

Perciformes

Suborders Mugiloidei, Polynemoidei, Labroidei

Selected meristic characters in species belonging to the suborders Mugiloidei, Polynemoidei and Labroidei whose adults or larvae have been collected in the study area. Classification sequence follows Eschmeyer, 1990, except for the inclusion of Pomacentridae in the Labroidei (Kaufman and Leim, 1982). Some recent authors (e.g. Harrison, 2002; Leis and Carson-Ewart, 2004) have considered the Mugiliformes as a separate order from the perciforms (see comments on opposite page). PrC = principal caudal fin rays. Sources: Martin and Drewry, 1978; Richards and Leis, 1984; Feltes, 2002

Suborder					
Family					
Species	Vertebrae	Dorsal Fin	Anal Fin	Caudal Fin	Pectoral Fin
Mugiloidei					
Mugilidae					
<i>Mugil cephalus</i>	11+13=24	IV, I, 8	III, 8	7–8+7+7+7–8	15–18
<i>Mugil curema</i>	11+13=24	IV, I, 8	III, 9	7–8+7+7+7–8	15–18
Polynemoidei					
Polynemidae					
<i>Polydactylus octonemus</i>	10+14=24	VII, I, 11–13	III, 12–14	12–13+9+8+12–13	17+8 ¹
<i>Polydactylus virginicus</i>	10+14=24	VIII, I, 11–12	III, 11–14	12–13+9+8+12–13	15+7 ¹
Labroidei					
Labridae					
<i>Decodon puellaris</i>	12+16=28	XI, 10	III, 10	10–11+7+7+10–11	16
<i>Doratonotus megalepis</i>	9+16=25	IX, 10	III, 9	7+7 PrC	11–12
<i>Halichoeres</i> sp. ²	10+15=25	IX, 11–12	III, 11–12	6–7+7+7+6	12–15
<i>Lachnolaimus maximus</i>	12–13+17=29–30	XIV, 11–12	III, 10–11	6–7+7+7+6–7	15–16
<i>Tautoga onitis</i>	17+18=35	XVII, 11	III, 8	8+7+7+6	16
<i>Tautogolabrus adspersus</i>	17+19=36	XVIII, 9–10	III, 8–9	8+7 PrC	16
<i>Thallosoma bifasciatum</i>	11+14=25	VIII, 12–13	III, 10–11	6+7+7+5	14–15
<i>Xyrichtys novacula</i>	9+16=25	VIII–IX, 12–13	III, 12	4–5+7+7+3–4	12
Scaridae					
<i>Nicholsina usta</i>	25	IX, 10	III, 8–9	7–8+7+6+6–7	13–17
<i>Scarus coeruleus</i>	25	IX, 10	III, 8–9	7+6 PrC	13–17
<i>Scarus iseri</i>	10+15=25	IX, 10	III, 9	6–7+7+6+6–7	13–17
<i>Sparisoma rubripinne</i>	10+15=25	IX, 10	III, 8–9	7–8+7+6+6–7	13–17
Pomacentridae					
<i>Abudefduf saxatilis</i>	11+15=26	XIII, 13	II, 12	6+9+8+5–6	16–20

¹ Number of simple fin rays + separated pectoral filaments

² Five species reach their northern limit off North Carolina, south of the study area: *Halichoeres bathyphilus*, *H. bivittatus*, *H. caudalis*, *H. maculipinna* and *H. radiatus*.

Perciformes

Suborders Mugiloidei, Polynemoidei, Labroidei

Mugiloidei

It is not generally agreed that the Mugiloidei constitutes a suborder of the Perciformes. Considerable evidence suggests a relationship with atheriniforms, gasterosteiforms or a few other groups (Stiassny, 1990; 1993; Johnson and Patterson, 1993), but these relationships are not yet well-demonstrated (Parenti and Song, 1996). Except for their heavy, bulky guts, the larvae of Mugilidae exhibit no specialized characters. For the interim, fishes in the group meet the simplest perciform tests: presence of spines in the dorsal and anal fins, 1 spine and 5 or fewer rays in the pelvic fin, lack of an adipose fin, presence of 17 or fewer principal caudal rays arranged on 5 or fewer hypural bones (plus the parahypural), presence of 7 or fewer branchiostegal rays and 4 gill arches. The inclusion of mugiloids as a perciform suborder follows Eschmeyer (1990) but this arrangement should be regarded as provisional pending future analysis.

Spawning of *Mugil cephalus* and *M. curema* occurs south of the study area and neither eggs nor larvae have been collected north of 35°N. Pelagic-juveniles, however, occur commonly in neuston samples taken over deep continental shelf or slope locations. Young-of-the-year use study-area estuarine habitats as nurseries, then emigrate offshore and south in the fall (usually October). There is no evidence that subsequent year-classes return to the study area.

Polynemoidei

Although this group is treated here as a perciform suborder, following Eschmeyer (1990), some authors (e.g. Johnson and Patterson, 1993; Leis and Carson-Ewart, 2004) have proposed or supported a superfamily Polynemoidea (including Polynemidae and Sciaenidae) based on adult osteology, characters of the sensory canal, and general resemblance of the larvae, first observed by de Sylva (1984c). Larvae of the 2 polynemid species that occur in the study area are undescribed. Larvae of congeners have been described and illustrated (Okiyama, 1988; Sandknop and Watson, 1996e; Leis and Trnski, 2004c) as have those of *Galeoides polydactylus* (Aboussouan, 1966b). See Motomura (2004) for classification of the family.

Labroidei

The suborder Labroidei includes the wrasses (Labridae), parrot fishes (Scaridae) and damselfishes (Pomacentridae). They are among the most abundant and conspicuous coral-reef fishes, and their larvae are readily recognizable. Larvae of typical, tropical, labroid species occur in the study area only after advection via the Gulf Stream, although two "northern" labrid species are common residents of inner continental shelf or coastal regions. It is widely accepted that the Labridae and Scaridae (plus the extralimital Odacidae) comprise a monophyletic assemblage, and merging them into a single family is often discussed, or followed, by some authors (Gomon and Russell, 1981; Stiassny and Jensen, 1987; Webb, 1990; Parenti and Randall, 2000). However, monophyly has yet to be established for several proposed subfamilies or tribes within these groups (Westneat, 1993; Nelson, 1994).

Labrids occur in all oceans of the world, and have been estimated as being the third largest family of fishes, with just under 500 species. Most are found in the Indo-Pacific region. In the North Atlantic Ocean, there are measurable differences between larvae of tropical and "northern" species. Those species occurring commonly in the study area (and in the northeast Atlantic as well) have larvae that are typically more heavily pigmented than tropical ones (e.g. Fives, 1976.) Most tropical labrid larvae are laterally compressed, have deep caudal peduncles, small mouths and light, or no, pigment. Body shapes and subtle pigment patterns differ between genera (see Victor (1987) for illustrations). The Labridae and Scaridae are closely related, and scarids can be thought of as specialized labrids in which the teeth are fused into plates. Scarid larvae are characterized by a series of melanophores along the base of the anal fin and another one just behind the anus. The eye is typically elliptical or rectangular. They also have characteristic series of small erythrophores above the anal fin and along the lateral midline.

The Pomacentridae were recently re-classified from Percoidei to Labroidei, based largely on pharyngeal anatomy (Kaufman and Leim, 1982). Pomacentrid larvae have a different body form, and are more heavily pigmented, than larvae of other labroids. They more closely resemble larvae of percoids. *Abudefduf* larvae from the Great Barrier Reef (and western Atlantic) have been described as having early-forming dorsal spines and pelvic rays (Kavanaugh, *et al.*, 2004), whereas larvae in other genera have later forming dorsal spines (see Paris-Lamouzy *et al.*, 2006).

Mugil cephalus* Linnaeus, 1758*Mugilidae****Striped mullet**

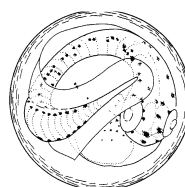
Range: Worldwide in temperate and tropical waters, less common in tropics; in the western Atlantic from Maine to Argentina, including Gulf of Mexico; a single juvenile report from Nova Scotia; juveniles reported from Canadian waters are most likely *Mugil curema* (Gilhen, 1972)

Habitat: Coastal ocean, estuaries, bays, lagoons and rivers; early juveniles strongly pelagic, neustonic; later juveniles common in most study area estuaries (in the U.S.), often in oligohaline or freshwater habitats

Spawning: Oct–Feb, peak Jan–Apr; outer continental shelf off southeastern U.S.; neither eggs nor larvae have been reported from study area

Eggs:

- Pelagic, spherical, straw-colored
- Diameter: 0.88–0.99 mm
- Chorion: smooth, fine raised striations
- Yolk: homogeneous
- Oil globule: single, 0.30–0.36 mm in diameter
- Perivitelline space: narrow

**Meristic Characters**

Myomeres:	24
Vertebrae:	11 + 13 = 24
Dorsal fin rays:	IV, I, 8
Anal fin rays:	III, 8
Pectoral fin rays:	15–18
Pelvic fin rays:	I, 5
Caudal fin rays:	7–8+7+7+7–8



Yolk-sac larva

Larvae:

- Body relatively stubby with large, bulky gut, moderate head, small mouth
- Preanus length up to 70% SL
- Flexion occurs at about 4.0–5.0 mmSL
- Sequence of fin ray formation: C – D₂, A – D₁ – P₂ – P₁
- Two dorsal fins short-based, well separated; P₁ fins high on body (noticeable early)
- Head spines lacking or very weakly developed; see checklist below
- Pigment heaviest on dorsum from head to insertion of D₂; dorsal surface of gut darkly pigmented; venter pigmented from anus to caudal fin base; see comments below re: juvenile pigment

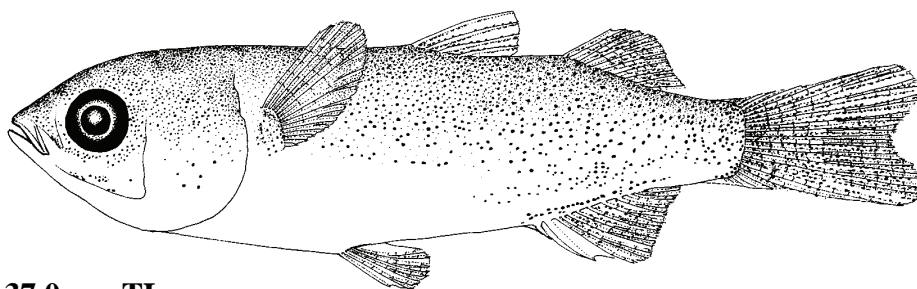
Head spine checklist:

Preopercle: very weak spines possible along edge

Note: 1. Anal fin formula II, 9 in young stages; 1st fin ray transforms into spine at about 30–40 mmTL resulting in formula of III, 8 in adults

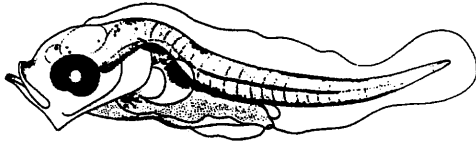
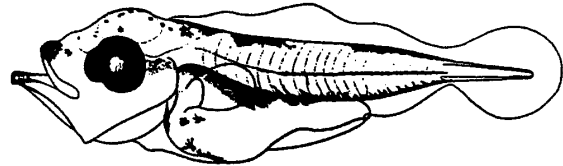
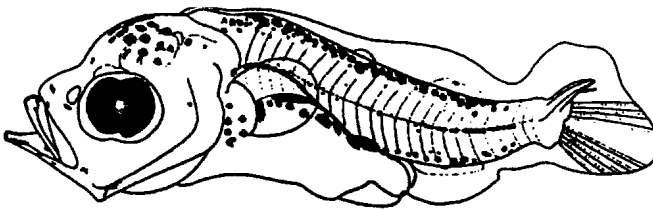
Early Juvenile:

Also known as "querimana" stage, with flat sides and silvery coloration with dark blue dorsum

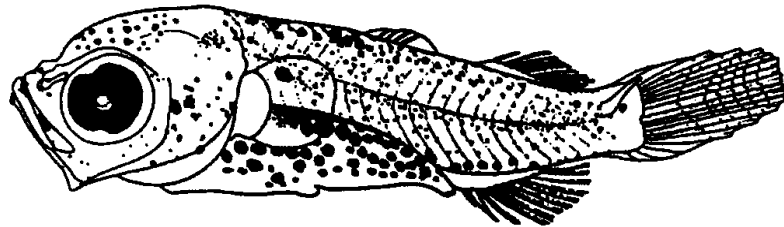
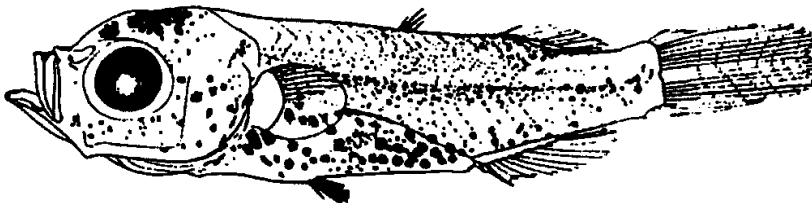
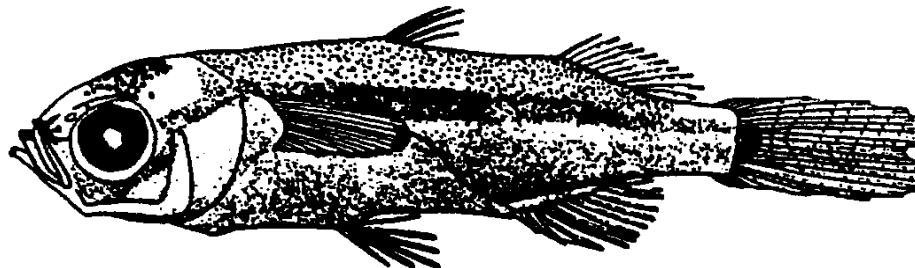
**G. 37.0 mmTL**

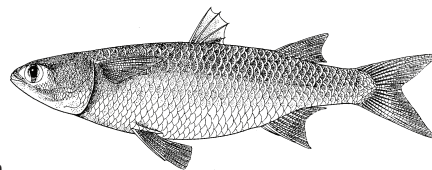
Figures: Adult: Harrison, 2002; Egg: Henry Orr (Matarese and Sandknop, 1984); Yolk-sac larva and A–F: Jack Javech (Ditty *et al.*, 2000); G: Nancy Arthur (Able and Fahay, 1998)

References: Anderson, 1958; Gilhen, 1972; Powles, 1981; Scott and Scott, 1988; Able and Fahay, 1998; Collins and Stender, 1989; Harrison, 2002

Mugil cephalus**A. 2.5 mmSL****B. 3.0 mmSL****C. 4.0 mmSL**

Early stages have a dark line of pigment including internal pigment under the brain, behind the eye, dark peritoneal pigment, and dense melanophores along venter of tail

**D. 5.5 mmSL****E. 7.0 mmSL****F. 10.8 mmSL**

Mugil curema* Valenciennes, 1836*Mugilidae****White mullet**

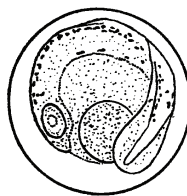
Range: Western and eastern Atlantic Ocean; in the western North Atlantic from Nova Scotia to Brazil; juvenile *Mugil* from Canadian waters are likely to be this species

Habitat: Coastal ocean and estuarine waters; usually not in freshwater habitats; early juveniles strongly pelagic, neustonic; later juveniles fairly common in most study area estuaries, most often in meso- or polyhaline habitats

Spawning: Feb–Oct, peak Apr–Jun; outer continental shelf off southeastern U.S.; neither eggs nor larvae have been collected in study area

Eggs:

- Pelagic, spherical
- Diameter: 0.86–0.92 mm
- Chorion: finely etched
- Yolk: homogeneous
- Oil globule: single, 0.03 mm in diameter
- Perivitelline space: very narrow

**Meristic Characters**

Myomeres:	24
Vertebrae:	11 + 13 = 24
Dorsal fin rays:	IV, I, 8
Anal fin rays:	III, 9
Pectoral fin rays:	15–18
Pelvic fin rays:	I, 5
Caudal fin rays:	7–8+7+7+7–8

Larvae:

- Body relatively stubby, with large, bulky gut, moderate head, small mouth
- Preanus length up to 70% SL
- Flexion occurs at about 4.0–5.0 mmSL
- Sequence of fin ray formation: C – D₂, A – D₁ – P₂ – P₁
- Two dorsal fins short-based, well separated; P₁ fins high on body (noticeable early)
- Head spines lacking or very weakly developed; see checklist below
- Pigment heaviest on top of head and dorsum from nape to insertion of D₂; dorsal surface of gut darkly pigmented; venter pigmented from anus to caudal fin base; postflexion larvae are dark over most of body; see comments below regarding juvenile pigment

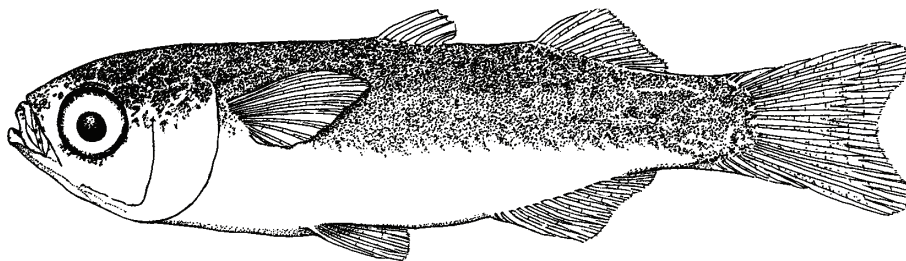
Head spine checklist:

Preopercle: very weak spines possible along edge

Note: 1. Anal fin formula II, 10 in young stages; 1st fin ray transforms into spine at about 30–40 mmTL, resulting in formula of III, 9 in adults

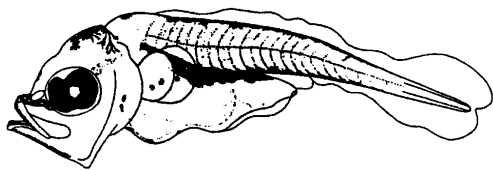
Early Juvenile:

Also known as "querimana" stage, with flat sides and silvery coloration with dark blue dorsum

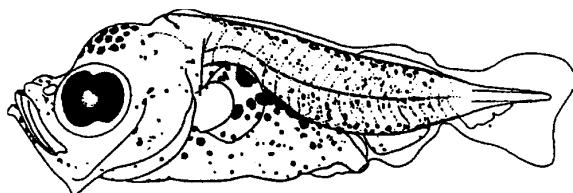
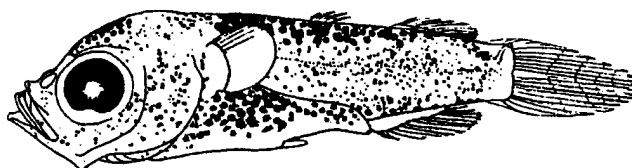
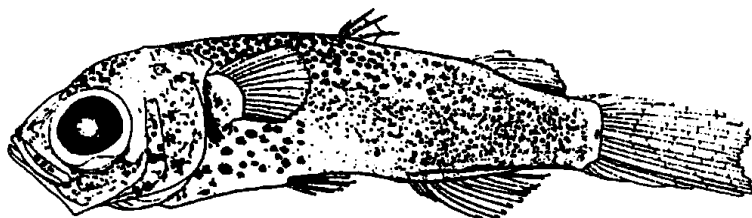
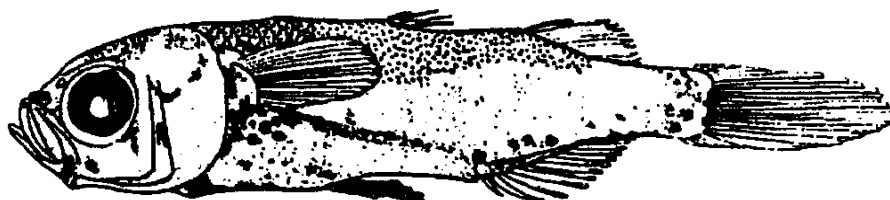
**F. 24.2 mmSL**

Figures: Adult: Harrison, 2002; Egg: Anderson, 1957; A–E: Jack Javech (Ditty *et al.*, 2000); F: Susan Kaiser (Able and Fahay, 1998)

References: Anderson, 1957; Gilhen, 1972; Powles, 1981; Scott and Scott, 1988; Collins and Stender, 1989; Able and Fahay, 1998; Harrison, 2002

Mugil curema**A. 3.4 mmSL**

Early stages have a dark line of pigment including internal pigment under the brain, behind the eye, dark peritoneal pigment, and dense melanophores along venter of tail

**B. 4.0 mmSL****C. 5.3 mmSL****D. 7.0 mmSL****E. 10.3 mmSL**

Polydactylus* sp.*Polynemidae****Threadfins**

Range: *Polydactylus octonemus* (Girard, 1858) occurs around Florida and Gulf of Mexico, rarely along east coast of the U.S. as far north as Long Island; *P. virginicus* (Linnaeus, 1758) occurs from New Jersey to Brazil, not including Gulf of Mexico except off Yucatán

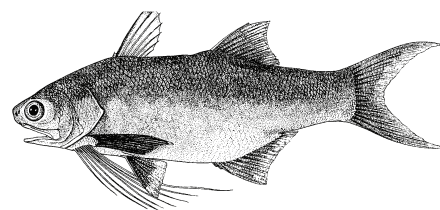
Habitat: Coastal, usually shallow waters over sand or mud substrates, often in surf zone, commonly in estuaries; young stages pelagic

Spawning: *Polydactylus octonemus* Dec–Mar (Texas and Louisiana); larvae occur well offshore. *P. virginicus* probably year-round, based on continuous presence of juveniles, often near river mouths

Eggs: – Undescribed

Larvae:

- Generalizations below largely based on extralimital material (see "References" below for sources) and Hillen and Ditty (2006)
- Body moderately long, with large, bulbous head, long caudal peduncle, voluminous gut and short preanus length
- Mouth initially moderate, becomes inferior and large, extending well beyond eye; teeth very early forming
- Flexion occurs at 3.5–4.5 mm
- Sequence of fin ray formation: C – D₂, A – D₁, P₁ – P₂
- Pectoral fin rays separate into 2 groups; lower group filamentous
- Pelvic fins originate well posterior to level of pectoral fins, closer to anus; migrate anteriorly at transformation
- Two dorsal fins short-based, initially close together, then widely separated
- D₂ and A fins have about same number of fin rays
- Head spines absent or very weak; see checklist below
- Pigmentation generally light with few, distinct melanophores in preflexion stages, becoming heavy in postflexion stages; in several species, melanophores along venter become fewer during development; an unpigmented patch near terminus of anus typical in many species; very distinct patterns that change during development characterize species

*Polydactylus octonemus***Meristic Characters**

(Total range in 2 species)

Myomeres: 24

Vertebrae: 10 + 14 = 24

Dorsal fin rays: VII–VIII, I, 11–13

Anal fin rays: III, 11–14

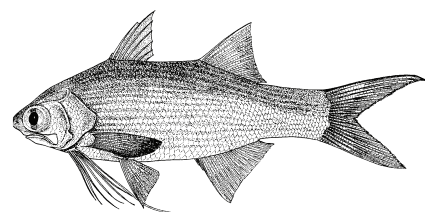
Pectoral fin rays: 15–17 + 7–8 free

Pelvic fin rays: I, 5

Caudal fin rays: 12–13+9+8+12–13

Supraneurals: 0/0/2/1+1/1 etc

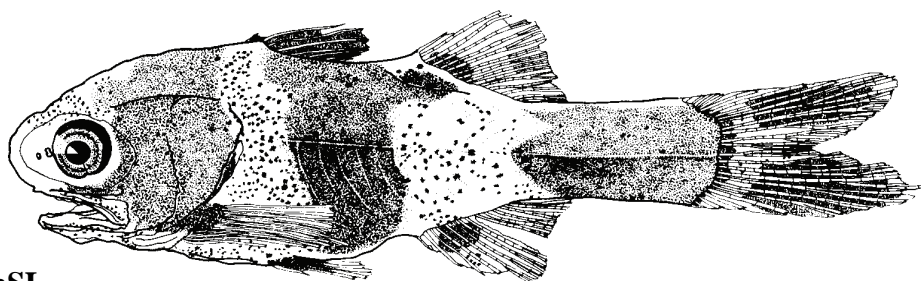
or: 0/0/0+2/1+1/1 etc

*Polydactylus virginicus***Head spine checklist:**

Preopercle: absent in most; tiny spines on edge, more rarely on lateral ridge in a few extralimital species

Early Juvenile:

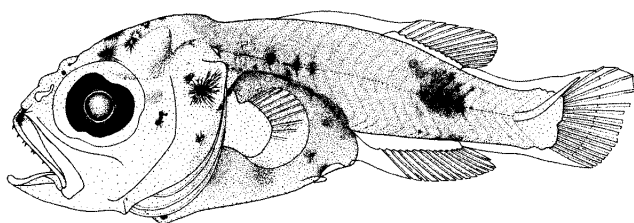
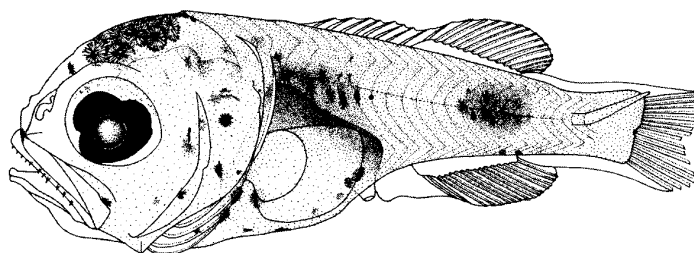
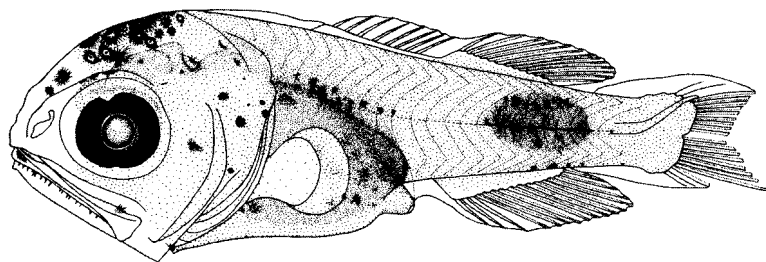
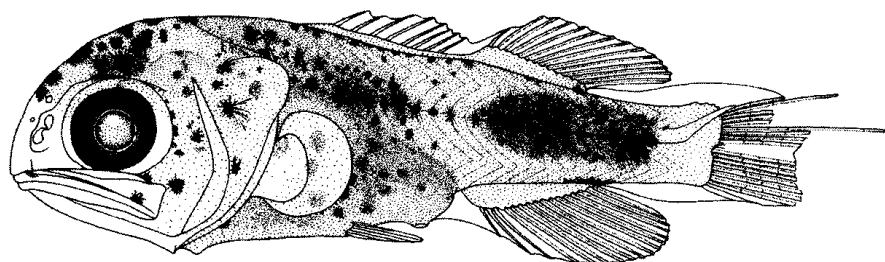
Body shape and fin placement superficially similar to apogonids

**F. 26.5 mmSL***(Polydactylus sexfilis)*

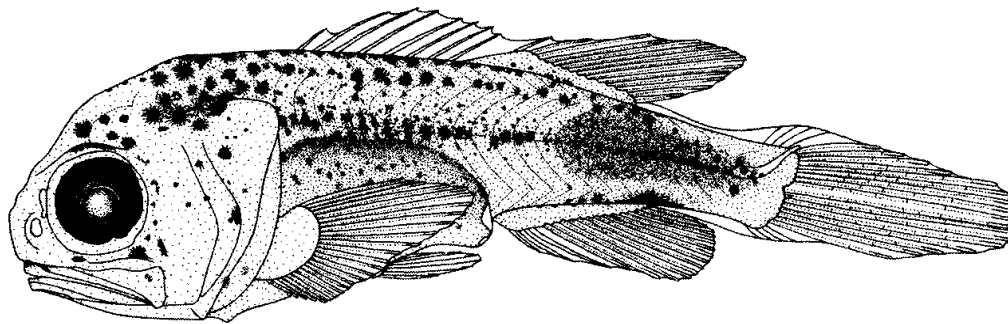
Indo-Pacific)

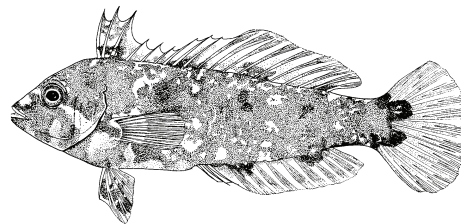
Figures: Adults: Feltes, 2002; A–E: Jack Javech (Hillen and Ditty, 2006); F: S. F. Lu *In*: Okiyama, 1988

References: Aboussouan, 1966b; de Sylva, 1984b; S.F. Lu *In*: Okiyama, 1988; Sandknop and Watson, 1996e; Feltes, 2002; Leis and Trnski, 2004c; Hillen and Ditty, 2006

Polydactylus octonemus**A. 5.0 mmSL****B. 5.5 mmSL****C. 6.0 mmSL****D. 7.7 mmSL**

Larvae in Fig. A-D
identified only to
Polydactylus sp.
Pectoral fin ray
count necessary for
specific
identification

**E. 9.2 mmSL**

Doratonotus megalepis* Günther, 1862*Labridae****Dwarf wrasse**

Range: Eastern and western Atlantic Ocean; in the western North Atlantic from Bermuda, Florida Keys and margin of Caribbean Sea; larvae have been collected in the study area (Slope Sea), probably transported north by the Gulf Stream

Habitat: Shallow sea grass beds in depths to 15 m

Spawning: Undescribed

Eggs: – Undescribed

Larvae:

- Body elongate, laterally compressed, dorsal and ventral margins almost parallel, caudal peduncle deep
- Head small, with moderately pointed snout
- Mouth small, ending well short of anterior edge of eye
- Eye nearly round
- Preanus length <60% SL
- Flexion occurs at about 3.0 mmSL
- Sequence of fin ray formation: C – D, A – P₁ – P₂
- Pectoral fin base low, below midpoint of body depth
- Pigment light or absent (see note box on opposite page)

Meristic Characters

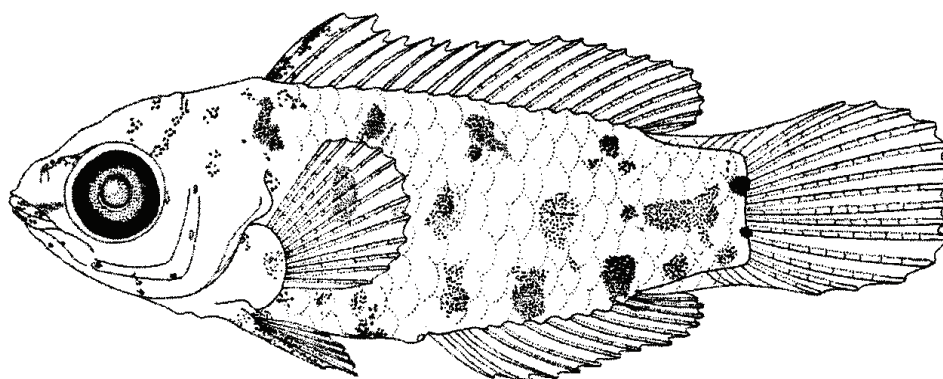
Myomeres:	25
Vertebrae:	9 + 16 = 25
Dorsal fin rays:	IX, 10
Anal fin rays:	III, 9
Pectoral fin rays:	11–12
Pelvic fin rays:	I, 5
Caudal fin rays:	7+7 PrC

Head spine checklist: None

Note:

1. Distinguish from postflexion stage *Halichoeres* sp. by anal fin ray count
2. All stages have patch of thickened, white tissue on both margins of caudal peduncle

Early Juvenile:

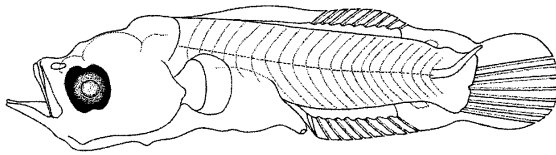
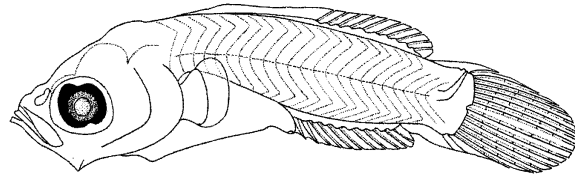
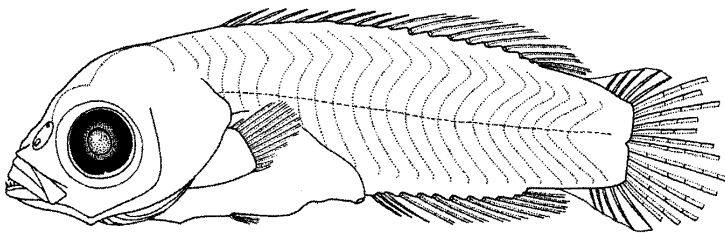
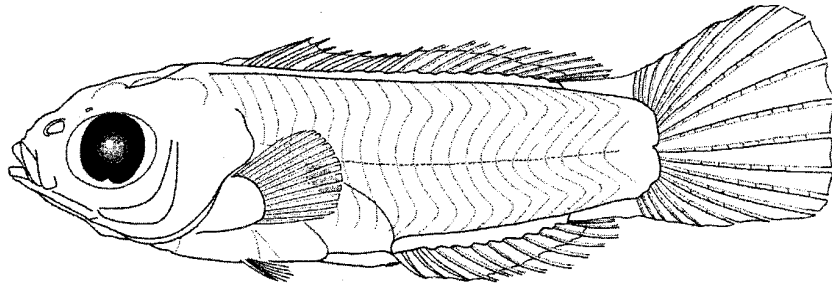


E. 8.8 mmSL

Larvae planktonic for 20–24 days in water column before settlement to bottom; size at settlement is probably about 7.5 mmSL (see note box on opposite page)

Figures: Adult: Westneat, 2002a; A–C, E: Jack Javech (Jones *et al.*, 2006a); D: Jack Javech (Richards, 1990)

References: Richards and Leis, 1984; Victor, 1986a; 1986b; Richards, 1990; Hare *et al.*, 2001; Westneat, 2002a; Jones *et al.*, 2006a

Doratonotus megalepis**A. 3.0 mmSL****B. 3.8 mmSL****C. 6.8 mmSL****D. 7.5 mmSL**

Notes on 2 larvae (USNM 353880 and USNM 353543), both 7.5 mmSL, represented by photographs on website <http://www.nmnh.si.edu/vert/fishes/larval/labroi.html>
Larval Fishes from Carrie Bow Cay, Belize; National Museum of Natural History, Department of Systematic Biology. (Vertebrae in these 2 larvae 22–24.)

Both larvae are characterized by a broad, reddish pigment bar crossing the mid-point of the tail; more red pigment is present behind the head and on the venter of gut and throat; the only melanophores present are dorsal to the posterior gut. The second larva shown, although the same length as the first, is beginning transformation to the juvenile stage and the adult pigment pattern is developing on the head. After preservation, the red pigment will be lost. Therefore, preserved larvae of this species are unpigmented or have, at most, a few melanophores over the posterior portion of the gut.

Although the lengths of these larvae (7.5 mmSL) coincide with that of the above illustrated larva (Fig. D), they are three separate specimens. This is a probable demonstration of the capability of larval labrids to delay transformation, and temporarily suspend growth, until suitable settlement habitat is encountered. See Victor (1986b) for more information on the settlement process in the related labrid species *Thalassoma bifasciatum*.

Halichoeres sp. Labridae

Range: 5 species reach northern limit off North Carolina (*Halichoeres bathyphilus*, *H. bivittatus*, *H. caudalis*, *H. maculipinna* and *H. radiatus*); larvae (species undetermined) have been collected in study area, especially in waters associated with Slope Sea, Gulf Stream or warm-core rings

Habitat: Ranges from coral or rocky reefs to seagrass beds

Spawning: Undescribed

Eggs: – Undescribed

Larvae:

- Body elongate, laterally compressed, deepest through pectoral region, caudal peduncle deep
- Head small, with moderately pointed snout
- Mouth small, not reaching anterior edge of eye
- Eye round
- Preanus length about 60% SL
- Flexion occurs at unknown size
- Sequence of fin ray formation: C – D, A – P₁ – P₂; pelvic fin rays late-forming
- Pectoral fin base low, below mid-point of body depth
- Pigment very light; a melanophore on dorsum of gut near anus in larval *H. maculipinna*; blotches of pigment on D and A fins in larval *H. bivittatus*; other pigment lacking

Meristic Characters

(ranges in 5 species)

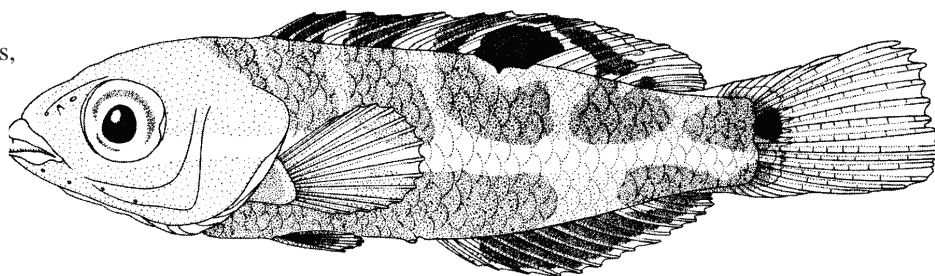
Myomeres:	25
Vertebrae:	10 + 15 = 25
Dorsal fin rays:	IX, 11–12
Anal fin rays:	III, 11–12
Pectoral fin rays:	12–15
Pelvic fin rays:	I, 5
Caudal fin rays:	6–7+7+7+6

Head spine checklist: None

Note: 1. Larval series for several species of Pacific Ocean *Halichoeres* are illustrated and described in Okiyama (1988) and Watson (1996x)

Early Juvenile:

Juveniles acquire characteristic pigment patterns consisting of bars, stripes, or bold spots



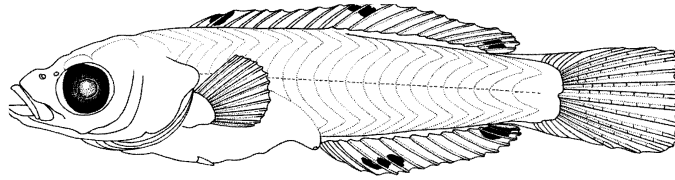
E. 17.0 mmSL (*Halichoeres radiatus*)

Larvae planktonic for at least 22 days in water column before settlement to bottom; upper limit of larval duration ranges from 26–31 days in 5 species; size at settlement <15.0 mmSL; larvae bury on settlement, emerge days later exhibiting juvenile pigmentation

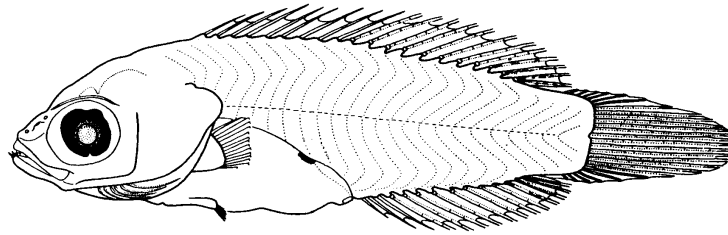
Figures: Adult *H. bivittatus*: Westneat, 2002a; **A, E:** Jack Javech (Jones *et al.*, 2006a); **B:** Jack Javech (Richards, 1990); **C, D:** R. Estrada (Jones *et al.*, 2006a)

References: Randall and Böhlke, 1965; Richards and Leis, 1984; Victor 1986a; 1986b; Richards, 1990; Sponaugle and Cowen, 1997; Hare *et al.*, 2001; Westneat, 2002a; Jones *et al.*, 2006a

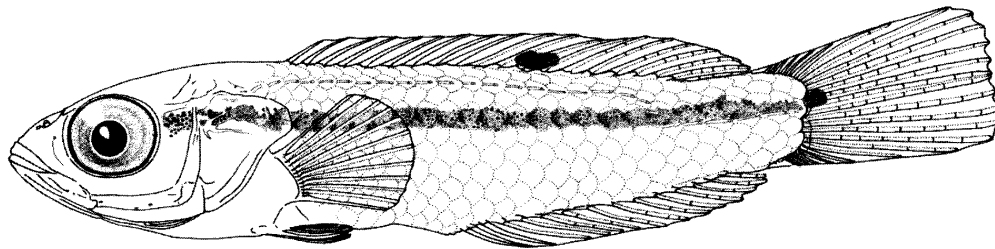
Halichoeres sp.



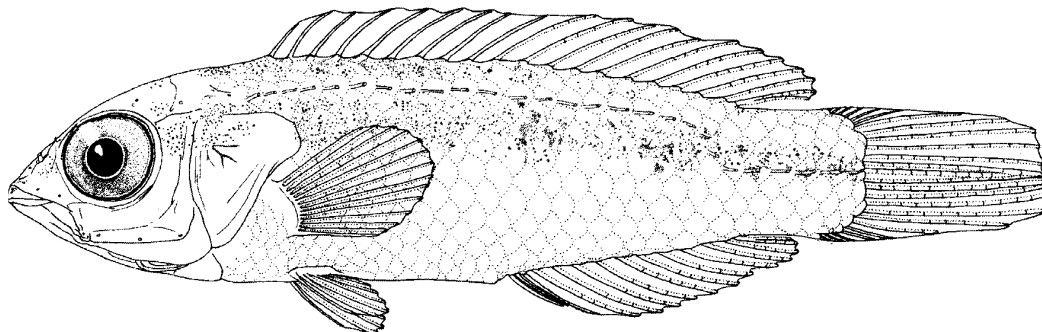
A. 11.0 mmSL (*Halichoeres bivittatus*)



B. 11.3 mmSL (*Halichoeres maculipinna*)



C. 14.2 mmSL (*Halichoeres bivittatus*)



D. 15.6 mmSL (*Halichoeres maculipinna*)

Lachnolaimus maximus* (Walbaum, 1792)*Labridae****Hogfish**

Range: Western North Atlantic Ocean from North Carolina and Bermuda to northern coast of South America, including Gulf of Mexico and Caribbean Sea; juveniles and adults 2–75 cm have been collected in southern part of study area by NMFS bottom trawl survey (as far north as vicinity of Veatch Canyon); reports of occurrences off Nova Scotia require confirmation

Habitat: Hard substrates such as coral reefs, rocky ledges, wrecks; occasionally over open substrates near banks and reefs

Spawning: Dec–Apr (Puerto Rico); side-by-side pair courtship and spawning

Eggs:

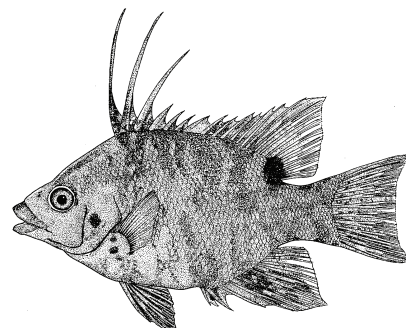
- Pelagic, spherical
- Diameter: 1.2 mm
- Oil globule: single, 0.17 mm in diameter

Larvae:

- Body moderately elongate with small head, moderately pointy snout
- Small mouth, not extending beyond anterior margin of eye
- Preanus length about 60% SL; bulging gut tapers to narrow posterior end
- Dorsal and ventral margins of body almost parallel; caudal peduncle relatively deep
- Flexion occurs at about 4.5–5.5 mmSL
- Sequence of fin ray formation: C – D₂, A – D₁ – P₂ – P₁
- Posterior margins of D₂ and A fins well rounded
- Pigment in early larvae includes melanophores along dorsal margin of gut and internal pigment through eye; spots on sides and venter of anterior gut; flexion larvae have rows of pigment along dorsum of tail, along notochord and along venter of tail; in later larvae, pigment becomes heavier along the midline of body; later larvae also develop a prominent bar through anterior dorsal fin spines and across body to pectoral fin base; juvenile pattern begins with the formation of 3 prominent blotches along the anal fin base

Head spine checklist: None

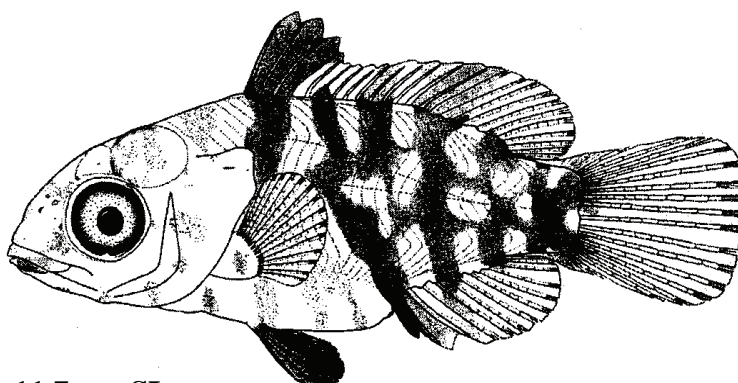
Early Juvenile:

**Meristic Characters**

Myomeres:	29–30
Vertebrae:	12–13+17 = 29–30
Dorsal fin rays:	XIV, 11–12
Anal fin rays:	III, 10–11
Pectoral fin rays:	15–16
Pelvic fin rays:	I, 5
Caudal fin rays:	6–7+7+7+6–7



Yolk-sac larva, about 2.8 mmNL



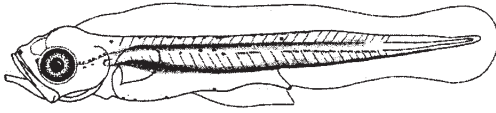
F. 11.7 mmSL

Larvae settle from water column to reef habitats at 10 mmSL, after 21–30 days in planktonic stage

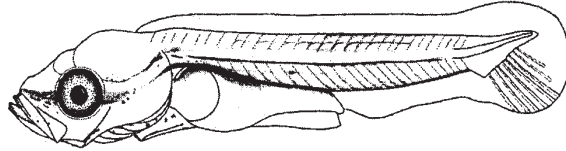
Figures: Sub-adult: Westneat, 2002a; Yolk-sac larva: Colin, 1982; **A, C–F:** Jack Javech (Jones *et al.*, 2006a); **B:** Jack Javech (Richards and Leis, 1984)

References: Colin, 1982; Richards and Leis, 1984; Victor, 1986a; 1986b; Westneat, 2002a; Leis and Rennis, 2004b

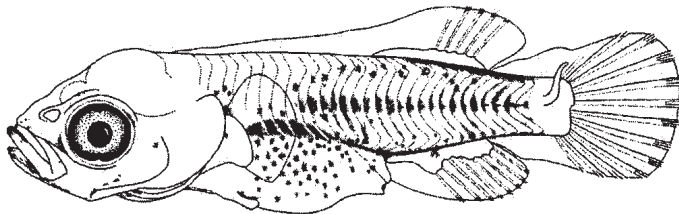
Lachnolaimus maximus



A. 3.8 mmSL

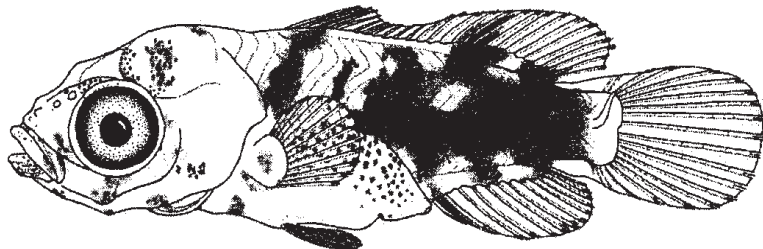


B. 5.0 mmSL

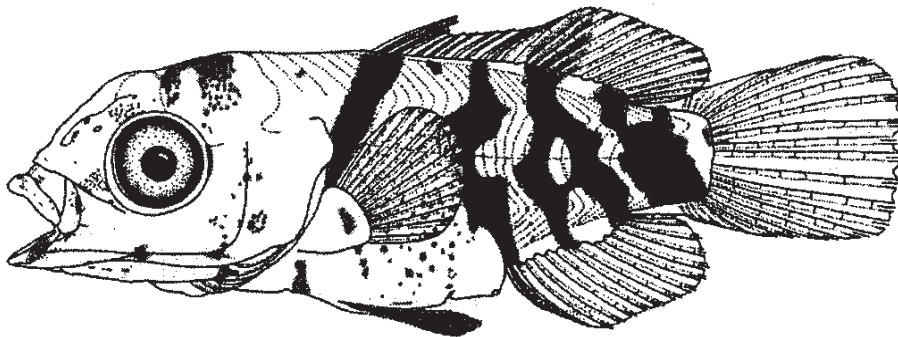


C. 5.7 mmSL

Late larvae known to form
mucous bubbles at the
surface, under which they
rest at night



D. 6.2 mmSL



E. 7.5 mmSL

Tautoga onitis* (Linnaeus, 1758)*Labridae****Tautog**

Range: East coast of North America from Nova Scotia to South Carolina; most common between Cape Cod and Chesapeake Bay

Habitat: Coastal waters in habitats offering structure (such as jetties, pilings, boulders, and rocky shorelines) in depths usually shallower than 30 m; rarely over smooth substrates (e.g. Cape Cod Bay); early stages in a variety of estuarine habitats, mostly vegetated (e.g. *Ulva lactuca* and *Zostera marina*); older juveniles favor structured habitats such as pilings, wrecks or jetties

Spawning: Apr–Aug in estuaries, bays and inner continental shelf; begins in Apr in southern part of study area, peaks Jun–Jul in New York Bight, declines in Aug

Eggs:

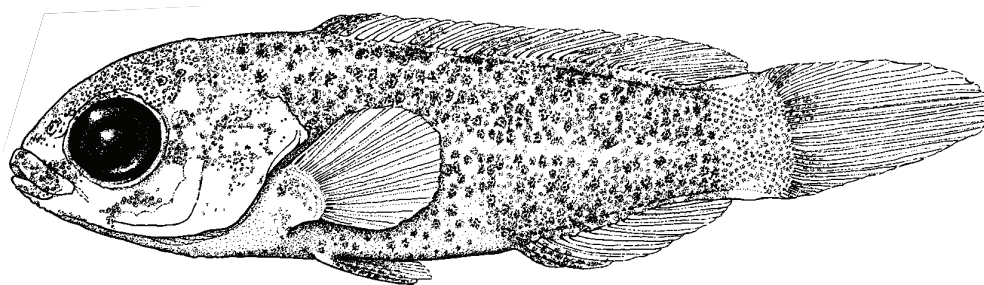
- Pelagic, spherical
- Diameter: 0.97–1.00 mm
- Chorion: smooth
- Yolk: homogeneous
- Oil globules: none (unusual for family)
- Perivitelline space: narrow
- Embryo (excised from egg) has heavy pigment between the eyes and wide gap between yolk and anus

Larvae:

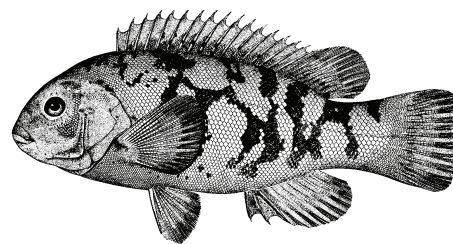
- Hatching occurs at about 2.0 mm, eyes unpigmented, mouth undeveloped
- Body elongate with small head, snout moderately pointed, mouth small
- Preanus length about 50% TL
- Flexion occurs between 5.0 and 10.0 mm
- Sequence of fin ray formation: C – D₂, A – D₁ – P₁ – P₂
- Pigmentation generally heavy over much of body; caudal peduncle unpigmented; melanophores on top of head, tip of snout and tip of lower jaw

Head spine checklist: None

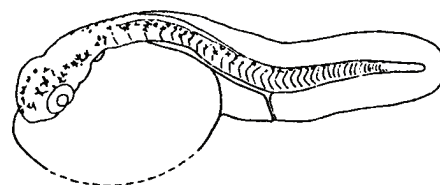
Early Juvenile:



E. 11.4 mmTL

**Meristic Characters**

Myomeres:	35
Vertebrae:	17 + 18 = 35
Dorsal fin rays:	XVII, 11
Anal fin rays:	III, 8
Pectoral fin rays:	16
Pelvic fin rays:	I, 5
Caudal fin rays:	8+7+7+6



Embryo

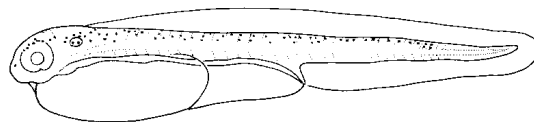
Pigment dense over-all, except caudal peduncle lighter; no pigment spot on dorsal fin rays

Larvae are planktonic for 22–30 days before settlement to bottom habitats at sizes 7.6–13.2 mmSL

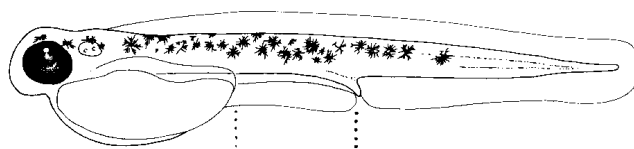
Figures: Adult: H. L. Todd (Munroe, 2002c); embryo: Peter Berrien (Fahay, 1983); A: Aggasiz and Whitman, 1885 (redrawn); B–D: Kuntz and Radcliffe, 1917 (redrawn); E: Susan Kaiser (Able and Fahay, 1998)

References: Kuntz and Radcliffe, 1917; Williams, 1967; Colton and Marak, 1969; Fahay, 1983; Victor 1986a; 1986b; Sogard *et al.*, 1992; Able and Fahay, 1998; Munroe, 2002c

Tautoga onitis



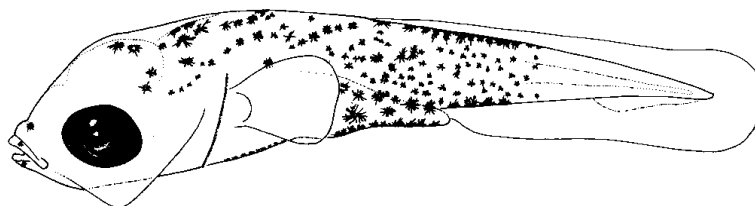
A. 2.2 mmSL



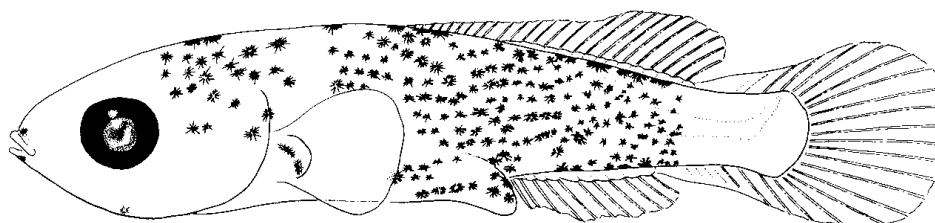
18% TL

B. 2.9 mmSL

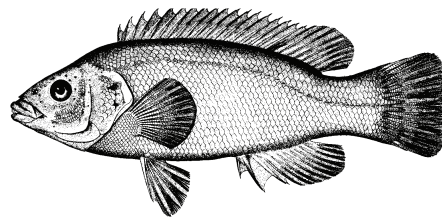
Note space between posterior edge of yolk-sac and anus greater than in *Tautogolabrus adspersus*



C. 5.0 mmSL



D. 10.0 mmSL

Tautogolabrus adspersus* (Walbaum, 1792)*Labridae****Cunner**

Range: East coast of North America from Newfoundland and Gulf of St. Lawrence to New Jersey, less commonly to Chesapeake Bay

Habitat: Primarily ocean waters, close to shore, less common on offshore banks; occur in depths to 128 m (maximum) but usually found from subtidal zone to 30 m; rarely in low-salinity habitats; strongly associated with structure (vegetation, rocks, pilings); early stages occur in estuaries as far south as Delaware Bay

Spawning: Apr–Oct in inner continental shelf waters; begins earlier in northern part of study area (e.g. Massachusetts Bay); peaks Jun–Jul in most of study area

Eggs:

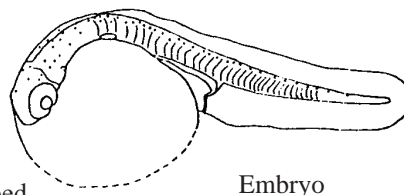
- Pelagic, spherical
- Diameter: 0.84–0.92 mm
- Chorion: smooth
- Yolk: homogeneous
- Oil globules: none (unusual for family)
- Perivitelline space: narrow
- Embryo (excised from egg) has light pigment between the eyes and narrow gap between yolk and anus

Meristic Characters

Myomeres:	36
Vertebrae:	17 + 19 = 36
Dorsal fin rays:	XVIII, 9–10
Anal fin rays:	III, 8–9
Pectoral fin rays:	16
Pelvic fin rays:	I, 5
Caudal fin rays:	8+7 PrC

Larvae:

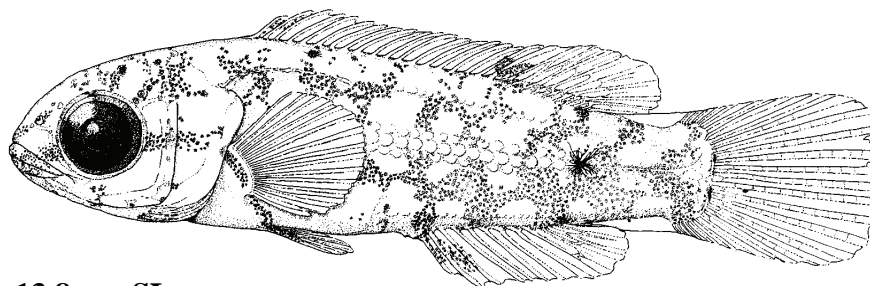
- Hatching occurs at about 2.2 mm, eyes unpigmented, mouth undeveloped
- Body elongate with small head, snout pointed, mouth small
- Preanus length about 50% TL
- Flexion occurs at about 5.0 mm
- Sequence of fin ray formation: C – D₂, A – D₁ – P₁ – P₂
- Pigmentation includes light scattering of melanophores over much of head and body in early stages, with prominent cluster over anus; later stages have 2 corresponding spots on dorsum and venter at level of dorsal and anal fin insertions; a persistent spot in nape area



Embryo

Head spine checklist: None

Early Juvenile:

**E. 13.8 mmSL**

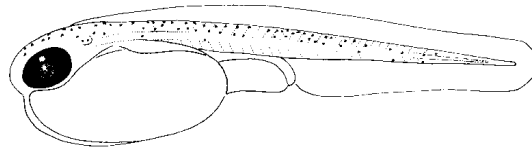
Pigment consists of blotchy pattern over body; remnants of 2 larval spots located at insertions of dorsal and anal fins, plus a prominent spot between these at the midline; a prominent spot present on anterior dorsal fin rays.

Larvae are planktonic for 25–32 days before settlement to bottom habitats at sizes 8–14 mm

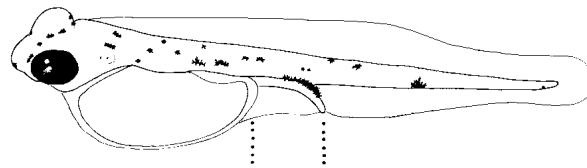
Figures: H. L. Todd (Munroe, 2002c); embryo: Peter Berrien (Fahay, 1983); **A–D:** Kuntz and Radcliffe, 1917 (redrawn); **E:** Susan Kaiser (Able and Fahay, 1998)

References: Kuntz and Radcliffe, 1917 Colton and Marak, 1969; Fahay, 1983; Tupper and Boutilier, 1995; Victor 1986a; 1986b; Able and Fahay, 1998 Munroe, 2002c

Tautogolabrus adspersus



A. 2.2 mmSL



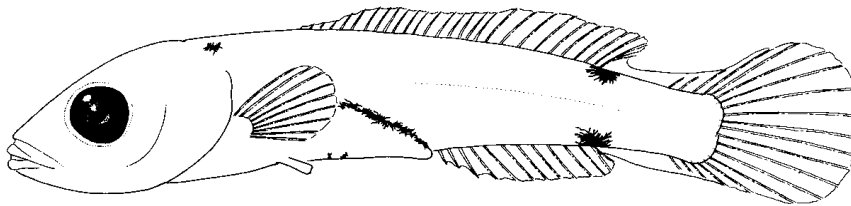
11% TL

B. 2.5 mmSL

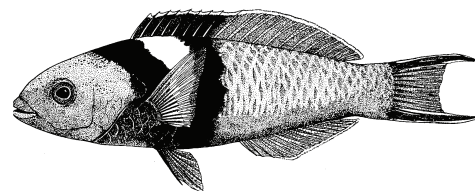
Note space between posterior
edge of yolk-sac and anus less
than in *Tautoga onitis*



C. 4.2 mmSL



D. 8.0 mmSL

Thalassoma bifasciatum* (Bloch, 1791)*Labridae****Bluehead**

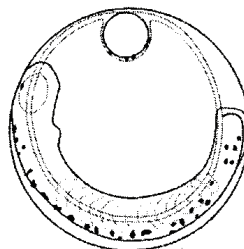
Range: Western North Atlantic Ocean from Bermuda, North Carolina, Bahamas and Florida to northern South America, including Gulf of Mexico and coast of Central America; larvae are often collected in study area, e.g. over Continental Slope

Habitat: Shallow reefs and over reef flats

Spawning: Year-round; males establish leks

Eggs:

- Pelagic, spherical
- Diameter: 0.54 mm
- Chorion: smooth
- Yolk: homogeneous
- Oil globule: single, 0.10 mm in diameter

**Meristic Characters**

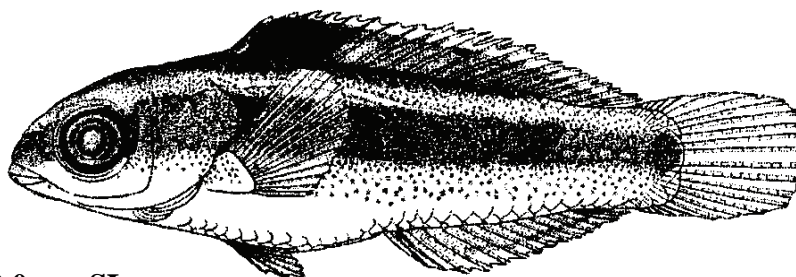
Myomeres:	25
Vertebrae:	11 + 14 = 25
Dorsal fin rays:	VIII, 12–13
Anal fin rays:	III, 10–11
Pectoral fin rays:	14–15
Pelvic fin rays:	I, 5
Caudal fin rays:	6+7+7+5

Larvae:

- Body elongate, laterally compressed, somewhat deeper through pectoral region, caudal peduncle deep
- Head proportionately larger than other labrid larvae, with pointed snout
- Mouth very small, ending well short of anterior edge of eye
- Eye almost round
- Preanus length about 50% SL
- Gut initially straight, becomes coiled at flexion
- Flexion occurs at 3.0–4.0 mmSL
- Sequence of fin ray formation: C – D, A – P₁, P₂
- Pectoral fin base low, below midpoint of body depth
- Pigment includes melanophores on membranes between anterior dorsal fin spines; a series of small black dots occur along the distal edges of the dorsal, anal, and caudal fins; larvae are otherwise unpigmented

Head spine checklist: None

Early Juvenile:



E. 19.0 mmSL

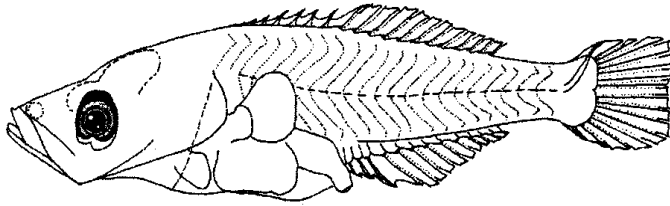
Pigmentation includes broad stripe from snout, through eye, along mid-body to spot at end of caudal peduncle; proximal portions of dorsal spines and fin rays dark (especially anterior several spines), distal tips of dorsal spines and fin rays unpigmented; dorsum darkly pigmented from over eye to under 2nd dorsal fin

Larvae planktonic for 38–78 days in water column before settlement to bottom habitats at sizes of about 10–13 mmSL. See Victor (1986b) for details of delayed transformation and the process of settlement

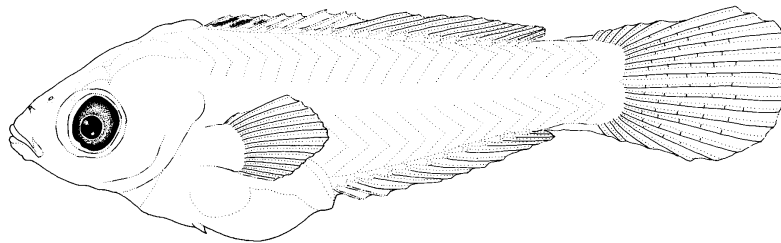
Figures: Adult: Westneat, 2002a; Egg: Jones, 1993; **A:** L. Marcus (Jones *et al.*, 2006); **B:** Betsy Washington (Richards and Leis, 1984); **C, E:** Jack Javech (Richards, 1990); **D:** Jack Javech (Jones *et al.*, 2006a)

References: Leis, 1983; Richards and Leis, 1984; Victor, 1986a; 1986b; Richards, 1990; Hare *et al.*, 2001; Jones *et al.*, 2006a

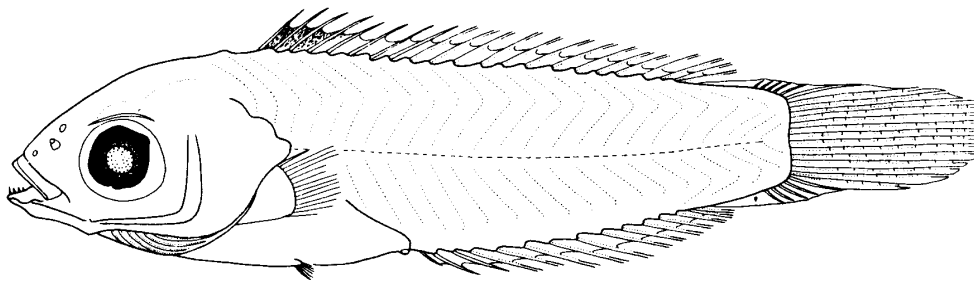
Thalassoma bifasciatum



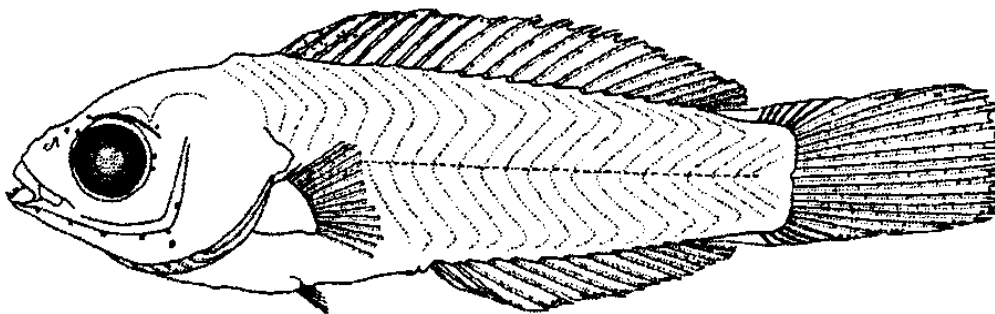
A. 4.3 mmSL



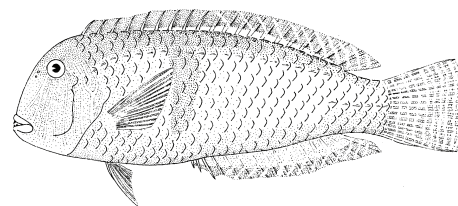
B. 8.2 mmSL



C. 11.4 mmSL



D. 11.6 mmSL

Xyrichtys novacula* (Linnaeus, 1758)*Labridae****Pearly razorfish**

Range: North Atlantic Ocean and Mediterranean Sea; in the western North Atlantic from South Carolina to Brazil, including Gulf of Mexico and Caribbean Sea; also eastern Atlantic from Spain to Gulf of Guinea; larvae often collected in study area as far north as Scotian Shelf

Habitat: Sandy substrates in depths of 5–60 m; dives head-first into sand for cover

Spawning: Spring-summer (possibly more protracted) in continental shelf waters south of Cape Hatteras, as well as more tropical areas

Eggs:

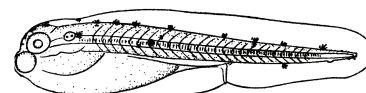
- Pelagic, spherical
- Diameter: 0.60 mm
- Chorion: smooth
- Yolk; homogeneous
- Oil globule: single, 0.14 mm in diameter

Larvae:

- Body elongate, dorsal and ventral margins nearly parallel, caudal peduncle deep
- Body very laterally compressed, with small, pointed head
- Mouth very small, failing to reach anterior edge of eye by wide margin
- Eye elliptical, top oriented either toward 1 o'clock or 11 o'clock; choroid tissue on ventral aspect of eye
- Gut is initially straight and long, becomes coiled after flexion
- Preanus length 40–50% SL (after coiling)
- Flexion occurs at <5.0 mmSL
- Sequence of fin ray formation: C – D, A – P₁, P₂; pelvic fin rays late-forming
- Pectoral fin base low on body, moderately stalked
- Pigment absent; larvae rarely have 1 or 2 spots midlaterally on trunk

Meristic Characters

Myomeres:	25
Vertebrae:	9 + 16 = 25
Dorsal fin rays:	VIII–IX, 12–13
Anal fin rays:	III, 12
Pectoral fin rays:	12
Pelvic fin rays:	I, 5
Caudal fin rays:	4–5+7+7+3–4



2.6 mm yolk-sac larva

Head spine checklist: None

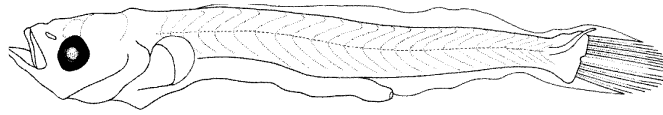
- Note:**
1. Evidence suggests that larvae are spawned south of Cape Hatteras, are commonly advected into the study area by the Gulf Stream, and then are further transported cross-slope and cross-continental shelf via flow associated with the western edges of warm-core rings (Hare and Cowen, 1991; Hare *et al.*, 2001)
 2. Two patterns of lateral line canals occur in adults of the genus *Xyrichtys*: a complete canal with an abrupt bend, and a disjunct pattern consisting of discontinuous sections of the canal, separated by a gap (Webb, 1990). The differences in these character states suggest a lack of monophyly in *Xyrichtys*. It is not known whether larval morphology may also reflect these differences
 3. Larval series for several species of Pacific Ocean *Xyrichtys* are illustrated and described in Okiyama (1988), Watson (1996x) and Leis and Rennis (2004b). The latter 2 series demonstrate completely the change in gut morphology from long and straight to short and tightly coiled.

Larvae planktonic for 38–62 days in water column before settlement to bottom habitats at undescribed sizes.

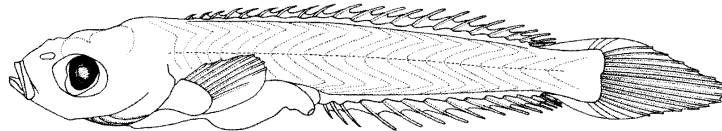
Figures: Adult: Westneat, 2002a; Egg, yolk-sac larva: Sparta, 1956; **A, B, D:** Jack Javech (Jones *et al.*, 2006a); **C:** Betsy Washington (Richards and Leis, 1984); **E:** Jack Javech (Richards, 1990)

References: Markle *et al.*, 1980; Richards and Leis, 1984; Victor, 1986a; Richards, 1990; Hare and Cowen, 1991; Hare *et al.*, 1994; 2001

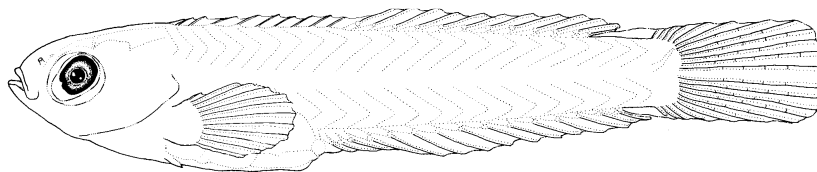
Xyrichtys novacula



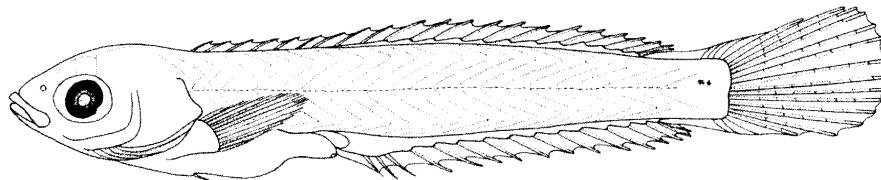
A. 5.2 mmSL



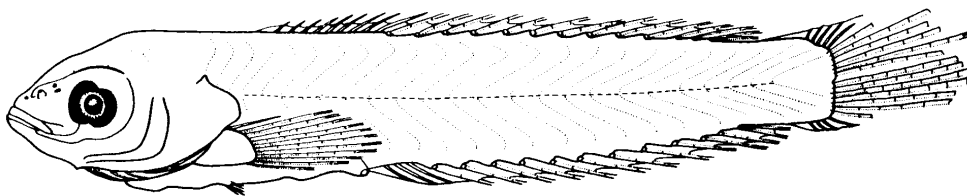
B. 6.6 mmSL



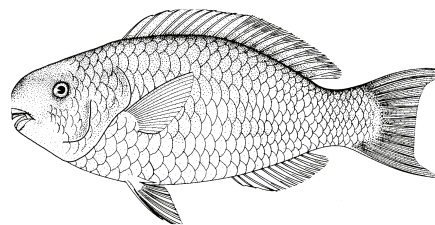
C. 10.5 mmSL



D. 12.3 mmSL



E. 13.4 mmSL (*Xyrichtys* sp.) (Measurement corrected to 10.5 mmSL in Jones *et al.*, (2006a))

Nicholsina usta*, *Scarus sp.*, *Sparisoma rubripinne**Scaridae****Parrotfishes**

Range: *Nicholsina usta* (Valenciennes, 1840) occurs from New Jersey to Brazil; *Scarus coeruleus* (Bloch, 1786) occurs from Maryland to Brazil; *Scarus iseri* (Bloch, 1789) occurs from North Carolina to Brazil, straying as far north as Massachusetts; *Sparisoma rubripinne* (Valenciennes, 1840) occurs from Massachusetts to Brazil; all 4 species also occur in eastern parts of Gulf of Mexico and Caribbean Sea; larvae may occur in study area as far north as Scotian Shelf

Habitat: These 4 species occur in coral reefs or sea grass beds or both

Spawning: *S. rubripinne* spawns Apr–Jun with 2nd peak in Oct

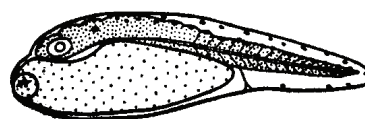
Eggs: – (Description based on eggs of *S. rubripinne*)
 – Pelagic, spherical
 – Diameter: 0.68 mm
 – Oil globule: single, 0.14 mm in diameter, anterior in yolk
 – Perivitelline space: narrow

Larvae: – Hatch at <2.0 mm; eyes unpigmented, mouth-parts unformed
 – Typical larval scarids have laterally compressed, slab-shaped body with deep caudal peduncle
 – Head small, snout moderately rounded
 – Mouth very small, not reaching anterior edge of eye
 – Gut initially straight, long, with slight constriction at posterior end; anterior gut becomes coiled at flexion; air bladder over mid- to posterior-gut, may be inflated only at night
 – Gut has obvious rugosity
 – Eye elliptical, oval or squarish in some; choroid tissue may occur on dorsal or ventral edge of eye
 – Sequence of fin ray formation: C – D₂, A – D₁, P₁ – P₂
 – All fin spines short, weak, slender
 – Pectoral fin base low, below midline of body
 – Pigment is light and typically includes series of melanophores along base of anal fin, continuing onto venter of caudal peduncle, often resembling photophores (e.g. as in myctophids); many species have 1 to several prominent melanophores over posterior end of gut

Meristic Characters

(Ranges in 4 species)

Myomeres:	25
Vertebrae:	9–11 + 14–16 = 25
Dorsal fin rays:	IX, 10
Anal fin rays:	III, 8–9
Pectoral fin rays:	13–17
Pelvic fin rays:	I, 5
Caudal fin rays:	6–8+7+6+6–7

Yolk-sac larva (*S. rubripinne*)

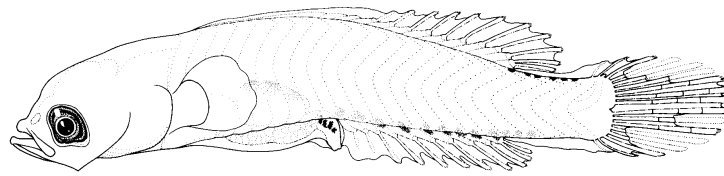
Head spine checklist: None

Note: 1. See references for descriptions and/or illustrations of larval scarids from Atlantic and Pacific oceans; larvae illustrated in Figs. A and B are from eastern Pacific Ocean
 2. Larvae may resemble those of myctophids or gobiids; myctophid larvae have 30+ myomeres; gobiid larvae lack rugose guts, have a more conspicuous air bladder and round eyes. After completion of fin rays, counts of dorsal and anal fins will distinguish scarid larvae from both of these families

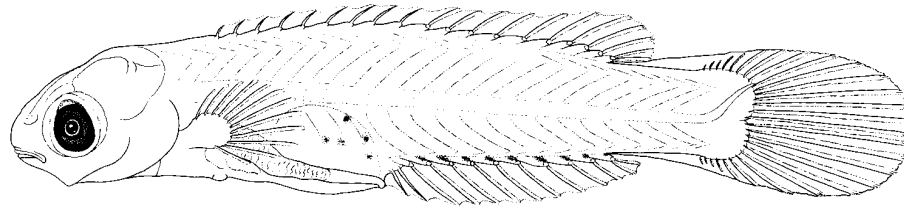
Figures: Adult (*Scarus coeruleus*): Westneat, 2004b; yolk-sac larva: Randall and Randall, 1963; **A:** Watson, 1996x; **B:** Barbara Sumida MacCall (Watson, 1996x); **C:** Jack Javech (Richards, 1990); **D:** Betsy Washington (Richards and Leis, 1984); **E:** Jack Javech (Jones *et al.*, 2006b)

References: Randall and Randall, 1963; Munro *et al.*, 1973; Markle *et al.*, 1980; Okiyama, 1988; Richards, 1990; Watson, 1996x; Leis and Rennis, 1983; 2004c; Westneat, 2004b; Jones *et al.*, 2006b

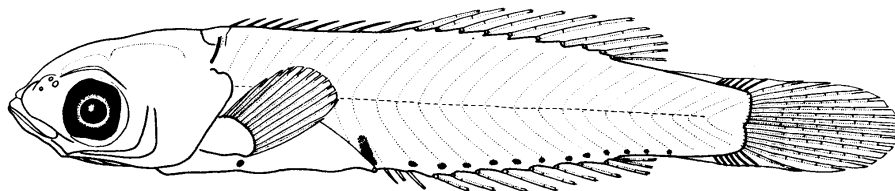
Scaridae



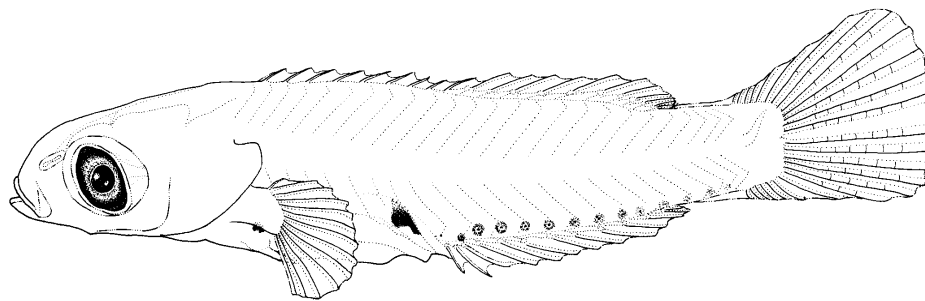
A. 4.2 mmSL (*Scarus* sp.)



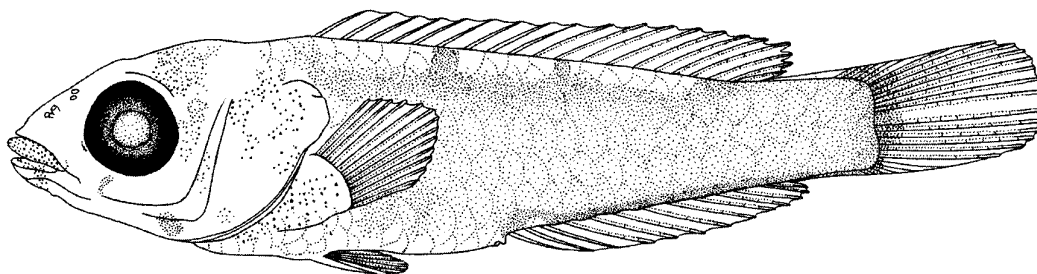
B. 7.9 mmSL (*Nicholsina denticulata*)



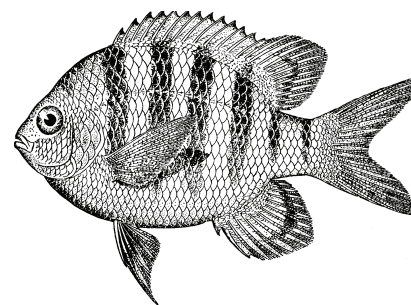
C. 9.0 mmSL (*Sparisoma* sp.)



D. 9.3mmSL (Unidentified scarid)



E. 11.4 mmSL (*Nicholsina usta*)

Abudefduf saxatilis* (Linnaeus, 1758)*Pomacentridae****Sergeant major**

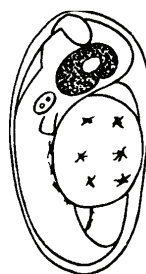
Range: Western Atlantic Ocean from Rhode Island to Uruguay, including Gulf of Mexico; also eastern Atlantic and Red Sea; larvae have been collected in the study area at least as far north as 37°18' N, 70° 22' W (MCZ 61213)

Habitat: Usually over shallow coral reefs, in depths <15 m, grass beds, and structured habitats including pilings, rocks; juveniles occur in tide-pools, often in dense schools, but are also sometimes associated with *Sargassum* clumps, well offshore

Spawning: Apr, secondary peak Sep; no activity Jan–Mar

Eggs:

- Elliptical, demersal, attached to hard substrates
- Diameter: 0.80–1.25 mm (long dimension)
- Chorion: reddish to pink, with adhesive filaments
- Yolk: deep red
- Oil globule: single large, with few smaller
- Perivitelline space: narrow

**Meristic Characters**

Myomeres:	26
Vertebrae:	11 + 15 = 26
Dorsal fin rays:	XIII, 13
Anal fin rays:	II, 12
Pectoral fin rays:	16–20
Pelvic fin rays:	I, 5
Caudal fin rays:	6+9+8+5–6
Supraneurals:	0/0/0+1/1+1/

Larvae:

- Hatching occurs at lengths of 2.9–3.5 mmTL; eyes well-pigmented, mouth parts formed
- Body initially elongate, laterally compressed; deepens after flexion
- Head deep with rounded snout; head length increases from about 20% NL to <40% SL in juveniles
- Gut deep, coiled at hatching; preanus length increases from about 40% NL to >70% SL
- Flexion occurs between 5.3 and 9.2 mmTL
- Sequence of fin ray completion: D_1 , $P_2 - C - D_2$, $A - P_1$ (later forming D_1 in *Microspathodon* and *Stegastes*)
- Pigment: early larvae have melanophores in forehead region and behind otic capsule; a series of small melanophores along venter of tail; dorsum of gut heavily pigmented; later larvae have distinct spots on dorsum of gut; spots begin to form on lateral aspect of body; pelvic fin rays darkly pigmented; in early flexion larvae, anterior part of body becomes densely pigmented; pigment covers opercle and top of head; late flexion larvae characterized by well-defined pattern of pigment over head, opercle, gut, and anterior two-thirds of body; caudal peduncle mostly unpigmented

Head spine checklist: Preopercle: described as lacking spines or serrations (Paris-Lamouzy *et al.*, 2006), although illustration indicates presence of weak spines along edge (Fig. C)

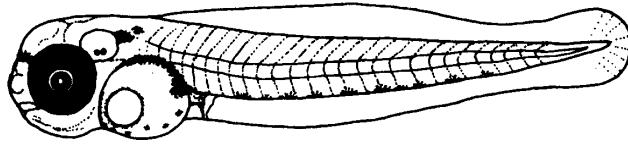
Note:

1. See Potthoff *et al.* (1987) for complete description of larval and osteological development in the related pomacentrid *Microspathodon chrysurus*. Larvae of the latter have not yet been reported from study area, but they might have been collected and overlooked. Larvae of the pomacentrid genera *Chromis* and *Stegastes* (Fig. D–E) have occurred in the study area, but their specific identifications remain unknown. The larvae of these three genera have weak to moderately well-developed preopercle spination

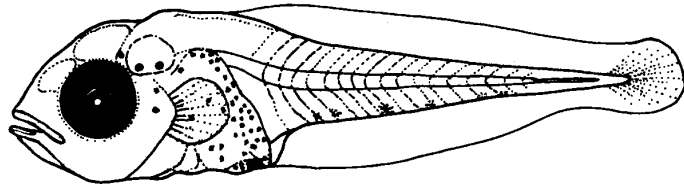
Early Juvenile: Heavily pigmented over much of head and body, except snout, caudal fin and base, D_2 and A fins, and clear vertical bar on body over pelvic fin unpigmented. See photograph (16.4 mmTL) in Alshuth *et al.*, 1998

Figures: Adult: Evermann and Marsh, 1902; egg: Shaw, 1955; **A–B:** Alshuth *et al.*, 1998; **C:** Jack Javech (Paris-Lamouzy *et al.*, 2006); **D–E:** Victor, 1987

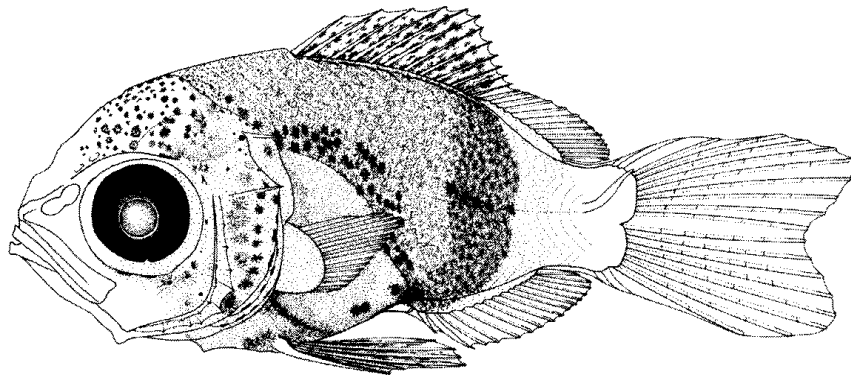
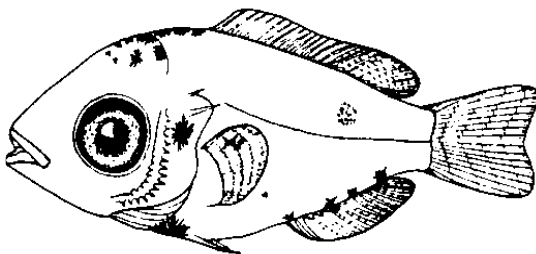
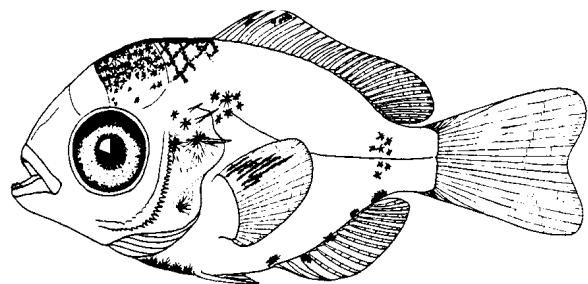
References: Shaw, 1955; Munro *et al.*, 1973; Fahay, 1975; Thresher, 1984; Potthoff *et al.*, 1987; Alshuth *et al.*, 1998; Carter and Kaufman, 2002

Abudefduf saxatilis**A. 3.3 mmTL**

Note: in later larvae, number of spots in ventral series on tail decreases

**B. 3.6 mmTL**

membranes of D₁ fin heavily pigmented

**C. 5.2 mmTL****D. 5.0 mmSL (*Stegastes* sp.)****E. 7.7 mmSL (*Stegastes* sp.)**

Larvae in Figs. D and E from eastern Pacific