:	24
Dorsal fin rays:	IX, 21–23
Anal fin rays:	III, 17–18
Pectoral fin rays:	17–18
Pelvic fin rays:	I, 5
Caudal fin rays:	5 + 9 + 8 + 5
Supraneurals:	2 or 3 (pattern?)

Head Spine Checklist:

Supraoccipital: small, dorsally directed spine in small larvae

Preopercle: large spines along posterior edge, smaller spines on lateral ridge

Opercle: small, thin spine at upper angle

Posttemporal: spines and spiny ridges present

Interopercle: spine present, hidden by large preopercle angle spine

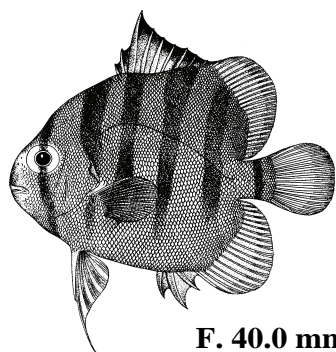
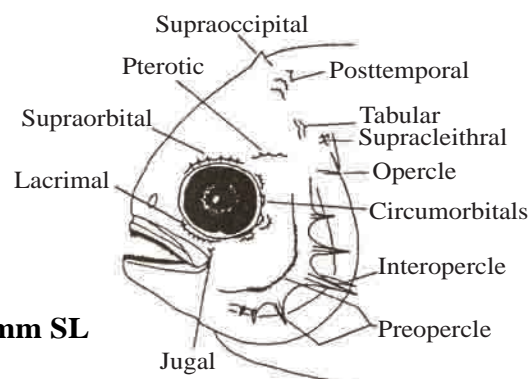
Tabular: spines present

Supracleithral: spines present

Pterotic: short, spiny ridge present

Supraorbital: spiny ridge present by 3.5 mm

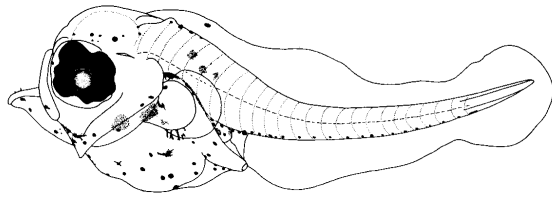
Circumorbitals (including Lacrimal): spiny ridges on all, downward projecting spine on 2nd (Jugal)

Early Juvenile:**F. 40.0 mm****G. 7.0 mm SL**

Figures: Adult: Burgess, 2002; A–E, G: Ditty *et al.*, 1993; F: Fowler, 1945

References: Ryder, 1887; Hildebrand and Cable, 1938; G. D. Johnson, 1978; 1984; Ditty *et al.*, 1993

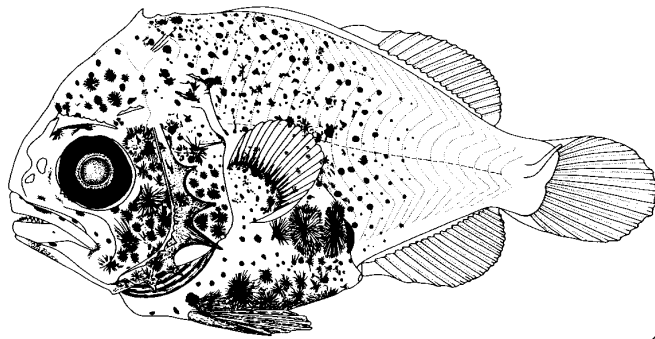
Chaetodipterus faber



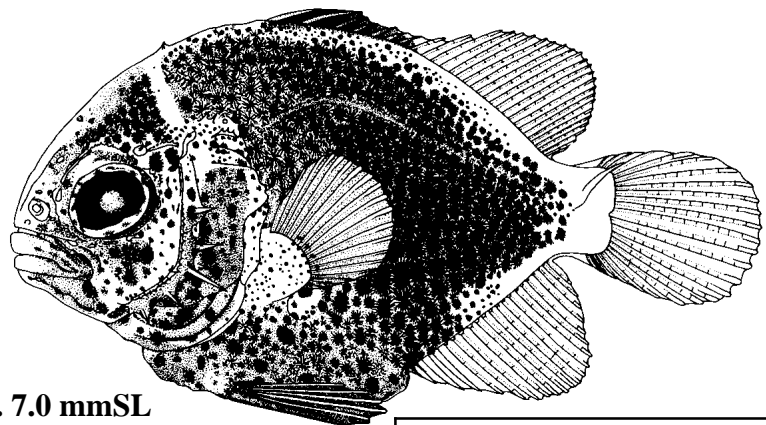
A. 1.8 mm



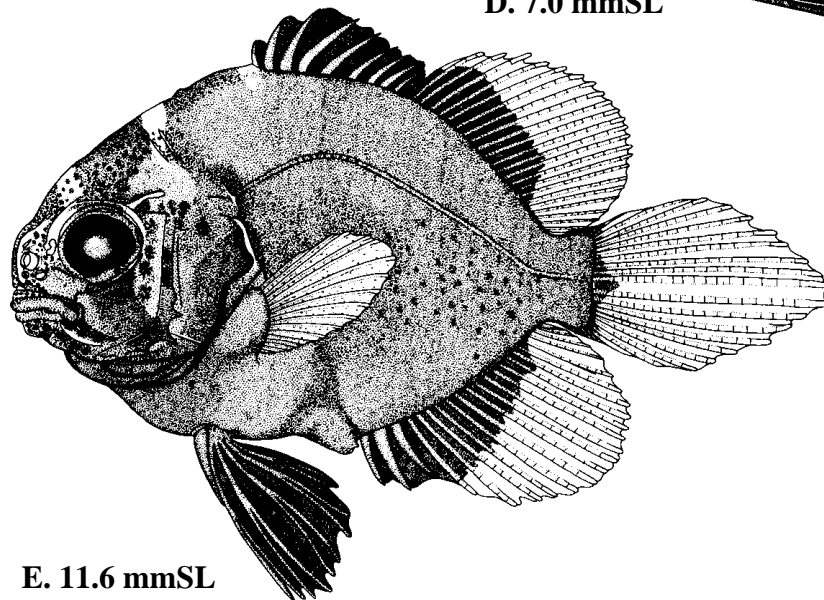
B. 3.5 mmSL



C. 5.0 mmSL



D. 7.0 mmSL



E. 11.6 mmSL

A series of early stages collected in the Gulf of Mexico and attributed to *Hyperoglyphe bythites* (Centrolophidae) (Dawson, 1971) probably refers to *Chaetodipterus faber* (Ditty et al., 1993). See discussion on *Hyperoglyphe perciformes* page

Luvarus imperialis* Rafinesque, 1810*Luvaridae****Louvar**

Range: Worldwide in temperate and tropical waters; in the western North Atlantic from southern New England to Gulf of Mexico; several records of larvae over continental slope in study area

Habitat: Epi- to mesopelagic in depths to 400 m

Spawning: Possibly summer (based on a single gravid female)

Eggs: – Undescribed

Larvae:

- Deep, especially head and anterior body
- Head blunt, preorbital length long, mouth very small
- Preanus length decreases from about 70% SL to 50% SL
- Flexion occurs at 4.0–5.0 mmSL
- Sequence of fin ray formation: P₁, P₂ – C, D – A (P₁ and P₂ early)
- Second and third D₁ and P₂ spines elongate and serrated
- Supernumerary fin rays present in dorsal and anal fins in early stages
- Head with many spines or serrated ridges; see checklist below
- Very small spines cover soft rays of all fins (>5.6 mmSL)
- Larval scales, with fan-shaped projections, cover body (Fig. G)
- Pigment light; few spots on caudal fin rays and base; few spots on bases of P₁, D₂ and A fins; light pigment on gut

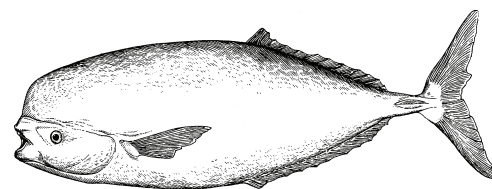
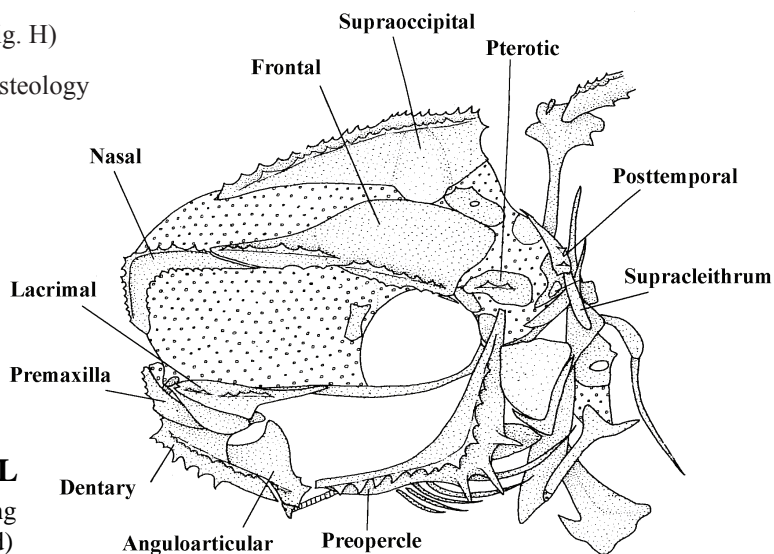
Note: 1. Compare head spination with that of closely related acanthurids. Both groups also have locking apparatus on anterior dorsal fin pterygiophores

Head Spine Checklist: Extensive spination (see Fig. H)

Early Juvenile: See Tyler *et al.*, 1989 for osteology of juvenile, 79.2 mmSL

Early stages, identified as "Hystricinella", "Astrodermella" or "Luvarella" have been illustrated by Roule, 1924 and Roule and Angel, 1930

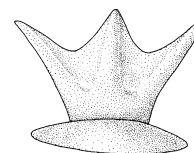
H. 10.5 mmSL
(Bones not bearing spines unlabeled)

**Meristic Characters**

Myomeres:	23
Vertebrae:	9+13 = 23
Dorsal fin rays:	II, 12–13 ¹
Anal fin rays:	13–14 ²
Pectoral fin rays:	17–20
Pelvic fin rays:	I, 4
Caudal fin rays:	7+8+8+8
Supraneurals:	2/1/1/ etc.

¹ up to 23 rays in early stages
² up to 18 rays in early stages

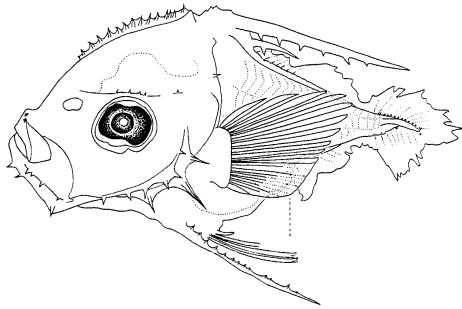
G. 10.5 mmSL
(Ventral View)



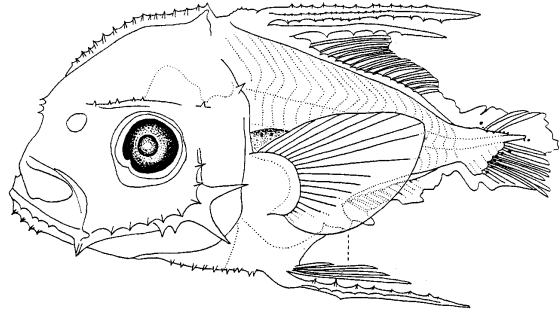
Figures: Adult: Gregory and Conrad, 1943; A–E: Nishikawa, 1987b; F: Blache, 1964 (redrawn); G–H: Johnson and Washington, 1987

References: Leis and Richards, 1984; Johnson and Washington, 1987; Nishikawa, 1987b; Tyler *et al.*, 1989; Moore *et al.*, 2003

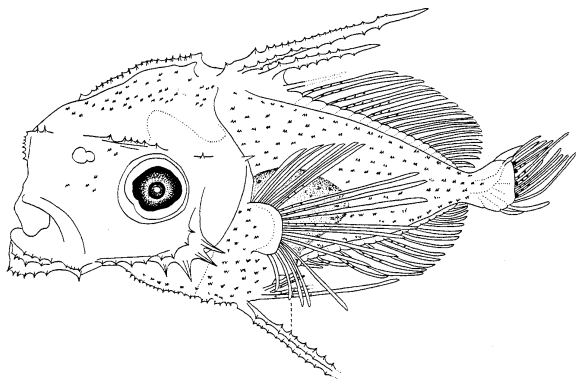
Luvarus imperialis



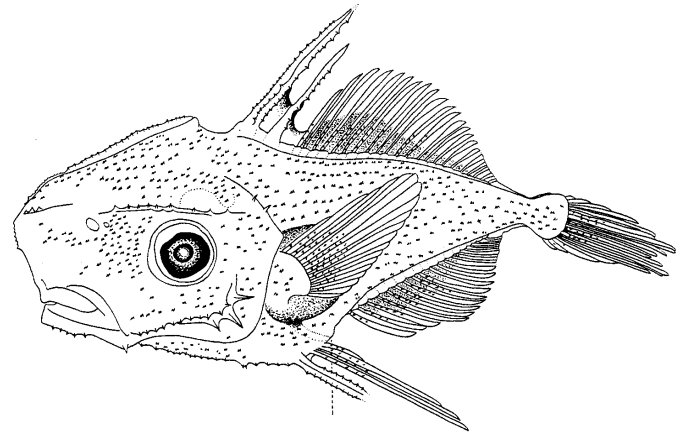
A. 3.5 mmSL



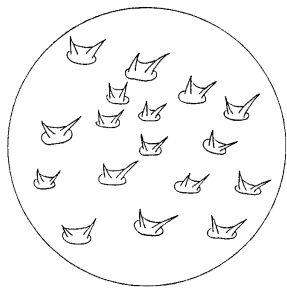
B. 4.6 mmSL



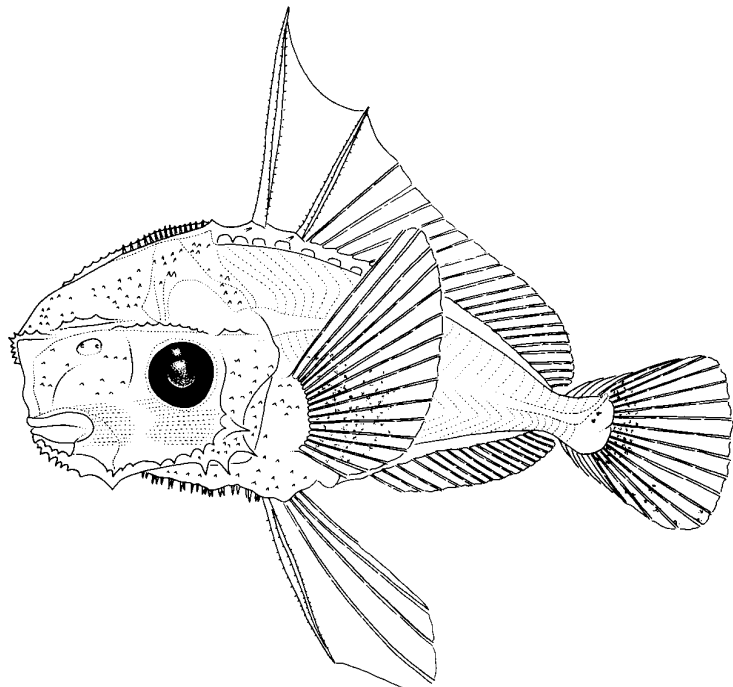
C. 6.9 mmSL



D. 10.7 mmSL



E. 10.7 mmSL: Larval scales on central body
Note horizontal, irregular scale orientation (vertical, ordered in rows in larval acanthurids)



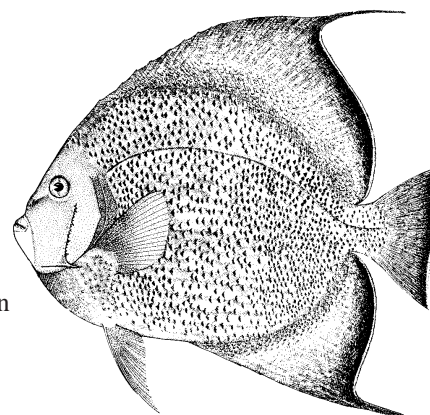
F. 11.5 mmSL

Pomacanthus arcuatus* (Linnaeus, 1758)*Pomacanthidae****Grey angelfish**

- Range:** Western North Atlantic Ocean from New York to Brazil; introduced in Bermuda; winters Florida and south
- Habitat:** Reefs and rocky substrates
- Spawning:** In pairs, probably winter, based on observations of spawning behavior in Puerto Rico

- Eggs:** – Pelagic, spherical
– Diameter: about 0.90 mm

- Larvae:** – Undescribed; notes below pertain to generalized pomacanthid development, largely based on *Centropyge* sp. larvae (Leis and Rennis, 2004d)
- Body moderately deep and laterally compressed in preflexion, deepens further in later stages until quite disk-shaped and very compressed laterally
 - Tip of notochord long and narrow in early larvae
 - Gut coils very early; preanus length >50% SL
 - Head moderate to large, deep, with short snout
 - Mouth small, in some species reaching only to middle of eye
 - Flexion occurs at 3.5–4.4 mmSL
 - Sequence of fin ray formation: C, D, A – P₁ – P₂
 - Prominent spines on several bones of the head; many form very early; see checklist below
 - Preopercle angle spine becomes smooth and elongate in postflexion larvae; retained in adults
 - Spinous scales cover body in larvae up to 19 mm; begin in preflexion on dorsal parts of body, spread to include top of head, gut, ventral part of tail; spinules cover entire head and body in postflexion stages; spinules gradually transform into scales as they spread, and then develop additional spines or ctenii resulting in a 'rough' body surface
 - Pigment varies in different species, but in general is relatively heavy

**Meristic Characters**

Myomeres:	24
Vertebrae:	10 + 14 = 24
Dorsal fin rays:	IX, 31–33
Anal fin rays:	III, 23–25
Pectoral fin rays:	19–20
Pelvic fin rays:	I, 5
Caudal fin rays:	4+9+8+3–4
Supraneurals:	0/0/2/1+1/
or:	0//2/1+1/

Head Spine Checklist:

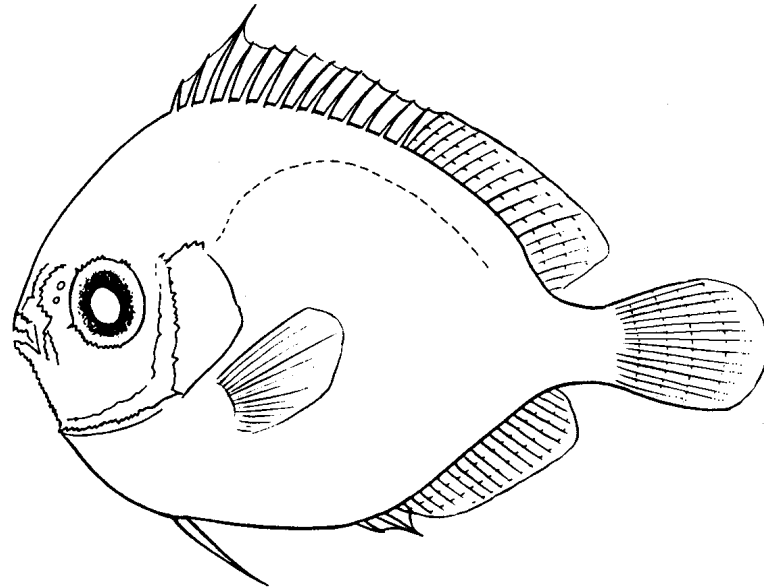
- Preopercle: early-forming, prominent spines on posterior edge and lateral ridge
- Posttemporal: small spines present
- Tabular: small spines present
- Supracleithral: small spines present
- Subopercle: few prominent spines
- Interopercle: small spines present
- Nasal: prominent spine present
- Dentary: spiny ridge present
- Supraorbital: spiny crest comprised of a few prominent spines
- Lacrimal: spiny ridge present

- Early Juvenile:** At settlement, body very deep, laterally compressed, with a narrow aural peduncle; head serrations become less conspicuous and lateral line forms a high arch

Figures: Adult: Burgess, 2002; **A:** Burgess, 1978; **B–C:** Leis and Rennis, 2004d

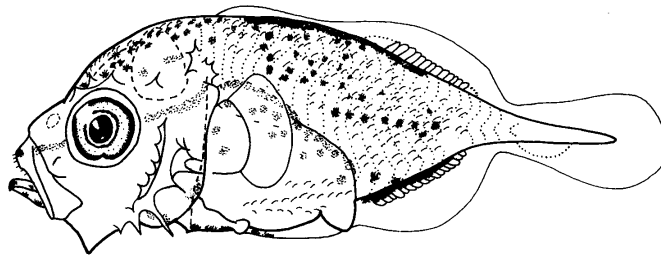
References: Moe, 1976; 1977; Thresher, 1982; 1984; G. D. Johnson, 1984; Colin and Clavijo, 1988; Leis and Rennis, 2004d

Pomacanthus arcuatus



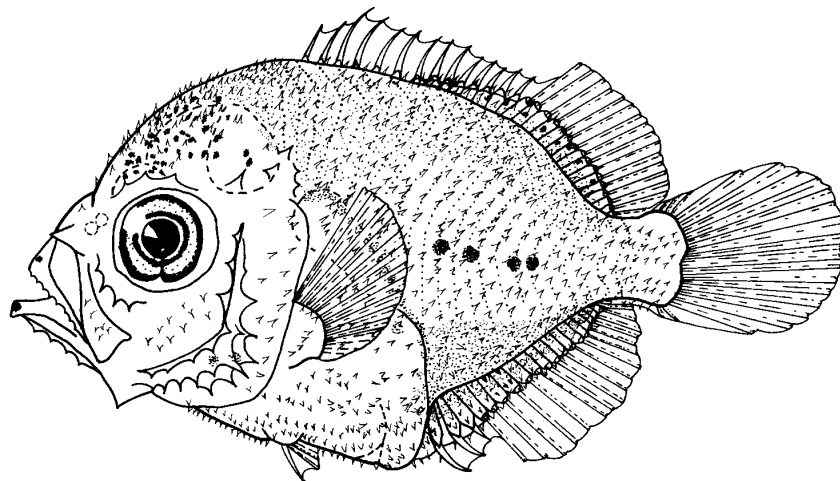
A. 12.0 mm (generalized pomacanthid larva)

Larvae of Chaetodontidae are less laterally compressed and lack the over-all covering of short spinules.



B. 3.7 mmSL (*Centropyge* sp.)

Larvae of Carangidae are less laterally compressed, are more lightly pigmented, have a supraoccipital crest, and lack short spinules covering the body



C. 4.4 mmSL (*Centropyge* sp.)