### Perciformes
#### Suborders Sphyraenoidei and Scombroidei

Selected meristic characters in species belonging to the suborders Sphyraenoidei and Scombroidei whose adults or larvae have been collected in the study area. Classification and sequence modified after Collette et al. (1984b) and Eschmeyer (1990), but see comments on next pages. Sources: Collette and Nauen (1983); Collette et al. (1984b); Richards (1989); Nakamura and Parin, 1993; Russell, 2002; Parin and Nakamura, 2002a, 2002b; Collette, 2002q

<table>
<thead>
<tr>
<th>Suborder</th>
<th>Family</th>
<th>Species</th>
<th>Vertebrae</th>
<th>Dorsal Fin</th>
<th>Anal Fin</th>
<th>Caudal Fin</th>
<th>Pectoral Fin</th>
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<tbody>
<tr>
<td><strong>Sphyraenoidei</strong></td>
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<td><em>Sphyraena barracuda</em></td>
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<td><em>Aphanopus carbo</em></td>
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<td>II, 44–50</td>
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<td><em>Aphanopus intermedius</em></td>
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<td>102–107</td>
<td>XL–XLIV, 54–59</td>
<td>II, 46–50</td>
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<td><em>Benthodesmus simonyi</em></td>
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<td>XLIV–XLVI, 104–110</td>
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<td>5+9+8+5</td>
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<td><em>Evoxymetopon taeniatus</em></td>
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<td>103–104</td>
<td>X, 77–86</td>
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<td><em>Lepidopus altifrons</em></td>
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<td>98–107</td>
<td>90–96 (total)</td>
<td>II, 52–58</td>
<td>Small, 9+8 (PrCr)</td>
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<td><strong>Xiphiidae</strong></td>
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<td><em>Xiphus gladius</em></td>
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<td>25–27</td>
<td>38–45, 4–5</td>
<td>12–16</td>
<td>8–10+9+8+9–11</td>
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</table>
Selected meristic characters in species belonging to the suborder Scombroidei whose adults or larvae have been collected in the study area (Cont’d). In the Istiophoridae, note that two dorsal fins are comprised of soft rays only, whereas the first anal fin is comprised of spines, the second of soft rays. See individual species accounts for counts of finlets following the dorsal and anal fins in the Scombridae.

<table>
<thead>
<tr>
<th>Suborder</th>
<th>Family</th>
<th>Species</th>
<th>Vertebrae</th>
<th>Dorsal Fin</th>
<th>Anal Fin</th>
<th>Caudal Fin</th>
<th>Pectoral Fin</th>
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<tbody>
<tr>
<td>Scombroidei</td>
<td>Istiophoridae</td>
<td>Istiophorus albicans</td>
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<td>42-47+6-7</td>
<td>XI-XV+6-7</td>
<td>11-12+9+8+11-12</td>
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<td>Makaira nigricans</td>
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<td>38-46+5-6</td>
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<td>9+8 (PrC)</td>
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<td>Auxis rochei</td>
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<td>15+9+8+16</td>
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<td>Auxis thazard</td>
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<td>Katsuwonus pelamis</td>
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<td>XIV-XVI, 14-16</td>
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<td>Scomber colias</td>
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<td>IX-XIII, 11-12</td>
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<td>10-11+9+8+10-12</td>
<td>19-22</td>
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<td>Scomber scombrus</td>
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<td>Scomberomorus cavalla</td>
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<td>Scomberomorus maculatus</td>
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<td>11-13+9+8+11-13</td>
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<td>Scomberomorus regalis</td>
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<td>Thunnus alalunga</td>
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<td>Thunnus atlanticus</td>
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<td>Thunnus obesus</td>
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<td>Thunnus thynnus</td>
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<td>11-16</td>
<td>15-17+9+8+15-17</td>
<td>30-36</td>
</tr>
</tbody>
</table>

1 *Gasterochisma melampus* Richardson, 1845, occurs in the Southern Ocean, mostly between 30° and 50°S. However, there are records of this species in the North Pacific Ocean, and a specimen (USNM 00344351) was brought to the attention of the author by a New Jersey commercial fisherman and its identification confirmed by a colleague. There were no collection data associated with this specimen, it is therefore suspect of local provenance, and it is not included in this table or in the checklist of fishes occurring in the present study area. The larvae of this enigmatic species are undescribed, but details of its ontogeny would be a critical contribution to a resolution of its position either in the Scombroidei or in the Percoidei (G. D. Johnson, 1986).
Perciformes
Suborders Sphyraenoidei and Scombroidei

The Sphyraenoidei-Scombroidei relationship: In some recent revisions and phylogenetic analyses (e.g. G.D. Johnson, 1986), the barracudas (Sphyraena spp.) are included in the Scombroidei as a sister group to all other "scombroids". Most characters supporting this relationship are osteological, observable in adult stages. Within this expanded suborder, certain characters allow for the separation of Sphyraena from the remaining taxa, and certain of these characters may be seen in early stages. The table below illustrates these differences. Pending a future study on the relationship between the two groups based on early life history characters, the classification used herein follows Eschmeyer (1990), with the acknowledgment that they are closely related.

<table>
<thead>
<tr>
<th>Character</th>
<th>Sphyraena spp.</th>
<th>Other Scombroids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraneurals (= predorsal bones)</td>
<td>3, interdigitate dorsally</td>
<td>Absent (except 1 in Ruvettus)</td>
</tr>
<tr>
<td>Finlets</td>
<td>Absent</td>
<td>Present in some, independently lost in Trichiuridae, Gempylidae (some), Xiphidae, Istiophoridae</td>
</tr>
<tr>
<td>Hypural bones</td>
<td>Hypurals 1–5 remain autogenous</td>
<td>Hypurals 1–2 and 3–4 fuse during ontogeny</td>
</tr>
<tr>
<td>Caudal keels</td>
<td>Absent</td>
<td>Present laterally at base of caudal fin in most taxa (absent in some)</td>
</tr>
<tr>
<td>Procurent spur</td>
<td>Well developed, with foreshortened preceding ray</td>
<td>Absent</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>Few (e.g. 24)</td>
<td>Varies from few (24) in Istiophoridae, moderate (31–64) in Scombridae, many (31–168) in Gempylidae and Trichiuridae</td>
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</tbody>
</table>

1 See glossary for description of these characters

Comments on families

Sphyraenidae: The relative positions of fins (postflexion into adult stages) is a valuable character for discriminating species in the study area. Also see notes on species account pages.

Scombroabracididae: Scombroabrax heterolepis is considered by some authors to be the sole member of the perciform suborder Scombroabracoidei (e.g. Nakamura and Parin, 2002), or a primitive sister group to the Scombroidei (Collette et al., 1984b), or as a primitive outgroup with uncertain relationships to an expanded assemblage including Pomatomus and the scombroids (G. D. Johnson, 1986.) It is here included in the Scombroidei solely on the basis of the resemblance of the larvae to those of the Scombridae. It has a reduced procurent spur on the posteriormost, ventral procurent ray (vs none in other scombroids) and the preceding ray base is foreshortened (vs not shortened in other scombroids). A low myomere count and 3 anal fin spines, combined with characteristic body shape and pigment pattern, will serve to distinguish larvae from those of the Scombridae.
Perciformes

Comments on families (Cont’d)

Gempylidae: Larvae of this family are well-described, and may be readily recognized by a suite of characters. The bodies are deep, short, and compressed. The head and mouth are both large and prominent, and the snout length is exaggerated in most taxa. Early-forming canine teeth are present anteriorly in both jaws. Head spines are prominent (see figure), and those of the preopercle form distinctive patterns of varying lengths and serrations. Early forming spines in the dorsal and pelvic fins are typically elongate and serrated along two edges. Larvae decrease in body depth as they approach transformation and juveniles are typically slender and elongate with relatively smaller heads. Useful characters in distinguishing larvae at the species level include: meristic characters; patterns of head spines; pigment patterns and presence or absence of melanophores on certain loci; and relative lengths of serrated dorsal and pelvic spines. See Nishikawa (1982; 1984; and 1987a) for more thorough descriptions of gempylid larvae.

Trichiuridae: In contrast to the Gempylidae, larvae of the Trichiuridae are not well known. The larvae of only 2 (of 7) species from the study area are described. When they become better known, these larvae should be distinguishable based on meristic characters, because these characters vary widely within the family. All known larvae have elongate, laterally compressed bodies with 100 or more myomeres. Pelvic fins are reduced or absent. Spines in the first dorsal and anal fins are serrated. Fin development begins with the first dorsal. Preanus length increases during ontogeny. The caudal fin is reduced or absent in some genera.

Xiphiidae: Both adults and early stages closely resemble those of the Istiophoridae, and all stages share many important morphological characters. See Collette et al. (1984b; table 161) for a listing of osteological characters comparing the two families. Xiphiids lack a pelvic fin (and pelvic girdle) and early stages lack the elongate pterotic and preopercle spines that characterize early stages of Istiophoridae. Fin rays in the dorsal and anal fin begin in the centers of the fins and form in anterior and posterior directions, whereas larvae of Istiophoridae begin fin ray formation in the anterior part of the fin and ossification proceeds posteriorly. Caudal fin rays are supported by 2 centra (vs. 3 in Istiophoridae), postcleithra number 1 (vs 2 in Istiophoridae), and there is 1 autogenous haemal spine in the caudal fin skeleton (vs 2 in Istiophoridae). See Collette et al. (1984b; table 157) for other osteological characters differentiating the 2 families. Potthoff and Kelley (1982) present a detailed study of osteological development. Larvae and juveniles are covered with prickly squamation, and some of these modified scales are retained on various parts of the adult body (Govoni et al., 2004). Adults have 2 dorsal and 2 anal fins but in larvae and juveniles these fins are single and continuous. During development, the central fin rays stop developing and become subcutaneous. In adults, these central fin rays, along with their supporting pterygiophores, are invisible but present subcutaneously.

Istiophoridae: (See notes preceding Istiophoridae species accounts)

Scombridae: (See notes preceding Scombridae species accounts).
**Sphyraena barracuda** (Edwards, 1771)
**Sphyraenidae**
Great barracuda

**Range:** Atlantic and Indo-western Pacific oceans; in the western North Atlantic from Massachusetts (rarely) to Brazil; also eastern Atlantic Ocean

**Habitat:** Adults solitary in reef areas and offshore, deep waters; young stages often in schools in shallow waters over sandy or weedy substrates

**Spawning:** Spring through fall over continental shelf; may form schools when spawning

**Eggs:**
- Pelagic, spherical
- Diameter: 0.74–0.81 mm

**Larvae:**
- Body elongate, with long, sharp head, elongate jaws
- Dorsal and ventral body margins parallel or slightly deeper at level of D₁
- Snout very pointed, lower jaw extends beyond upper
- Mouth large, but not reaching level of anterior eye (compare to congeners)
- Fleshy knob absent at tip of lower jaw (compare to congeners)
- Flexion occurs at 5–6 mmSL
- Sequence of fin ray formation: C – D₂, A – D₁, P₁ – P₂
- D₁ origin posterior to level of P₂ origin (compare to congeners)
- P₁ fin reaches beyond P₂ origin
- Pigmentation dorsally is faint; scattered melanophores along anal fin base, on body midline, and along dorsal fin base; scattered pigment on isthmus; heavy lateral band forms later; in larger larvae (about 20 mm) dark blotches form along dorsal midline

**Head spine checklist:** None

**Note:** 1. Supraneurals in sphyraenids are unusual in their strong, dorsal interdigitation (but lacking distal radial elements), unlike the isolated, splint-like bones found in percoids and others. See G. D. Johnson (1986) for significance of these bones in a discussion of relationships of Sphyraenidae with the Scombroidei (or Gempylidae).

**Juvenile:**

**G. 213 mmSL**

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myomeres</td>
<td>24</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>24</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>V, I, 8–10</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>III, 7–9</td>
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<tr>
<td>Pectoral fin rays</td>
<td>11–12</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>I, 5</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>8+9+8+7</td>
</tr>
<tr>
<td>Supraneurals</td>
<td>/0+0/0/2/1</td>
</tr>
</tbody>
</table>

(see note)

**Figures:**
Early Stages of Fishes in the Western North Atlantic Ocean

*Sphyraena barracuda*

A. 5.5 mmSL

B. 6.6 mmSL

C. 8.6 mmSL

D. 11.9 mmSL

E. 17.2 mmSL

F. 23.7 mmSL
**Sphyraena borealis** DeKay, 1842

**Sphyraenidae**

**Sennet**

**Range:** Western Atlantic Ocean from Nova Scotia to 36°S, including Bermuda, Gulf of Mexico and Caribbean Sea

**Habitat:** Coastal waters in depths of 10–65 m over several bottom types, but usually muddy substrates; often forms large schools; young-of-the-year occur in estuarine marsh creeks and marsh surfaces in the study area, where they presumably maintain pelagic habits

**Spawning:** Spring over continental shelf off southern United States; larvae drift north via Gulf Stream and early stages often occur in estuaries in study area

**Eggs:**
- Pelagic, spherical
- Diameter: 1.22–1.24 mm
- Chorion: transparent, smooth
- Yolk: lightly segmented
- Oil globule: single, 0.27–0.29 mm in diameter

**Larvae:**
- Body elongate, with long head; preanus length 63–72% SL
- Dorsal and ventral margins of body parallel
- Snout very pointed, lower jaw extends beyond upper
- Mouth large, but not reaching level of anterior eye (compare to congeners)
- Fleshy knob present at tip of lower jaw (compare to congeners)
- Flexion occurs at 7.5–10.0 mmSL
- Sequence of fin ray formation: C – D₂, A – D₁, P₁ – P₂
- D₁ origin at about the level of P₂ origin (compare to congeners)
- P₁ fin does not reach P₂ origin
- Pigment concentrated along dorsal, lateral and ventral midlines; scattered melanophores on top of head and over gut; a few spots on preopercle and opercle; pigmentation in juveniles features square to rectangular blotches along dorsal and lateral midlines

**Head spine checklist:** None

**Note:**
1. See comments regarding supraneurals on *Sphyraena barracuda* page
2. *Sphyraena picudilla* (Poey, 1860), occurring in tropical waters, is a junior synonym of *S. borealis* (Russell, 2002), although some authors continue to treat it as a separate species. Larvae of this nominal form have not been described.

**Early Juvenile:**

Scales on posterior part of lateral line are ridged, forming a keel-like structure on caudal peduncle (>14.5 mmSL)

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Myomeres</td>
<td>24</td>
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<tr>
<td>Vertebrae</td>
<td>24</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>V, I, 8–9</td>
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<tr>
<td>Anal fin rays</td>
<td>II, 8–9</td>
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<td>Pectoral fin rays</td>
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<td>Pelvic fin rays</td>
<td>1, 5</td>
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<tr>
<td>Caudal fin rays</td>
<td>9+9+8+9</td>
</tr>
<tr>
<td>Supraneurals</td>
<td>/0/0/0/2/1</td>
</tr>
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</table>

(see note)

**I. 56.0 mmSL**

**Figures:** Adult: Russell, 2002; Egg, yolk-sac larva and A–H: Joy Godfrey (Houde, 1972); I: Nancy Arthur (Able and Fahay, 1998)

Early Stages of Fishes in the Western North Atlantic Ocean

*Sphyraena borealis*

A. 3.8 mmSL

B. 4.3 mmSL

C. 5.3 mmSL

D. 7.4 mmSL

E. 9.4 mmSL

F. 12.3 mmSL

G. 14.5 mmSL

H. 21.0 mmSL
**Sphyraena guachancho** Cuvier, 1829
*Sphyraenidae*
**Guanchanche**

**Range:** Western North Atlantic Ocean from Massachusetts (rarely) to Brazil, including Gulf of Mexico and Caribbean Sea; also eastern Atlantic

**Habitat:** Occurs in schools in shallow, turbid, coastal waters, often over muddy substrates

**Spawning:** Summer over continental shelf

**Eggs:** Undescribed

**Larvae:**
- Body elongate, dorsal and ventral margins parallel
- Gut thick; body depth decreases from 17% SL to 13% SL
- Preanus length 65% SL in preflexion, increases to 70% SL
- Head length increases from 27% SL to 38% SL
- Snout very pointed, lower jaw extends beyond upper
- Mouth large, reaching level of anterior eye (compare to congeners)
- Fleshy knob develops at tip of lower jaw (compare to congeners)
- Flexion occurs at 3.7–7.1 mmSL
- Sequence of fin ray formation: C – D₂, A – D₁, P₁ – P₂
- D₁ origin equal to, or slightly posterior to, P₂ origin
- P₁ fin reaches slightly beyond P₂ origin
- Pigmentation over body and tail somewhat more dense than in congeners, but note relatively unpigmented space on side of body over gut; ventral row of spots from isthmus to anus; top of head lightly pigmented, or unpigmented, until late larval stages; few spots on side of snout; 2 barlike blotches form on body in juveniles, with a third crossing caudal peduncle

**Head spine checklist:**
Preopercle: 3–4 tiny spines on posterior edge

**Note:**
1. See comments regarding supraneurals on *Sphyraena barracuda* page

**Early Juvenile:**

![Early Juvenile Image]

**H. 23.3 mmSL**

**Meristic Characters**

<table>
<thead>
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<th>Value</th>
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<tr>
<td>Myomeres</td>
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<td>V, I, 9–10</td>
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<td>Anal fin rays</td>
<td>I–II, 7–8</td>
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<td>Pectoral fin rays</td>
<td>11–12</td>
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<td>Pelvic fin rays</td>
<td>1, 5</td>
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<tr>
<td>Caudal fin rays</td>
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<tr>
<td>Supraneurals</td>
<td>/0+0/0/2/1</td>
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</table>

**References:**

**Figures:** Adult: Russell, 2002; A–H: Matsuura and Suzuki, 1997
Early Stages of Fishes in the Western North Atlantic Ocean

*Sphyraena guachancho*

A. 2.5 mmNL

B. 3.7 mmNL

C. 3.7 mmNL (Ventral and Dorsal Views)

D. 4.5 mmNL

E. 6.5 mmSL

F. 10.8 mmSL

G. 10.8 mmSL (Ventral and Dorsal Views)
Scombrolabrax heterolepis Roule, 1922
Scombrolabracidae
Black mackerel

Range: Atlantic, Pacific and Indian oceans in tropical and subtropical waters; in the western North Atlantic Ocean from Slope Water between Hudson Canyon and Bear Seamount to French Guiana, including Gulf of Mexico

Habitat: Mesopelagic in depths of 100–900 m

Spawning: Not well described; possibly year-round

Eggs: Undescribed

Larvae: Body moderate, deepest through pectoral fin region
- Preanus length ranges from 55–60% SL
- Head length 35–45% SL; snout moderately pointed
- Mouth large, reaching to mid-point of eye
- Flexion occurs at 4.2–5.3 mmNL
- Head spines prominent on preopercle; see checklist below (and Fig. J)
- Sequence of fin ray development: C – D₂, A – D₁ – P₂ – P₁
- Pigmentation lacking on ventral part of tail; other pigmentation increases with development; melanophores in smallest larvae begin at tip of lower jaw and posterior gut over anus; pigment on top of head spreads and joins dorsal patch under anterior D₁ fin, then spreads posteriad; dense pigment on peritoneum; melanophores increase on both jaws and gular region; Midline pigment most dense in a cluster anterior to caudal peduncle; later stages have expanding pigment along midline of body

Head spine checklist:
- Preopercle: several (up to 5) early forming, long spines on edge, a few smaller spines on lateral ridge
- Opercle: 2 or 3 spines on upper part of bone, with the smallest at upper angle
- Interopercle: a single small spine (not described, but shown in illustrations)

Early Juvenile:

I. 22.5 mmSL
(Pacific Ocean specimen)

Meristic Characters
- Myomeres: 30
- Vertebrae: 30
- Dorsal fin rays: XII, 15–16
- Anal fin rays: III, 15–17
- Pectoral fin rays: 18–19
- Pelvic fin rays: I, 5
- Caudal fin rays: 7–9+9+8+8–10
- Supraneurals: none

References: Potthoff et al., 1980; Collette et al., 1984b; G. D. Johnson, 1986; Ozawa, 1986g; Nakamura and Parin, 2002
Early Stages of Fishes in the Western North Atlantic Ocean

*Scombrolabrax heterolepis*

A. 3.1 mmNL
(Indian Ocean specimen)

B. 3.7 mmNL

C. 4.4 mmNL

D. 5.0 mmSL

E. 6.1 mmSL

F. 7.2 mmSL

G. 9.7 mmSL

H. 14.7 mmSL
Diplospinus multistriatus Maul, 1948
Gempylidae
Striped escolar

Range: Worldwide in central water masses of all major oceans; in the western North Atlantic from south of Grand Bank to South America, including Gulf of Mexico and Caribbean Sea

Habitat: Mesopelagic in depths to 1,000 m

Spawning: Undescribed

Eggs: – Undescribed

Larvae: – Body deepest through pectoral region, then tapers to thin caudal peduncle; body elongates in juveniles and adults
– Preanus length increases slightly from 67%SL in early larvae to 70% SL in juveniles
– Snout elongate and pointed; head length decreases from >40% SL to about 35% SL
– Mouth moderate, does not reach anterior edge of eye
– Forward-directed teeth develop on lower jaw
– Head spines prominent; see checklist below
– Sequence of fin ray formation: D1, P2 – P1 – A, C – D2
– Dorsal and anal finlets lacking
– Pelvic fin spine very long, serrate; fin rays lacking
– Dorsal fin spines develop serrations
– Pigmentation includes melanophores on forebrain and on branchiostegal membrane; few spots anterior to orbit; spots form a line along dorsum of body; scattered spots over gut, top of head and on gular membrane; few, bold spots on dorsal fin membrane; line of pigment on snout lacking

Head spine checklist:
Supraoccipital: none
Supraocular: low crest with few spines
Preopercle: 3 spines along edge; spine at angle serrate, longer than spine above it
Opercle: 1 or 2 spines cross bone
Posttemporal: 2 spines
Pterotic: none

Note: 1. Gempylus "Type A" larvae described by Voss (1954; 1957) pertain to this species

Early Juvenile:

F. 21.0 mmSL

Meristic Characters

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<tr>
<td>Pelvic fin rays</td>
<td>I, 0 (no rays)</td>
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<tr>
<td>Caudal fin rays</td>
<td>4+9+8+5</td>
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<tr>
<td>Supraneurals</td>
<td>none</td>
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</tbody>
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References:
Voss, 1954; Strasburg, 1964; Nishikawa, 1982; 1987a; Collette et al., 1984b; Ozawa, 1986h; Parin and Nakamura, 2002a

Figures: Adult: Parin and Nakamura, 2002a; A, C–D: Nishikawa, 1987a; B: Jack Javech (Collette et al., 1984b); E: Strasburg, 1964; F: Evseenko and Serebryakov, 1974
Early Stages of Fishes in the Western North Atlantic Ocean

*Diplospinus multistriatus*

A. 6.9 mmNL

B. 7.1 mmSL

C. 9.3 mmNL

D. 14.3 mmSL

E. 17.4 mmSL

Note flattened ventral surface of gut caused by elongate posterior process of basipterygium. This feature is also present in *Gempylus serpens*, but is lacking in other gempylid larvae.
**Gempylus serpens** Cuvier, 1829  
**Gempylidae**  
Snake mackerel

**Range:** Worldwide in tropical and subtropical waters; in the western North Atlantic from near Block Canyon to Brazil; larvae have been collected as far north as Browns Bank (MCZ 83441)

**Habitat:** Epi- to mesopelagic in depths to >200 m

**Spawning:** Undescribed

**Eggs:** Undescribed

**Larvae:**
- Body elongate, deepest through pectoral region
- Snout elongate and pointed; head length increases from 30–40% SL
- Mouth moderately large, reaching past anterior edge of eye
- Pre anus length increases from about 62% SL in early larvae to 72% SL in juveniles
- Teeth on lower jaw moderate; none protruding anteriorly
- Head spines prominent; see checklist below
- Sequence of fin ray formation: D<sub>1</sub>, P<sub>2</sub> – P<sub>1</sub>, C – D<sub>2</sub>, A
- Dorsal and anal finlets 5–7 and 5–7 respectively (form in juveniles)
- Pelvic fin spine long, serrate
- Dorsal fin spines moderately serrate
- Pigmentation includes melanophores on forebrain and anterior to orbit; lines of spots form on dorsum, mid-lateral line, and venter of trunk; scattered spots over gut and on top of head; dorsal fin membranes heavily pigmented; line of pigment on snout lacking, branchiostegal membrane unpigmented

**Head spine checklist:**
- Supraoccipital: none
- Supraocular: low crest with few spines
- Preopercle: upper 2 (of 4) spines longer than lower 2; spines moderately long, not serrated
- Opercle: 1–2 spines cross upper part of bone
- Posttemporal: 1 or 2 small spines
- Pterotic: none

**Note:** 1. *Gempylus* "Type B" larvae described by Voss (1954) pertain to this species; a 5.1 mm larva attributed to *Nesiarchus nasutus* (Voss, 1954; fig. 3A) also pertains to this species

**Early Juvenile:**

**Meristic Characters**
- Myomeres: 51–55
- Vertebrae: 51–55
- Dorsal fin rays: XXVI–XXXII, I, 10–12
- Anal fin rays: II+I, 10–12
- Pectoral fin rays: 12–15
- Pelvic fin rays: I, 3–4
- Caudal fin rays: 8–10+9+8+9–10
- Supraneurals: none

**Figures:** Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a

**References:** Voss, 1954; Nishikawa, 1982; 1987a; Collette *et al*., 1984b; Ozawa, 1986h; Parin, 2002a
Early Stages of Fishes in the Western North Atlantic Ocean

Gempylus serpens

A. 3.5 mmNL

B. 4.4 mmNL

C. 6.6 mmSL

D. 7.5 mmSL

E. 8.8 mmSL

F. 14.0 mmSL

Note flattened ventral surface of gut caused by elongate posterior process of basipterygium. This feature is also present in Diplospinus multistriatus, but is lacking in other gempylid larvae.
*Lepidocybium flavobrunneum* (Smith, 1843)
**Gempylidae**
Escolar

**Range:** Worldwide in tropical and subtropical waters; in the western North Atlantic from Emerald Bank and Georges Bank to Brazil

**Habitat:** Mesopelagic in depths to >200 m

**Spawning:** Undescribed

**Eggs:**
- Undescribed

**Larvae:**
- Body moderately stubby, deepest through pectoral region
- Snout moderate, pointed; head length about 40% SL
- Mouth large, extending past anterior edge of eye
- Forward projecting teeth on lower jaw lacking
- Preanus length increases from 55% SL in early larvae, to about 67–70% SL in juveniles
- Head spines prominent; see checklist below
- Flexion occurs at 5–6 mmSL
- Sequence of fin ray formation: $D_1, P_2 - P_1, C - D_2, A$
- Dorsal and anal finlets 4–6 and 4–5 respectively (form in juveniles)
- Pelvic fin spine moderately long and serrated
- Dorsal fin spines serrated
- Pigmentation lacking on much of the head and body, but includes dense covering in gut cavity; line of pigment begins on dorsum under 1st dorsal fin, spreads in later stages; older larvae have pigment on edges of anterior dorsal fin membranes

**Head spine checklist:**

- Supraoccipital: 2 prominent, short spines, most obvious in early stages
- Supraocular: low crest with few, low spines
- Preopercle: 3–5 spines along edge, spine at angle much longer and serrated
- Opercle: 2 spines cross upper part of bone
- Posttemporal: 2 spines
- Pterotic: single spine

**Note:**
1. Lowest dorsal fin spine count among all gempylids from study area

**Early Juvenile:**

G. 33.0 mmSL

**Meristic Characters**

<table>
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<th>Character</th>
<th>Value</th>
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<td>Anal fin rays</td>
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<td>Pectoral fin rays</td>
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<td>Caudal fin rays</td>
<td>10+9+8+10</td>
</tr>
<tr>
<td>Supraneurals</td>
<td>none</td>
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</tbody>
</table>

**Figures:** Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a

**References:** Nishikawa, 1982; 1987a; Collette *et al*., 1984a; Ozawa, 1986h; Parin and Nakamura, 2002a
Lepidocybium flavobrunneum

A. 3.1 mmNL  
B. 4.9 mmNL  
C. 5.4 mmNL  
D. 5.7 mmSL  

Larvae about 5.0 mmSL may have entire dorsal fin membrane heavily pigmented; see Collette et al. (1984b, fig. 313).

E. 6.6 mmSL  
F. 16.0 mmSL
**Nealotus tripes Johnson, 1865**  
**Gempeylidae**  
Black snake mackerel

**Range:** Worldwide in temperate to tropical waters; in the western North Atlantic from Grand Bank to Brazil

**Habitat:** Epi- to mesopelagic in depths to 600 m; migrates vertically

**Spawning:** Undescribed

**Eggs:** – Undescribed

**Larvae:**  
– Body deep through pectoral fin region, then tapers to narrow caudal peduncle  
– Snout elongate and pointed; head length 40–45% SL, decreasing to 30% SL in juveniles  
– Mouth large, projecting beyond anterior edge of eye  
– Forward projecting teeth on lower jaw lacking  
– Preanus length increases from 55% SL in early larvae to 76% SL in late larvae and 72% SL in juveniles  
– Head spines prominent; see checklist below  
– Flexion occurs at about 6.0 mmSL  
– Sequence of fin ray formation: D₁ – P₁, P₂ – C – D₂, A  
– Dorsal and anal finlets 2 and 2 respectively  
– Pelvic fin spine long, stout and serrated  
– Dorsal fin spines serrated  
– Pigmentation occurs on forebrain, anterior to orbit, on gular membrane under lower jaw, and in a line along dorsum of body; an accumulation of spots laterally on caudal peduncle; other scattered pigment occurs on top of head, on maxilla and on pectoral fin base; line of pigment on snout and branchiostegal membrane pigment lacking; no pigment on dorsal or pelvic fin membranes or in gut cavity

**Head spine checklist:**

Supraoccipital: none  
Supraocular: low crest with few, small spines  
Preopercle: 3–5 moderately long spines along edge; spine at angle serrated, slightly longer than one above it  
Opercle: 1–2 spines cross upper part of bone  
Posttemporal: 2 spines  
Pterotic: none

**Note:** 1. A very long posterior process on 1st anal pterygiophore is apparent in sizes as small as 8.0 mmSL. In juveniles, this process fuses to the middle of 3 anal spines, therefore in adults only 2 anal spines are visible.

**Early Juvenile:**

**Meristic Characters**

<table>
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<th>Character</th>
<th>Value</th>
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<td>XIX–XXI, I, 16–19</td>
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<td>Anal fin rays</td>
<td>II, 15–19</td>
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<td>Pectoral fin rays</td>
<td>12–14</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>I, 1–2</td>
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<tr>
<td>Caudal fin rays</td>
<td>8+9+8+10</td>
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<tr>
<td>Supraneurals</td>
<td>none</td>
</tr>
</tbody>
</table>

**G. 28.5 mmSL**

**Figures:** Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a

**References:** Strasburg, 1964; Nishikawa, 1982; 1987a; Collette *et al*., 1984b; Ozawa, 1986h; Parin and Nakamura, 2002a
Early Stages of Fishes in the Western North Atlantic Ocean

*Nealotus tripes*

A. 4.0 mmNL  
B. 4.7 mmNL  
C. 7.3 mmSL  
D. 8.5 mmSL  
E. 9.1 mmSL  
F. 12.6 mmSL
**Neoepinnula americana (Grey, 1953)**

**Gempylidae**

**American sackfish**

**Range:** Western North Atlantic Ocean from Baltimore and Hydrographer canyons to northern South America, including Gulf of Mexico and Caribbean Sea

**Habitat:** Benthopelagic in depths of 180–460 m

**Spawning:** Undescribed

**Eggs:** Undescribed

**Larvae:**
- Body and head very deep, then tapers to a narrow caudal peduncle
- Snout moderately pointed; head length >40% SL until decreases to about 30% SL in juveniles
- Mouth large, extending to about the middle of eye
- Forward projecting teeth on lower jaw lacking
- Preanus length increases from 55% SL in early larvae to >70% SL in juveniles
- Head spines prominent; see checklist below
- Flexion occurs at about 6.0–8.0 mmSL
- Sequence of fin ray formation: \( D_1 - P_2 - P_1 - C - D_2, A \)
- Dorsal and anal finlets lacking
- Pelvic fin spine long, stout and serrated
- Dorsal fin spines serrated
- Pigment present on \( P_2 \) fin and on forebrain; dorsal fin membrane densely pigmented; dorsum of body covered with line of melanophores; pigment lacking anterior to eye, on branchiostegal membrane and on caudal peduncle; gut cavity not heavily pigmented

**Head spine checklist:**

- Supraoccipital: none
- Supraocular: low crest with several small spines
- Preopercle: 5 spines along edge; spine at angle is longest and serrated
- Opercle: 1–2 spines cross upper part of bone
- Posttemporal: 2 spines
- Pterotic: 1 small spine

**Note:**
1. Except for a 5.5 mmNL larva collected in the Gulf of Mexico and described by Collette *et al.* (1984b), larvae of this species are undescribed. Description and illustrations are based on larvae of a congener from the Pacific Ocean, which are presumably similar to those of *Neoepinnula americana*.

**Juvenile:**

**Meristic Characters**

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<thead>
<tr>
<th>Myomeres</th>
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<td>Dorsal fin rays</td>
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<td>Anal fin rays</td>
<td>II, I, 17–20</td>
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<td>Pectoral fin rays</td>
<td>15–16</td>
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<td>Pelvic fin rays</td>
<td>I, 5</td>
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<tr>
<td>Caudal fin rays</td>
<td>9–10+9+8+9–10</td>
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<tr>
<td>Supraneurals</td>
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</table>

**G. 113.0 mmSL**

**Figures:** Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a

**References:** Nishikawa and Nakamura, 1978; Nishikawa, 1984; 1987a; Collette *et al.*, 1984b; Ozawa, 1986h; Parin and Nakamura, 2002a
Neoepinnula americana

A. 3.4 mmNL  
B. 4.0 mmNL  

Note very high, densely pigmented D₁ fin; origin is displaced anteriorly

C. 5.8 mmSL  
D. 6.5 mmSL  

E. 9.3 mmSL  
F. 13.4 mmSL  

Early Stages of Fishes in the Western North Atlantic Ocean
**Nesiarchus nasutus** Johnson, 1862  
**Gempylidace**  
Black gemfish

<table>
<thead>
<tr>
<th>Range:</th>
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<tr>
<td>Habitat:</td>
<td>Meso- to benthopelagic in depths of 200–1,200 m; migrates vertically</td>
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<tr>
<td>Spawning:</td>
<td>Undescribed</td>
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<tr>
<td>Eggs:</td>
<td>– Undescribed</td>
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</table>
| Larvae: | – Body moderately elongate, slightly deeper through pectoral fin  
– Snout elongate and pointed; head length >40% SL until decreases to about 35% SL in juveniles  
– Mouth large, not quite reaching anterior edge of eye  
– Forward projecting teeth on lower jaw lacking  
– Preanus length increases from 60% SL in early larvae to 78% SL in juveniles  
– Head spines prominent; see checklist below  
– Flexion occurs at about 6.0 mmSL  
– Sequence of fin ray formation: \( D_1, P_2 - P_1 - C - D_2, A \)  
– Dorsal and anal finlets 2–3 and 2–3 respectively  
– Pelvic fin spine long and serrated  
– Dorsal fin spines serrated  
– Pigmentation includes prominent stripe of melanophores on snout; pigment also present on forebrain, a spot anterior to eye, and on gular membrane of lower jaw; a line of pigment forms along dorsum of body and spots occur on lateral surface of caudal peduncle; pigment very light on dorsal fin and gut cavity; no pigment on branchiostegal membrane or on \( P_2 \) fin |

**Head spine checklist:**
- Supraoccipital: none  
- Supracocular: very low crest with barely distinguishable spines  
- Preopercle: 4 smooth-edged spines along edge; 2 at angle about the same length  
- Opercle: 1–2 spines cross upper part of bone  
- Posttemporal: 2 small spines  
- Pterotic: none

**Note:** 1. A series of larvae 4.0–16.0 mmSL has also been illustrated by Richards (1989) and a 7.5 mmSL larva has been described by Collette *et al.* (1984b). A 5.1 mmNL larva described as this species by Voss (1954; fig. 3A) pertains to *Gempylus serpens*.

**Early Juvenile:**

**Figures:**  
Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a

**References:**  
Voss, 1954; Nishikawa, 1982; 1987a; Collette *et al.*, 1984b; Ozawa, 1986h; Richards, 1989; Parin and Nakamura, 2002a

<table>
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<td>Caudal fin rays:</td>
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<tr>
<td>Supraneurals:</td>
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</table>
Early Stages of Fishes in the Western North Atlantic Ocean

*Nesiarchus nasutus*

A. 3.0 mmNL

B. 4.1 mmNL

C. 5.0 mmNL

D. 7.3 mmSL

E. 8.8 mmSL

F. 12.3 mmSL

Note formation of cartilaginous processes at tips of both jaws, beginning at about 7.5 mmSL
**Promethichthys prometheus** (Cuvier, 1832)

**Gempylidae**

Roudi escolar

**Range:** Worldwide in tropical and subtropical waters; in the western North Atlantic from southern New England to Brazil, including S.E. Gulf of Mexico and Caribbean Sea

**Habitat:** Benthopelagic in depths of 100–750 m

**Spawning:** Undescribed

**Eggs:** Undescribed

**Larvae:** Body moderate, slightly deeper through pectoral fin region; Snout elongate and pointed; head length >40% SL until decreases slightly in juvenile stage; Mouth large, reaching beyond anterior edge of eye; Forward projecting teeth on lower jaw lacking; Preanus length increases from 50% SL in early larvae to 75% SL in juveniles; Head spines prominent; see checklist below; Flexion occurs at 6.0–8.0 mmSL; Sequence of fin ray formation: $D_1, P_2 - C - D_2 - A - P_1$; Dorsal and anal finlets 2 and 2 respectively; Pelvic fin spine very long and serrated; fin rays lacking; note origin anteriorly placed; Dorsal fin spines serrated; Pigmentation includes prominent stripe of melanophores on snout; pigment also occurs on pelvic fin, onforebrain, in a spot anterior to eye, on gular membrane, and in a line of spots along dorsum of body; a few spots laterally on caudal pigment; dorsal fin and gut cavity only lightly pigmented; branchiostegal membrane unpigmented

**Head spine checklist:**

- Supraoccipital: none
- Supraocular: low crest with very small spines
- Preopercle: 3–4 smooth-edged spines along edge, upper 2 longest
- Opercle: 2 spines cross upper part of bone
- Posttemporal: 2 spines
- Pterotic: none

**Early Juvenile:**

**G. 23.5 mmSL**

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Value</th>
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<tbody>
<tr>
<td>Myomeres</td>
<td>34</td>
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<td>Vertebrae</td>
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<tr>
<td>Dorsal fin rays</td>
<td>XII–XIV, I, 17–21</td>
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<tr>
<td>Anal fin rays</td>
<td>I–II, 15–17</td>
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<tr>
<td>Pectoral fin rays</td>
<td>14</td>
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<tr>
<td>Pelvic fin rays</td>
<td>I, 0 (no rays)</td>
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<tr>
<td>Caudal fin rays</td>
<td>10–11+9+8+10</td>
</tr>
<tr>
<td>Supraneurals</td>
<td>none</td>
</tr>
</tbody>
</table>

**Figures:** Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a

**References:** Nishikawa, 1982; 1987a; Gorbunova, 1982; Collette *et al*., 1984b; Ozawa, 1986h; Parin and Nakamura, 2002a
Promethichthys prometheus

A. 3.5 mmNL
B. 5.4 mmNL
C. 6.1 mmNL
D. 8.4 mmSL
E. 9.6 mmSL
F. 19.4 mmSL
**Ruvettus pretiosus** Cocco, 1833
**Gempylidae**
**Oilfish**

**Range:** Worldwide in tropical and subtropical waters; in the western North Atlantic from Grand Bank to Brazil

**Habitat:** Benthopelagic in depths of 100–700 m

**Spawning:** Undescribed

**Eggs:** Undescribed

**Larvae:**
- Body deepest through pectoral fin region, then tapers to moderately narrow caudal peduncle
- Snout long and moderately pointed; head length increases from 35% SL to 45% SL in late larvae; decreases to about 30% SL in juveniles
- Mouth large, reaching to middle of eye; well posterior to eye in juveniles
- Forward projecting teeth on lower jaw lacking
- Pre anus length increases from 58% SL to 78% SL in larvae, then decreases to 65% SL in juveniles
- Head spines prominent; see checklist below
- Flexion occurs at 5.0–6.0 mmNL
- Sequence of fin ray formation: \(D_1, P_2 – P_1, C – D_2, A\)
- Dorsal and anal finlets 2–3 and 2–3 respectively
- Pelvic fin spine long and serrated
- Dorsal fin spines serrated
- Pigment occurs at tip of snout, on forebrain, on gular membrane; a line of spots forms on dorsum under the junction between \(D_1\) and \(D_2\); the dorsal fin becomes heavily pigmented after flexion; a small spot forms laterally on caudal peduncle in later larvae; gut cavity only lightly pigmented; branchiostegal membrane unpigmented

**Head spine checklist:**

- Supraoccipital: none
- Supracleithrum: ridge with several spines
- Preopercle: 4–7 smooth-edged spines along edge, spine at angle longest
- Opercle: 1–2 spines cross upper part of bone
- Posttemporal: 2 small spines
- Pterotic: small spine

**Note:** Specialized scales with hook-like projections cover body of juveniles

**Early Juvenile:**

**G. 105.5 mmSL**

**Meristic Characters**

<table>
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<tr>
<th>Character</th>
<th>Value</th>
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<tr>
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<td>Vertebrae</td>
<td>32</td>
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<tr>
<td>Dorsal fin rays</td>
<td>XIII–XV, 15–18</td>
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<tr>
<td>Anal fin rays</td>
<td>III, 12–16</td>
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<tr>
<td>Pectoral fin rays</td>
<td>14–15</td>
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<tr>
<td>Pelvic fin rays</td>
<td>1, 5</td>
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<tr>
<td>Caudal fin rays</td>
<td>10+9+8+10</td>
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<tr>
<td>Supraneurals</td>
<td>0/2/1/1</td>
</tr>
</tbody>
</table>

**References:**
Nishikawa, 1982; 1984; 1987a; Potthoff et al., 1986; Parin and Nakamura, 2002a

**Figures:**
- Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a (C reversed)
Ruvettus pretiosus

A. 3.1 mmNL

B. 4.1 mmNL

C. 5.6 mmNL

D. 5.9 mmSL

E. 7.3 mmSL

F. 8.1 mmSL
**Benthodesmus tenuis** (Günther, 1877)

**Trichiuridae**

Slender frostfish

**Range:** Isolated areas of Atlantic, Pacific and Indian oceans; in the western North Atlantic known to occur off the coast of eastern United States, in the Gulf of Mexico and off Suriname

**Habitat:** Benthopelagic in depths of 200–850 m; juveniles are mesopelagic

**Spawning:** Undescribed

**Eggs:** – Undescribed

**Larvae:**

– Body moderately elongate with large head in early larvae, becomes more elongate with development

– Preanus length increases slightly with development, but remains about 60% SL in larvae illustrated

– Head moderately large, snout long and pointed

– Mouth large, occupying most of snout length, almost reaching anterior edge of eye

– Head spines restricted to preopercle; see checklist below

– Flexion occurs at unknown size

– Sequence of fin ray formation: D₁ – D₂ – A – P₂ – C, P₁

– Pelvic fin origin anterior to level of pectoral fin

– Pelvic fin becomes tiny, composed of scale-like spine and rudimentary ray in adults

– Pigmentation includes a line of spots along dorsum of body, scattering of spots over gut, a blotch on venter of tail in early larvae; later larvae have lines of spots along dorsum, lateral midline and venter of tail all located on posterior part of body

**Head spine checklist:**

Supraoccipital: none

Preopercle: few large spines on edge in early larvae

Supraocular: none

Pterotic: none

**Note:** 1. See larval development of other trichiurids (Padoa, 1956a; Gago, Leis and Trnski, 2004)

### Meristic Characters

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<th>Character</th>
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<td>Dorsal fin rays</td>
<td>XXXIX–XLII, 79–88</td>
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<td>Anal fin rays</td>
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<td>Pectoral fin rays</td>
<td>12–13</td>
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<td>Pelvic fin rays</td>
<td>I, 1 (tiny)</td>
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<td>Caudal fin rays</td>
<td>5+9+8+5</td>
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<tr>
<td>Supraneurals</td>
<td>none</td>
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</tbody>
</table>

**Figures:** Adult: Nakamura and Parin, 1993; A: Jack Javech (Collette et al., 1984b); B: Ozawa, 1986i

**References:** Collette et al., 1984b; Ozawa, 1986i; Nakamura and Parin, 1993
Early Stages of Fishes in the Western North Atlantic Ocean

*Benthodesmus tenuis*

A. 8.1 mmNL (*Benthodesmus* sp.)

B. 27.1 mmSL
Trichiurus lepturus Linnaeus, 1758
Trichiuridae
Largehead hairtail (cutlassfish)

Range: Worldwide in temperate and tropical waters; in the western Atlantic from Virginia (rarely Cape Cod) to northern Argentina, including Gulf of Mexico and Caribbean Sea

Habitat: Benthopelagic on continental shelves in depths to 350 m; usually in shallow, coastal waters over muddy substrates, sometimes near surface at night

Spawning: Jul–Aug (Mediterranean Sea); undescribed in study area

Eggs: Undescribed

Larvae: Body very elongate, becomes laterally compressed
- Pre anus length increases from 31% SL to 55% SL in larvae, then decreases to about 48% SL in juveniles
- Head moderately large, snout long and pointed
- Mouth large, occupying most of snout length, reaching anterior edge of eye
- Head spines moderately developed; see checklist below
- Flexion does not occur; no caudal fin rays or supporting structures present
- Sequence of fin ray formation: \( D_1 - D_2, P_1 - A \)
- Dorsal (and anal) fin spines serrated on anterior surfaces
- Note absence of pelvic and caudal fins
- Pigmentation: early larvae have offset, opposing blotches on dorsal and anal finfolds and scattered pigment on top of head; after dorsal fin spines begin to form, a series of melanophores forms on either side of the dorsal midline and the number of spots increases posteriorly as fin rays are added; a few spots may also occur on side of head and on lower jaw

Head spine checklist:
- Supraoccipital: none
- Preopercle: several small spines on posterior edge and on lateral ridge
- Supraocular: low crest forms in later larvae
- Pterotic: none

Note: 1. Somewhat similar to larvae of Paralepididae, but the latter have short-based, posterior dorsal fins and prominent peritoneal pigment patches; larvae of Gempylidae are less elongate, have more prominent head spines, and have fewer myomeres

Early Juvenile:

G. 39.0 mmSL

Meristic Characters

<table>
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<th>Value</th>
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<td>Vertebrae</td>
<td>162–168</td>
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<tr>
<td>Dorsal fin rays</td>
<td>III, 120–140</td>
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<td>Anal fin rays</td>
<td>II, 105–108</td>
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<td>Pectoral fin rays</td>
<td>I, 11–13</td>
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<td>Pelvic fin rays</td>
<td>none</td>
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<tr>
<td>Caudal fin rays</td>
<td>none</td>
</tr>
<tr>
<td>Supraneurals</td>
<td>none</td>
</tr>
</tbody>
</table>

Figures: Adult: Parin and Nakamura, 2002b; A, C–E, G: Okiyama, 1988; B, F: Jack Javech (Collette et al., 1984b)

References: Padoa, 1956a; Collette et al., 1984b; Ozawa, 1986i; Okiyama, 1988
Early Stages of Fishes in the Western North Atlantic Ocean

Trichiurus lepturus

A. 5.8 mmSL

B. 6.3 mmNL

C. 7.6 mmSL

D. Anterior dorsal spine detail

E. 12.5 mmSL

F. 17.0 mmNL
**Xiphias gladius** Linnaeus, 1758
Xiphiidae
Swordfish

**Range:** Worldwide in temperate and tropical waters; in the western Atlantic from Nova Scotia to Argentina, including Gulf of Mexico and Caribbean Sea

**Habitat:** Epipelagic to mesopelagic, usually farther offshore than coastal waters; occupies surface layers at night, deeper layers during day; small larvae often associated with the Gulf Stream

**Spawning:** Year-round, with seasons varying by location; larvae in study area are probably the result of spring to early summer spawning off southeastern United States, as far north as Cape Hatteras

**Eggs:**
- Pelagic, spherical
- Diameter: 1.6–1.8 mm
- Chorion: transparent
- Oil globule: single, 0.4–0.52 mm in diameter

**Larvae:**
- Body stubby, with bulky gut, becoming elongate
- Head shallow, with elongated jaws
- Mouth very large, extending posteriorly beyond eye; teeth well formed by 6.0 mmSL
- Preanus length 70–80% SL; anus moves anteriorly with growth
- Flexion occurs at about 8.0–12.0 mmSL
- Sequence of fin ray formation: C – D₂, A – D₁ – P₁ (pelvic fin lacking)
- Head spines apparent into early juvenile stage; see checklist below
- Spinous scales appear at 12–15 mmSL, develop in rows, with scattered spinous scales between the rows; scales continue to develop and enlarge into adult stage. (See Govoni *et al.*, 2004, for details.)
- Pigmentation includes scattered melanophores over body, somewhat heavier over gut; vague bars form over body during flexion; larger larvae and early juveniles have series of circular blotches along dorsal fin

**Head spine checklist:**
- Supraoccipital: none
- Frontal: spiny crest on dorsum anterior to eye
- Preopercle: large, often slightly curved, spines on edge and lateral ridge; 2 at angle longest
- Supraocular: crest with several strong spines
- Pterotic: 1–2 strong spines
- Posttemporal: 2 spines increase to 3

**Note:** 1. See Potthoff and Kelley (1982) for complete description of osteological development

**Early Juvenile:**

**L. 46.3 mmSL**

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Value</th>
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<tbody>
<tr>
<td>Myomeres</td>
<td>24</td>
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<tr>
<td>Vertebrae</td>
<td>25–27</td>
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<tr>
<td>Dorsal fin rays</td>
<td>38–45 + 4–5</td>
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<td>Anal fin rays</td>
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<td>Pectoral fin rays</td>
<td>16–19</td>
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<tr>
<td>Pelvic fin rays</td>
<td>none</td>
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<tr>
<td>Caudal fin rays</td>
<td>8–10+9+8+9–11</td>
</tr>
<tr>
<td>Supraneurals</td>
<td>none</td>
</tr>
</tbody>
</table>

**Figures:**
Early Stages of Fishes in the Western North Atlantic Ocean

Xiphias gladius

A. 4.9 mmTL

B. 6.1 mmNL

C. 7.9 mmTL

D. 12.1 mmSL

E. 15.6 mmSL

Development of head spines and spinous scales

F. 5.3 mmNL

G. 6.2 mmNL

H. 7.6 mmSL

I. 11.5 mmSL

J. 35.4 mmSL

K. 188.0 mmSL