**Beloniformes**

Selected meristic characters in species belonging to the order Beloniformes whose adults or larvae have been collected in the study area. Classification sequence follows Eschmeyer, 1990 and Collette *et al.*, 1984. Sources: Bruun, 1935; Berry and Rivas, 1962; Staiger, 1965; Parin, 1986; 2002a; Collette, 2003a; 2002p; Hardy and Collette, 2003.

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Vertebrae</th>
<th>Dorsal Fin Ray (+ finlets)</th>
<th>Anal Fin Rays (+ finlets)</th>
<th>Pectoral Fin Rays</th>
<th>Gill Rakers on First Gill Arch</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scomberesocidae</strong></td>
<td><em>Scomberesox saurus</em></td>
<td>64–70</td>
<td>9–12 (+5–6)</td>
<td>12–13 (+5–7)</td>
<td>12–15</td>
<td>34–45</td>
</tr>
<tr>
<td><strong>Belonidae</strong></td>
<td><em>Ablennes hians</em></td>
<td>93–97</td>
<td>23–26</td>
<td>24–27</td>
<td>12–15</td>
<td>None</td>
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<tr>
<td></td>
<td><em>Strongylura marina</em></td>
<td>69–77</td>
<td>14–17</td>
<td>16–20</td>
<td>9–12</td>
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<tr>
<td></td>
<td><em>Tylosurus acus</em></td>
<td>90–95</td>
<td>22–26</td>
<td>20–24</td>
<td>13–14</td>
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<tr>
<td></td>
<td><em>Tylosurus crocodilus</em></td>
<td>80–84</td>
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<td>18–22</td>
<td>13–15</td>
<td>None</td>
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<tr>
<td><strong>Hemiramphidae</strong></td>
<td><em>Euleptorhamphus velox</em></td>
<td>71–73</td>
<td>21–24</td>
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<td></td>
<td><em>Hemiramphus brasiliensis</em></td>
<td>52–55</td>
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<td>11–15</td>
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<td></td>
<td><em>Hyporhamphus meeki</em></td>
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<td><em>Oxyporhamphus micropterus</em></td>
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<tr>
<td><strong>Exocoetidae</strong></td>
<td><em>Cheilopogon cyanopterus</em></td>
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<td>13–15</td>
<td>21–28</td>
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<tr>
<td></td>
<td><em>Cheilopogon melanurus</em></td>
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<td>13–17</td>
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<tr>
<td></td>
<td><em>Cheilopogon exsiliens</em></td>
<td>43–44</td>
<td>13–15</td>
<td>8–10</td>
<td>13–16</td>
<td>16–26</td>
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<tr>
<td></td>
<td><em>Cheilopogon furcatus</em></td>
<td>44–46</td>
<td>11–14</td>
<td>8–12</td>
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<td>18–24</td>
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<tr>
<td></td>
<td><em>Cypselurus comatus</em></td>
<td>44–47</td>
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<td>8–9</td>
<td>12–14</td>
<td>18–24</td>
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<tr>
<td></td>
<td><em>Exocoetus obtusirostris</em></td>
<td>42–45</td>
<td>12–14</td>
<td>12–14</td>
<td>15–17</td>
<td>22–29</td>
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<tr>
<td></td>
<td><em>Exocoetus volitans</em></td>
<td>43–45</td>
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<td>14–16</td>
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<td><em>Hirundichthys affinis</em></td>
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<td>16–18</td>
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<tr>
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<td><em>Parexocoetus hillianus</em></td>
<td>36–40</td>
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<td>11–13</td>
<td>26–33</td>
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<tr>
<td></td>
<td><em>Prognichthys occidentalis</em></td>
<td>42–44</td>
<td>10–13</td>
<td>8–10</td>
<td>15–19</td>
<td>20–26</td>
</tr>
</tbody>
</table>

1 A tropical species (Florida to Brazil), but the original description was based on the collection of young stage "...with long mental barbel..." off New York (Mitchill, 1815).
Beloniformes

**Scomberesocidae**: A single species (*Scomberesox saurus*) occurs in the study area. It spawns large eggs, covered with short bristles. Larvae hatch at a large size and are heavily pigmented. A preanal finfold persists into later larval stages. Larger larvae lack greatly elongate upper or lower jaws, although the lower jaw becomes slightly longer than the upper. The presence of finlets behind the dorsal and anal fins (at sizes >20 mm) distinguish these larvae from those of other beloniform families.

**Belonidae**: This family is represented by 4 species in the study area. Their eggs are very large and covered with many long, threadlike, chorionic filaments. Larvae hatch at a large size, are heavily pigmented and with the urostyle already flexed and caudal fin rays formed. A preanal finfold persists into later larval stages. An elongate lower jaw "beak" forms in the early larvae of most species (during a "halfbeak stage") and this is joined by an elongate upper jaw in later larvae. The posterior portion of the dorsal fin is enlarged and darkly pigmented in larger larvae and juveniles of most species.

**Hemiramphidae**: This family is represented by 5 species in the study area. Eggs are moderately large and in most species are covered with many very long, threadlike, chorionic filaments. Larvae are not well described, but juveniles are fairly well known. Early stages are not as darkly pigmented as those of other families. A preanal finfold persists into later larval stages. The lower jaw elongates during ontogeny, but is not joined by an elongate upper jaw. The lower jaw "beak" is then lost in the adults of one species (*Oxyporhamphus micropterus)*.

**Exocoetidae**: (See summary in Exocoetidae introductory pages.)

For a summary of the ontogeny of jaw formation in these families, and the phylogenetic significance of the various patterns, see Lovejoy *et al.* (2004).

Selected ontogenetic characters in beloniform families. The eggs of beloniform species in the study area lack oil globules. The number and arrangement of chorionic filaments are described in more detail in the species accounts. Sources: Mito, 1958; Imai, 1959; Parin and Gorbunova, 1964; Kovalevskaya, 1972; Berkeley and Houde, 1978; Hardy, 1978a; Collette *et al.*, 1984a; Watson, 1996k; Hardy and Collette, 2003.

<table>
<thead>
<tr>
<th>Family</th>
<th>Egg Diameters</th>
<th>Egg Ornamentation</th>
<th>Hatching Size (mm)</th>
<th>First/Last Fin Rays to Form</th>
<th>Lower Jaw Beak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scomberesocida</td>
<td>1.5–2.5 mm (oval)</td>
<td>Numerous short bristles</td>
<td>4.0–8.5</td>
<td>Caudal/Pelvic</td>
<td>Slightly long, joined by slightly long upper jaw beak</td>
</tr>
<tr>
<td>Belonidae</td>
<td>3.0–4.1 mm</td>
<td>Long, chorionic filaments</td>
<td>6.8–14.4</td>
<td>Caudal/Pelvic</td>
<td>Long, joined by long upper jaw beak</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>1.5–2.5 mm</td>
<td>Long, chorionic filaments¹</td>
<td>3.0–11.0</td>
<td>C, D, A/Pelvic</td>
<td>Long, retained through adult stage</td>
</tr>
<tr>
<td>Exocoetidae</td>
<td>1.5–2.0 mm</td>
<td>Long, chorionic filaments²</td>
<td>3.5–6.1</td>
<td>Caudal/Pectoral</td>
<td>Absent in most; present, then disappears in some species³</td>
</tr>
</tbody>
</table>

¹ Length greatly reduced in *Oxyporhamphus micropterus*
² Except none in *Exocoetus*
³ In *Fodiator* and *Parexocoetus*
Scomberesox saurus (Walbaum, 1792)
Scomberesocidae
Atlantic saury

Range: Atlantic, Pacific and Indian oceans in temperate waters, mostly avoiding tropical latitudes; in the western North Atlantic from Newfoundland to Cape Hatteras, with scattered occurrences as far south as 32°N

Habitat: Epipelagic and highly oceanic, especially north and west of Gulf Stream; abundant in waters beyond continental shelf depths

Spawning: Occurs year-round, well offshore at temperatures between 16.5°C and 23.5°C

Eggs:
- Moderately large, slightly oval
- Greatest diameter: 2.15–2.76 mm
- Chorion: equipped with numerous very short, rigid, uniformly spaced bristles (remnants of chorionic filaments)
- Yolk: homogeneous
- Oil globules: none

Larvae:
- Hatching occurs at lengths of 4–8 mm; eyes pigmented, flexion underway
- Body long and slender; preanus length 60–70% TL
- Caudal fin well-developed at hatching
- Sequence of fin ray formation: C – A, D – P₁, P₂
- Dorsal, anal and pelvic fins located posteriorly on body
- Finlets form posterior to dorsal and anal fins at sizes >25 mm
- Note persistent preanal finfold
- Pelvic fin buds appear at 14–17 mm; rays form at about 20 mm
- Both jaws begin to elongate at 38–40 mm
- Pigmentation at hatching includes dense, deep blue coloring over entire body, excluding fins and yolk; later stages characterized by dark blue dorsum and silvery flanks
- Transformation occurs at about 25 mm when fin rays and finlets are complete

Juvenile:

F. 100 mmTL

Meristic Characters
Myomeres: 64–68
Vertebrae: 64–70
Dorsal fin rays: 9–12 (+5–6 finlets)
Anal fin rays: 12–13 (+5–7 finlets)
Pectoral fin rays: 12–15
Pelvic fin rays: 6
Caudal fin rays: 7+8 (PrC)

Figures: Adult: H. L. Todd; Egg: Collette et al., 1984a; A: Hardy and Collette, 2003; B: Sanzo, 1940a (redrawn); C: d'Ancona, 1931 (redrawn); D–F: d'Ancona, 1931 (redrawn in Hardy, 1978a)
References: Nesterov and Shiganova 1976; Fahay, 1983; Collette et al., 1984a; Collette, 2002p; Hardy and Collette, 2003
Scomberesox saurus

A. 4.4 mmSL

B. 7.5 mmSL

C. 13.0 mmTL

D. 24.8 mmTL

E. 48.0 mmTL
**Ablennes hians** (Valenciennes, 1846)

**Belonidae**

Flat needlefish

**Range:** Worldwide in tropical and warm-temperate waters; in the western North Atlantic from Massachusetts to Brazil

**Habitat:** Epipelagic in open ocean, usually not in coastal waters

**Spawning:** Occurs in spring (at least) in offshore waters

**Eggs:**
- Diameter: 3.0–3.5 mm
- Chorion equipped with uniformly spaced tufts of filaments, 1–6 per tuft, 37–59 total; filaments longer than diameter of egg
- Oil globules: none

**Larvae:**
- Hatching length undescribed
- Body long, slender and tapered
- Preanus length about 66% TL
- Pectoral and pelvic fins small in size, late-forming
- Note persistent preanal finfold
- Dorsal and anal fins large, posteriorly placed
- Prominent, enlarged, melanistic lobe forms in posterior part of dorsal fin
- Note high numbers of anal fin rays (24–27) compared to other belonids
- Early stages pass through a "half-beak stage" wherein the lower jaw elongates before the upper; note differences in relative jaw lengths between 12 and 36 mm
- Heavy, uniform pigment forms over most of body, interrupted by 3 relatively pale 'saddles' on dorsum

**Note:**
1. Vertical pigment bars and posterior, pigmented dorsal fin lobe retained in juveniles

**Early Juvenile:**

**Figures:** Adult: Collette, 2002p; A–C: Chen, 1988; D: Mildred H. Carrington (Collette et al., 1984a); E: Collette, 2003a

**References:** Fahay, 1983; Collette et al., 1984a; Chen, 1988; Collette 2003a
Early Stages of Fishes in the Western North Atlantic Ocean

*Ablennes hians*

A. 12.3 mmSL

B. 22.4 mmSL

C. 35.2 mmSL

D. 36.1 mmSL
**Strongylura marina** (Walbaum, 1792)
**Belonidae**
Atlantic needlefish

**Range:** Western North Atlantic Ocean from Massachusetts to Brazil; does not occur in Bahamas or West Indies

**Habitat:** Epipelagic in oceanic and estuarine waters; also extends into freshwater habitats

**Spawning:** Occurs in bays and estuaries during spring and summer; eggs often deposited among mats of algae

**Eggs:**
- Diameter: 3.5–3.6 mm
- Chorion: equipped with numerous filaments, distributed over the entire chorion surface; filaments about equal to or <egg diameter
- Oil globules: none

**Larvae:**
- Hatching occurs at 9.2–14 mm
- Flexion underway at hatching
- Body long, slender and tapered
- Preanus length about 66% TL
- Sequence of fin ray formation: C – D, A – P₁ – P₂
- Note persistent preanal finfold
- Dorsal and anal fins large, posteriorly placed
- Enlarged melanistic lobe lacking in dorsal fin
- Pigment heavy, especially below midline of body and in 2 distinct rows on each side of mid-dorsal line
- Early stages pass through a "half-beak stage" wherein the lower jaw elongates before the upper; upper and lower jaws are about equal in length when juveniles reach about 100 mm; note differences in relative jaw lengths between juvenile (Fig. C) and adult

**Juvenile:**
- Growth is very fast in young-of-the-year and individuals may reach lengths of 40 cm before their first winter; juveniles occupy epi-pelagic, estuarine habitats where they swim very close to the surface; they are found in open bay waters as well as subtidal creeks and subtidal shorelines, but do not occur in intertidal creeks or in marsh-surface pools
- Juveniles in the study area occur far upstream, often into freshwater (e.g. Chesapeake Bay); they have occurred as far up the Delaware River as Trenton, and as far up the Hudson River as the Tappan Zee Bridge
- Juveniles apparently leave estuaries in September and spend their first winter south of the study area (Able and Fahay, 1998)

**Meristic Characters**
- Myomeres: 69–77
- Vertebrae: 69–77
- Dorsal fin rays: 14–17
- Anal fin rays: 16–20
- Pectoral fin rays: 9–12
- Pelvic fin rays: 6
- Caudal fin rays: 3+7+8+3

**Figures:**
- Adult: Mildred H. Carrington (Collette, 2002b); Egg: Ryder, 1882; A–B: Peni G. Lang (Hardy, 1978a); C: Collette et al., 1984a

**References:**
- Breder, 1932; Fahay, 1983; Collette et al., 1984a; Able and Fahay, 1998; Collette, 2002b; 2003a
Early Stages of Fishes in the Western North Atlantic Ocean

Strongylura marina

A. 12.0 mmTL

B. 14.4 mmTL

C. 23.5 mmSL
Tylosurus acus (Lacepède, 1803)
Belonidae
Agujon needlefish

Range: Worldwide (except eastern Pacific Ocean) in tropical and subtropical waters; the subspecies Tylosurus acus acus occurs in the western North Atlantic from Massachusetts and Bermuda to Brazil

Habitat: Epipelagic in oceanic waters over continental shelf depths, less commonly in coastal waters

Spawning: Spring through summer in tropical areas; probably occurs well offshore

Eggs:  
- Demersal, spherical
- Diameter: 3.2–4.0 mm
- Chorion equipped with uniformly spaced tufts of 2–3 filaments; filaments longer than egg diameter
- Oil globules: none

Larvae:  
- Hatching occurs at 10.2 mm; caudal fin formed, flexion underway
- Body long, slender and tapered; preanus length about 66% TL
- Note persistent preanal finfold
- Dorsal and anal fin rays form before hatching
- Pectoral and pelvic fins small in size, late-forming
- Prominent, enlarged, melanistic lobe forms in posterior part of dorsal fin
- Early stages pass through a weakly expressed "half-beak stage" wherein the lower jaw elongates only slightly earlier than the upper; note differences in relative jaw lengths in juveniles
- Heavy pigmentation covers body, especially dense along lower half of flanks

Early Juveniles:

G. 48.0 mmTL

H. 130 mmSL

Young stages have a light green background color and sometimes have 4 silvery bars crossing the body through the eye, just before level of pelvic fins, at the dorsal fin origin, and across the caudal peduncle

Meristic Characters
Myomeres: 90–95
Vertebrae: 90–95
Dorsal fin rays: 22–26
Anal fin rays: 20–24
Pectoral fin rays: 13–14
Pelvic fin rays: 6
Caudal fin rays: 7+8 (PrC)


References: Fahay, 1983; Collette et al., 1984a; Collette, 2003a; 2002p
Early Stages of Fishes in the Western North Atlantic Ocean

Tylosurus acus

A. 10.2 mmTL

B. 10.9 mmSL

C. 18.3 mmSL

D. 23.3 mmSL  Note fleshy flap at tip of lower jaw

E. 30.0 mmSL  Lower jaw only slightly longer than upper

F. 36.6 mmSL

Larvae in Figs. B-F based on the subspecies Tylosaurus acus melanotus from Pacific Ocean
Tylosurus crocodilus (Péron and Lesueur, 1821)
Belonidae
Hound needlefish

Range: Worldwide (except eastern Pacific Ocean) in tropical and warm-temperate waters; in the western North Atlantic from North Carolina and Bermuda to Brazil

Habitat: Pelagic in oceanic waters over continental shelf depths; more common in coastal waters than Tylosurus acus

Spawning: Occurs during spring in tropical areas, possibly more protracted; eggs attached to vegetation

Eggs: – Demersal, spherical
– Diameter: 4.0–4.1 mm
– Chorion equipped with numerous, long filaments
– Oil globules: none or minute, scattered

Larvae: – Hatching occurs at 10.7–12.0 mm; caudal fin formed, flexion underway
– Body long, slender and tapered
– Preanus length about 66% TL
– Pectoral and pelvic fins small in size, late-forming
– Note persistent preanal finfold
– Dorsal and anal fins small, posteriorly placed
– Prominent, enlarged, melanistic lobe forms in posterior part of dorsal fin
– Early stages do not pass through a "half-beak stage" as in other belonids; upper jaw almost equal in length to lower through development
– Heavy, uniform pigment forms over most of body, especially dark along midline; base of caudal fin with prominent black pigment

Early Juvenile:

G. 96.3 mmSL

Meristic Characters
Myomeres: 80–84
Vertebrae: 80–84
Dorsal fin rays: 21–23
Anal fin rays: 18–22
Pectoral fin rays: 13–15
Pelvic fin rays: 6
Caudal fin rays: 7+8 (PrC)

References: Breder, 1932; Fahay, 1983; Collette et al., 1984a; Collette, 2003a; 2002p
Early Stages of Fishes in the Western North Atlantic Ocean

Tylosurus crocodilus

A. 10.9 mmTL

B. 12.0 mmSL

C. 16.6 mmSL

D. 24.3 mmSL

E. 37.9 mmSL
Euleptorhamphus velox Poey, 1868
Hemiramphidae
Flying halfbeak

Range: Both sides of Atlantic Ocean; in the western North Atlantic from Massachusetts and Bermuda to Brazil, including Gulf of Mexico and Caribbean Sea

Habitat: Epipelagic in open ocean; also around islands

Spawning: Not well described; one observation of ripe female in spring (May)

Eggs: Undescribed

Larvae: (Based on early stages of Euleptorhamphus viridis; see note box opposite)

– Body very long and slender
– Preanus length about 70% SL (tip of snout to caudal fin base)
– Lower jaw becomes very prolonged early in development
– Caudal, dorsal and anal fin rays form early, followed by pectoral fin rays; pelvic fin rays last to form
– Dorsal and anal fin bases long, positioned well posteriorly on body
– Small preanal finfold persists after formation of pelvic fin
– Lower lobe of caudal fin becomes longer than upper in late larvae and juveniles
– Pigment includes prominent stripe along upper edge of gut, continues forward to form bar behind eye; dorsum of head and body well pigmented; later larvae have well-defined stripe along midline of body

Note: 1. Distinguished from other hemiramphids in study area by extremely slender body shape, high number of myomeres/vertebrae, high dorsal and anal fin ray counts and early prolongation of lower jaw

Meristic Characters

<table>
<thead>
<tr>
<th>Character</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myomeres</td>
<td>About 71–73</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>71–73</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>21–24</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>20–24</td>
</tr>
<tr>
<td>Pectoral fin rays</td>
<td>7 + 1 splint</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

Figures: Adult: Collette, 2002p; A: Watson, 1996k; B–C: Chen, 1988; D: Collette, 1965

References: Collette et al., 1984a; Chen, 1988; Collette, 1965; 2002p, 2003b
Larvae of *Euleptorhamphus velox* are undescribed. Early stages of a closely related species from the Pacific Ocean, *E. viridis*, are included here based on the assumption that they are similar to those of *E. velox.*
**Hemiramphus balao (Lesueur, 1821)**  
**Hemiramphidae**  
Balao halfbeak

**Range:** Western North Atlantic Ocean from New York to Brazil, including Gulf of Mexico and Caribbean Sea; also eastern tropical Atlantic  
**Habitat:** Epipelagic in open ocean; usually not approaching coastal waters  
**Spawning:** Spring-early summer; females spawn daily batches  
**Eggs:**  
- Demersal, spherical, attached to vegetation  
- Diameter: about 1.5–1.6 mm  
- Chorion equipped with many threadlike filaments with well-separated attachment points  
- Oil globules: none  
**Larvae:**  
- Undescribed  
- Larvae of *Hemiramphus saltator* from the eastern Pacific are densely pigmented over the entire head and body; the lower jaw begins to elongate at about 14 mm; caudal, dorsal and anal fin rays form early, pectoral fins begin with formation of the upper rays at about 8.0 mm, and pelvic fin rays form last. See Watson (1996k) for illustrations and description.

**Notes:**  
1. In juvenile *Hemiramphus balao*, the pelvic fins acquire heavy pigment at the base of the rays (Fig. C); this contrasts with the pelvic fins of *Hemiramphus brasiliensis*, where the pigment is most dense at the tips of the rays, and *Hyporhamphus meeki*, where pelvic fin pigment is absent.

2. Body pigment bars are typical in the juveniles of *Hemiramphus*, but these are retained in sizes >175 mm in *H. balao*; these bars are lost in *H. brasiliensis* at sizes smaller than 120 mmSL and are absent in juveniles of *Hyporhamphus*. Body pigment bars are also absent in juveniles of *Euleptorhamphus velox* and *Oxyporhamphus micropterus.*

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myomeres</td>
<td>about 54–56</td>
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<tr>
<td>Vertebræ</td>
<td>54–56</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>11–15</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>10–13</td>
</tr>
<tr>
<td>Pectoral fin rays</td>
<td>10–12</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

**Figures:**  
Adult: Collette, 2002p; Egg: Rass, 1972; A, C: Collette et al., 1984a; B: Collette, 1962  
**References:**  
Collette, 1962; 2002p; 2003b; Collette et al., 1984a
C. Pelvic fin pigmentation in juvenile stages of *Hemiramphus balao*

Pelvic fin pigment begins to fade in juveniles 146 mm, and disappears by 163 mm.
**Hemiramphus brasiliensis** (Linnaeus, 1758)

**Hemiramphidae**

**Ballyhoo halfbeak**

**Range:** Western North Atlantic Ocean from Massachusetts to Brazil, including Gulf of Mexico and Caribbean Sea; also eastern tropical Atlantic; absent from Bermuda

**Habitat:** Epipelagic in oceanic waters, often in large schools; also inshore near sea grass beds

**Spawning:** Spring through summer; eggs attached to submerged aquatic vegetation

**Eggs:**
- Demersal, spherical, attached to vegetation
- Diameter: about 2.4 mm
- Chorion equipped with many threadlike filaments originating from all points of egg surface, but with tips congregating at one end
- Oil globules: none

**Larvae:**
- Hatching occurs at 5–7 mmSL
- Body long, slender, not tapered
- Preanus length about 66–75% of SL
- Note persistent preanal finfold
- Sequence of fin ray formation undescribed
- Dorsal and anal fins small and positioned posteriorly
- Lower jaw begins to elongate at about 30–40 mmSL
- Posterior dorsal fin rays become elongate and pigmented; posterior anal fin rays also become pigmented, but are only slightly elongate
- Pigment light until a length of 13 mmSL; 2 rows of small spots form along dorsal edge; dorsal and ventral rows of pigment give way to a bold stripe along midline of body; pigment bars form across body in juveniles, but are lost at about 120 mmSL (cf: *Hemiramphus balao*).

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myomeres</td>
<td>about 52–55</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>52–55</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>12–15</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>11–15</td>
</tr>
<tr>
<td>Pectoral fin rays</td>
<td>10–12</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

**Figures:**

- Adult: Collette, 2002p; Egg: Berkeley and Houde, 1978; A–B: Hardy, 1978a; C: Collette *et al.*, 1984a; D: Collette, 1962

**References:**

Collette, 1962; 2002p; 2003b; Berkeley and Houde, 1978; Fahay, 1983; Collette *et al.*, 1984a
Early Stages of Fishes in the Western North Atlantic Ocean

Hemiramphus brasiliensis

A. 13.5 mmSL

Compare placement of pelvic fins, relative to opercles and anal fin origin, to placement in Hyporhamphus meeki

B. 46.0 mmSL

C. 50.0 mmSL

D. 119 mmSL
Hyporhamphus meeki Banford and Collette, 1993
Hemiramphidae
Meek's halfbeak

Range: Western North Atlantic Ocean from Cape Cod to Florida, northern Gulf of Mexico and Yucatan Peninsula

Habitat: Strongly surface oriented in coastal ocean and estuarine waters; often over sandy substrates near submerged vegetation

Spawning: Summer (Chesapeake Bay); eggs attached to floating eel grass blades

Eggs:
- Demersal, spherical, attached to vegetation
- Diameter: 2.0 mm
- Chorion equipped with several very long filaments
- Oil globules: none

Larvae:
- Hatching occurs at sizes <3.0 mm
- Body long, slender, not tapered
- Preanus length about 66% of TL
- Note persistent preanal finfold
- Dorsal and anal fins small and positioned posteriorly; posterior dorsal fin rays do not elongate
- Lower jaw begins to elongate at about 10–15 mmSL
- Lower lobe of caudal fin not elongate
- Dorsal pigment heavy at small sizes; 2 rows of large, dorsal spots almost merge posteriorly (Fig. E); row of melanophores forms along gut; line of pigment present along base of anal fin

Note: 1. Records of Hyporhamphus unifasciatus (Ranzani, 1841) in the present study area probably refer to Hyporhamphus meeki. The range of H. unifasciatus includes tropical waters from southern Florida to Venezuela, where it occurs in inshore waters (including estuaries) along coasts and around islands in the Caribbean Sea. It also occurs in Bermuda, but it is unlikely that it drifts very far into oceanic waters, and there are no records of its young stages occurring north of 35°N.

Meristic Characters
Myomeres: about 50–53
Vertebrae: 50–53
Dorsal fin rays: 12–16
Anal fin rays: 14–18
Pectoral fin rays: 10–13
Pelvic fin rays: 6
Caudal fin rays: 7+8 (PrC)

Figures: Adult: Mildred Carrington (Banford and Collette, 1993; Egg, B–C: Hardy, 1978a; A, D–E: Hardy and Johnson, 1974
References: Fahay, 1983; Collette et al., 1984a; Banford and Collette, 1993; Collette, 2002p; 2003b
Early Stages of Fishes in the Western North Atlantic Ocean

_Hyporhamphus meeki_

A. 7.0 mmSL

B. 9.5 mmSL

C. 11.6 mmSL

D. 15.8 mmSL

Compare placement of pelvic fins, relative to opercles and anal fin origin, to placement in _Hemiramphus brasiliensis_

E. 15.8 mmSL (Dorsal View)
**Oxyporhamphus micropterus Bruun, 1935**  
**Hemiramphidae**  
Atlantic smallwing flyingfish

**Range:** Atlantic Ocean in tropical and subtropical waters; in the western North Atlantic from 40°N to equator, including Gulf of Mexico and eastern Caribbean Sea; a different subspecies occurs in the Indo-Pacific Ocean

**Habitat:** Epipelagic in oceanic waters, usually far from coast

**Spawning:** Undescribed

**Eggs:**
- Pelagic, spherical, pinkish-brown
- Diameter: 1.8–2.1 mm
- Chorion equipped with 74–120 very short attachment filaments
- Oil globules: none

**Larvae:**
- Hatching occurs at about 3.0 mmSL; body moderately long with bulging yolk mass, weakly pigmented eye, mouth well-formed, caudal fin rays formed
- Preanus length about 70% SL
- Note persistent preanal finfold after all fin rays are formed
- Caudal, dorsal and anal fin rays form early, followed by pectoral and pelvic fin rays
- Dorsal and anal fins short-based, located far posteriorly; pectoral fins moderately elongate
- Lower lobe of caudal fin begins to elongate soon after acquisition of fin rays
- Early stages pass through a "half-beak stage" wherein the lower jaw elongates before the upper; note increase in lower jaw length during larval and early juvenile stage, followed by loss of elongate lower jaw in late juvenile stage (at about 70–100 mmSL)
- Pigment includes dense line of melanophores along dorsum of body and top of head; cluster of spots present along dorsal surface of gut; patch of pigment spots on opercle

**Early Juveniles:**

**H. 66.0 mmSL**

**I. 70.0 mmSL**  
(Note pigment on dorsal and anal fins)

**Meristic Characters**
- Myomeres: about 49–51
- Vertebrae: 49–51
- Dorsal fin rays: 13–15
- Anal fin rays: 13–16
- Pectoral fin rays: 11–13
- Pelvic fin rays: 6
- Caudal fin rays: 7+8 (PrC)

**Figures:**  

**References:** Imai, 1959; Kovalevskaya, 1963; 1980; Fahay, 1983; Collette *et al.*, 1984; Watson, 1996k; Collette, 2002p; 2003b
Early Stages of Fishes in the Western North Atlantic Ocean

Oxyporhamphus micropterus

The subspecies Oxyporhamphus micropterus similis occurs in the Atlantic; all figures, except G, pertain to the Pacific subspecies, Oxyporhamphus micropterus micropterus.
The early stages of 12 species of flyingfishes may be encountered in the study area. Some of these may only occur in Gulf Stream or northern Sargasso Sea waters. Eggs are only moderately large and most have a uniform covering of long, threadlike, chorionic filaments, or filaments grouped into specific areas of the chorion. Species in one genus (*Exocoetus*) lack ornamentation on the egg surface. Eggs of most species are not buoyant, but their chorionic filaments are used to attach to floating objects such as *Sargassum*, floating sea grass, driftwood, straw, feathers, coconuts, empty bottles, drifting nets. The eggs of some may be deposited on benthic substrates, or may sink when their point of attachment becomes water-logged.

Larvae hatch at large sizes, although smaller than those of other beloniforms. Pigmentation is typically heavy. The preanal finfold does not persist into later larval stages. Early stages lack elongate upper or lower jaws, but species in 2 genera (not included here) go through a "halfbeak stage" wherein an elongate process forms on the lower jaw, and then is lost at transformation. Barbels form on the mandible tip of many species during the juvenile stage, but they are absent in some species.

### Characters in larval and juvenile stages of flyingfishes occurring in the study area

<table>
<thead>
<tr>
<th>Species</th>
<th>Jaw &quot;Beak&quot;</th>
<th>Mandibular Barbels</th>
<th>Pectoral/Pelvic Length</th>
<th>Pelvic Fin Origin</th>
<th>Dorsal Fin Height</th>
<th>Pectoral Fin Pigment</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cheilopogon cyanopterus</em></td>
<td>None</td>
<td>Paired, very long</td>
<td>Long/Long</td>
<td>Closer to anal fin</td>
<td>High, uniformly dark</td>
<td>Dark upper and outer rays</td>
</tr>
<tr>
<td><em>C. exsiliens</em></td>
<td>None</td>
<td>Paired, moderate</td>
<td>Long/Long</td>
<td>Closer to anal fin</td>
<td>High, patterned</td>
<td>Bands and 2 spots</td>
</tr>
<tr>
<td><em>C. furcatus</em></td>
<td>None</td>
<td>Paired, short-moderate</td>
<td>Long/Long</td>
<td>Closer to anal fin</td>
<td>Moderate, sparse pigment anteriorly</td>
<td>Strongly barred pattern</td>
</tr>
<tr>
<td><em>C. melanurus</em></td>
<td>None</td>
<td>Short</td>
<td>Long/Long</td>
<td>Between pectoral and anal fins</td>
<td>Moderate, few blotches</td>
<td>Several large blotches, pale background</td>
</tr>
<tr>
<td><em>Cypselurus comatus</em></td>
<td>None</td>
<td>Single, long</td>
<td>Long/Long</td>
<td>Closer to anal in</td>
<td>Not high, pigment absent</td>
<td>Uniformly pigmented</td>
</tr>
<tr>
<td><em>Exocoetus obtusirostris</em></td>
<td>None</td>
<td>None</td>
<td>Long/Short</td>
<td>Closer to pectoral fin</td>
<td>Not high, spot posteriorly</td>
<td>Usually clear</td>
</tr>
<tr>
<td><em>E. volitans</em></td>
<td>None</td>
<td>None</td>
<td>Long/Short</td>
<td>Closer to pectoral fin</td>
<td>Not high, unpigmented</td>
<td>Unpigmented</td>
</tr>
<tr>
<td><em>Hirundichthys affinis</em></td>
<td>None</td>
<td>None</td>
<td>Long/Long</td>
<td>Closer to anal fin</td>
<td>Moderately high, black distally</td>
<td>Mottled, dark spot and bands</td>
</tr>
<tr>
<td><em>H. rondeletii</em></td>
<td>None</td>
<td>None</td>
<td>Long/Long</td>
<td>Closer to anal fin</td>
<td>Moderately high, black distally</td>
<td>Dark with clear edge</td>
</tr>
<tr>
<td><em>H. speculiger</em></td>
<td>None</td>
<td>None</td>
<td>Long/Long</td>
<td>Closer to anal fin</td>
<td>Low, black edged</td>
<td>Mottled with band</td>
</tr>
<tr>
<td><em>Parexocoetus hillianus</em></td>
<td>Small, on lower jaw</td>
<td>Paired, moderate</td>
<td>Moderate/Short</td>
<td>Closer to anal fin</td>
<td>Very high, black</td>
<td>Weak pigment</td>
</tr>
<tr>
<td><em>P. occidentalis</em></td>
<td>None</td>
<td>None</td>
<td>Long/Long</td>
<td>Closer to anal fin</td>
<td>Moderate, dark</td>
<td>Very dark</td>
</tr>
</tbody>
</table>
### Key to larval and juvenile exocoetids expected to occur in study area (modified after Cotten and Comyns, 2006)

1a **Body depth 10.5–13.0% SL when >5.0 mm; 50–51 vertebrae; pigment rows concentrated dorsally and ventrally; very light lateral pigment** ........................................... *Oxyporhamphus micropterus*  
(see Hemiramphidae) ........................................... 2

1b **Body depth >14.0 %SL; 38–49 vertebrae** ........................................................................................................... 3

2a **Body lightly pigmented** .................................................................................................................................................... 3

2b **Body darkly pigmented** ..................................................................................................................................................... 4

3a **13–15 dorsal fin rays; no internal row of pigment spots over notochord; chin barbels not visible until about 8.5–10.0 mm** ................................................................. *Cheilopogon exsiliens*

3b **12–14 dorsal fin rays; internal pigment present along notochord; chin barbels visible by 4.3 mm** ................................................. *Cheilopogon cyanopterus*

4a **Body uniformly covered with small melanophores giving appearance of brown background; guanine (silver pigment) covers entire body in freshly collected specimens** ........................................................................................................... 5

4b **Body speckled with larger melanophores; guanine only partially covers body in fresh specimens** ........................................................................................................... 7

5a **Tip of lower jaw forms a protruding, sharp, "jaw beak" >18.0 mm** ................................................................. *Parenchelys hillianus*

5b **Tip of lower jaw without sharp, protruding point** ........................................................................................................... 6

6a **Pelvic fin rays develop pigment by 4.3 mm** .................................................................................................................. 8

6b **Pelvic fin rays unpigmented** ........................................................................................................... *Exocoetus obtusirostris*

7a **10–13 dorsal fin rays and 11–13 anal fin rays** ........................................................................................................... 8

7b **12–14 (rarely 11 or 15) dorsal fin rays and 9–10 (rarely 7 or 11) anal fin rays** ........................................................................................................... 10

8a **Predorsal and preanus length 60.5–65.5 %SL; prepelvic length 49.0–50.5 %SL** ................................................ *Hirundichthys rondeletii*

8b **Predorsal and preanus length 67.0–72.0 %SL; prepelvic length 51.0–56.0 %SL** ................................................................. 9

9a **Pigment absent on snout and jaws** .................................................................................................................. *Hirundichthys speculiger*

9b **Pigment present on snout and/or jaws** .................................................................................................................. *Hirundichthys affinis*

10a **Body short and thick; prepelvic length 50.0–52.5%SL** ......................................................................................... *Cheilopogon furcatus*

10b **Body not short and thick; prepelvic length <50.0%SL or >52.5%SL** ......................................................................................... 11

11a **Small melanophores scattered over caudal fin** ......................................................................................... 12

11b **Dash-like pigment spots along 3–4 lowest caudal fin rays; 12 (rarely 10, 11 or 13) dorsal fin rays; 9 (rarely 8 or 10) anal fin rays; 15–19 pectoral fin rays** ........................................................................................................... *Prognichthys occidentalis*

12a **11–13 dorsal fin rays; 8–9 anal fin rays; a single, median chin barbel forms >11.0 mm** ................................................ *Cypselurus comatus*

12b **12–13 (rarely 11 or 15) dorsal fin rays; 8–10 (rarely 7 or 11) anal fin rays; a pair of chin barbels develops in juveniles 46 (rarely 44, 45 or 47) vertebrae** ........................................................................................................... *Cheilopogon melanurus*
*Cheilopogon cyanopterus* (Valenciennes, 1847)
Exocoetidae
Margined flyingfish

**Range:** Worldwide in Atlantic, western Pacific and Indian oceans; in the western Atlantic found between 40°N and 20°S; northernmost occurrences are juveniles in the Gulf Stream

**Habitat:** Epipelagic in open ocean waters; primarily a neritic species

**Spawning:** Summer (at least), perhaps more protracted; not well described

**Eggs:**
- Undescribed, demersal; ovarian eggs are 1.2 mm in diameter and have uniform arrangement of attachment filaments over their chorion

**Larvae:**
- Hatching length undescribed; body moderately long with rounded head, terminal mouth
- Mandibular barbels begin forming in early larvae
- Fin rays form early; pectoral fin rays last to form
- Pectoral and pelvic fin rays long; dorsal and anal fins positioned posteriorly on body, dorsal typically longer-rayed than anal until adult stage
- Lower lobe of caudal fin longer than upper; begins to form early in development
- Pigment in early larvae includes scattered melanophores across dorsum of body, top of head and along dorsal surface of gut; juveniles acquire characteristic pattern on pectoral and pelvic fins
- Dorsal fin in juveniles usually uniformly pigmented
- Paired mandibular barbels very long in juveniles 20–80 mmSL; barbel length may exceed body length

**Note:**
1. See box for comments on pectoral and pelvic fin pigment

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myomeres</td>
<td>about 43–46</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>43–46</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>12–14</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>9–11</td>
</tr>
<tr>
<td>Pectoral fin rays</td>
<td>13–15</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

**Early Juvenile:**

Pigment is acquired on the upper corner of pectoral fin, spreads to include entire length of upper 7 or 8 rays; in later juveniles, this pigment is interrupted by pale spots near base of fin. Pelvic and caudal fins acquire pattern of alternating dark and pale blotches.

**Figures:** Adult: Parin, 2002a; A–B, D: T. N. Steyker (Kovalevskaya, 1977); C: Chen, 1987; E: Howard E. Hamman (Gibbs and Staiger, 1970)

**References:** Gibbs and Staiger, 1970; Kovalevskaya, 1977; Parin, 2002a
Early Stages of Fishes in the Western North Atlantic Ocean

Cheilopogon cyanopterus

A. 4.2 mmSL

B. 10.2 mmSL

C. 24.7 mmSL

D. 67.5 mmSL
**Cheilopogon exsiliens (Linnaeus, 1771)**  
**Exocoetidae**  
Bandwing flyingfish

**Range:** Widespread Atlantic Ocean; in the western Atlantic from 40°N (in the Gulf Stream) to 25°S, including Gulf of Mexico, but absent or rare in Caribbean Sea

**Habitat:** Epipelagic in open ocean waters

**Spawning:** Undescribed

**Eggs:**  
– Pelagic; characters undescribed

**Larvae:**  
– Hatching length undescribed; body moderately long with rounded head, terminal mouth  
– Mandibular barbels begin forming in early larvae  
– Fin rays form early; pectoral fin rays last to form  
– Pectoral and pelvic fin rays long; dorsal and anal fins positioned posteriorly on body, dorsal typically longer-rayed than anal until adult stage  
– Lower lobe of caudal fin longer than upper; begins to form early in development  
– Dorsal fin pigment begins as light scattering on outer margin; pattern develops in juveniles  
– Pigment in early larvae includes scattered melanophores across dorsum of body and top of head; stripe of melanophores extend anteriorly from caudal peduncle; fins lightly peppered; later juveniles develop series of blotches along body and patterns develop on fins  
– Upper lobe of caudal fin remains very lightly pigmented throughout development; lower lobe develops 2 large pigment spots  
– Paired mandibular barbels present, moderately long and fleshy, grey with darker margins

**Note:**  
1. See box for comments on pectoral and pelvic fin pigment

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myomeres</td>
<td>about 43–44</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>43–44</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>13–15</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>8–10</td>
</tr>
<tr>
<td>Pectoral fin rays</td>
<td>13–16</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

**Pectoral Fin Patterns**

- **D. 18.8 mmSL**  
- **E. 42.5 mmSL**  
- **F. 60.0 mmSL**

**Figures:**  
Adult: Parin, 2002a; **A–C:** Parin and Belyanina, 1996; **D–F:** Staiger, 1965

**References:**  
Staiger, 1965; Shiganova and Kovalevskaya, 1991; Parin and Belyanina, 1996; Parin, 2002a
Early Stages of Fishes in the Western North Atlantic Ocean

Cheilopogon exsiliens

A. 13.5 mmSL

B. 28.0 mmSL

Relative height of dorsal fin higher than in juveniles of congeners

C. 50.5 mmSL
**Cheilopogon furcatus** (Mitchill, 1815)
**Exocoetidae**
Spotfin flyingfish

**Range:** Worldwide in tropical waters; in the western Atlantic Ocean from 44°N (in the Gulf Stream) to 18°S

**Habitat:** Epipelagic in highly oceanic waters; seldom, if ever, found close to land

**Spawning:** Year-round, with a possible low ebb during early fall, based on collections of young stages (Breder, 1932; Staiger, 1965)

**Eggs:**
- Demersal, attached to drifting algae or other floating objects
- Diameter: 1.7–1.9 mm; no other information

**Larvae:**
- Hatching length undescribed, <4.2 mmTL
- Head large, mouth oblique, body robust and compressed
- Mandibular barbels begin to form between 12 and 18 mmTL
- Fin rays in all fins begin to form at sizes <5.0 mmTL
- Pectoral and pelvic fin rays become elongate at about 12 mmTL
- Lower lobe of caudal fin noticeably longer than upper at 7.7 mmTL
- Dorsal fin pigment sparse, mostly on anterior half of fin
- Pigment includes scattering of melanophores on head and body, especially dorsally; 6 vague bars cross body during juvenile stage
- Paired mandibular barbels about 50% head length at 36 mmTL; (fully as long as head in 32.0 mmSL juvenile described by Parin and Belyanina, 1998, Fig. E)

**Note:**
1. See box for comments on pectoral and pelvic fin pigment

**Early Juvenile:**

**Meristic Characters**
- Myomeres: about 44–46
- Vertebrae: 44–46
- Dorsal fin rays: 11–14
- Anal fin rays: 8–12
- Pectoral fin rays: 14–17
- Pelvic fin rays: 6
- Caudal fin rays: 7+8 (PrC)

---

**Pigment on pectoral fin** begins at 16.4 mmSL with a blotch covering the base of fin and a band, with straight anterior edge, crossing the fin near its tip; tip of fin becomes covered with alternating light and dark areas; pelvic fin begins with few sooty strips on pale background, becomes very densely dark.

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**E. 32.0 mmSL**

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**Figures:**
- Adult: D. R. Harriott (Scott and Scott, 1988); A–D: Hildebrand and Cable, 1930 (modified); E: Parin, 2002a

**References:**
- Staiger, 1965; Shiganova and Kovalevskaya, 1991; Parin and Belyanina, 1998; Parin, 2002a
The series of larvae and juveniles collected off North Carolina and described by Hildebrand and Cable (1930) was apparently identified (as *Cypselurus furcatus* = *Cheilopogon furcatus*) based on the relative lengths of pelvic fins and on fin ray counts of 13 or 14 dorsal and 9 or 10 anal. The young stages of congeners reported to occur off North Carolina also have elongate pelvic fin rays, and dorsal and anal fin ray counts broadly overlap in all four species. Therefore those characters (considered alone) are of dubious value in identifying young stages of *Cheilopogon*. However, mandibular barbels in the young of two of these congeners are either extremely elongate (in *C. cyanopterus*) or flap-like, branched and darkly pigmented (in *C. exsiliens*). The barbels in *C. melanurus*, however, have been described as being very similar to those in the Hildebrand and Cable series, and much shorter than those in *C. furcatus* juveniles (Gibbs and Staiger, 1970; Parin, 2002a). Furthermore, a juvenile (32.0 mmSL) *C. furcatus* described by Parin and Belyanina (1998) (repeated in Parin, 2002a and shown here as Fig. E) has barbels that are considerably longer than those indicated in the Hildebrand and Cable series. Hildebrand and Cable (1930) also mention the presence of a “pearly-white spot near the base of the ventrals” in adults of *C. furcatus*. This character has not since been mentioned by students of the group, nor is it of any apparent value in the young stages. The juveniles of both *C. furcatus* and *C. melanurus* have been described as having 6 dark, transverse bars on a pale body (Parin, 2002a). Given the foregoing caveats, therefore, the identification of the present series should be considered putative until diagnostic characters can be described to separate the young stages of all the species contained in *Cheilopogon.*
Cheilopogon melanurus (Valenciennes, 1847)
Exocoetidae
Atlantic flyingfish

Range: Western Atlantic Ocean from 42°N to Trinidad, including Gulf of Mexico and Caribbean Sea; strays into Gulf of Maine; also coast of Brazil from Equator to 30°S

Habitat: Neritic species strongly associated with coastal waters; found offshore only in area between Gulf Stream and Bermuda

Spawning: Summer (at least); young stages collected year-round, southern United States

Eggs: – Demersal, spherical
  – Diameter up to 1.9 mm
  – Chorion equipped with uniform covering of attachment filaments

Larvae: – Early larvae undescribed
  – Hatching length undescribed
  – Pectoral and pelvic fin rays long; dorsal and anal fins positioned posteriorly on body, dorsal fin typically longer-rayed than anal fin in juvenile and adult stage
  – Lower lobe of caudal fin longer than upper; begins to form early in development
  – Dorsal fin in juveniles either uniformly pale, or pale with several dark blotches
  – Juvenile pigment includes series of bars crossing body and a stripe extending forward from caudal peduncle
  – Paired mandibular barbels present, but not exceedingly long (cf: Cheilopogon cyanopterus)

Note:
1. See box for comments on pectoral and pelvic fin pigment
2. Previously widely reported as Cheilopogon heterurus, which is now understood to be restricted to eastern Atlantic and Mediterranean Sea, with a disjunct population close to shore off Bermuda

Juvenile:

Meristic Characters
Myomeres: about 45–48
Vertebrae: 45–48
Dorsal fin rays: 12–13
Anal fin rays: 8–10
Pectoral fin rays: 13–17
Pelvic fin rays: 6
Caudal fin rays: 7+8 (PrC)

Pigment on juveniles’ pectoral fins begins with uniform dense shading with clear, unpigmented center. Larger juveniles have a spot at upper corner of fin, plus pattern of bars and stripes (Figs. B and D). Pelvic fin initially shaded, then develops cross-banding pattern.

D. 69.5 mmSL

Figures: Adult and A, B, D: Parin and Belyanina, 2000; C: Gibbs and Staiger, 1970
References: Staiger, 1965; Gibbs and Staiger, 1970; Fahay, 1975; Parin and Belyanina, 2000; Parin, 2002a
Two juveniles (23 and 28 mm) collected in the eastern tropical Atlantic and described as *Cheilopogon melanurus* by Gibbs and Staiger (1970) were identified as *C. milleri*, an eastern Atlantic species by Parin and Belyanina (2000). The 28.0 mm specimen is shown here (Fig. C). Juveniles of *C. milleri* differ from *C. melanurus* in morphology of mandibular barbel, dorsal fin height and shape, and pigment patterns on the pectoral and dorsal fins.
**Cypselurus comatus** (Mitchill, 1815)
Exocoetidae
Clearwing flyingfish

**Range:** Tropical western Atlantic Ocean; most common off Florida, the Bahamas, Antilles and Caribbean Sea; rarely in Gulf of Mexico or off Brazil; holotype (a juvenile) collected off New York

**Habitat:** Epipelagic in neritic waters; a juvenile has been reported from just south of study area at 34°17.03'N, 75°47.22'W (Quattrini *et al*., 2004) and others might be expected to occur in study area in Gulf Stream or Slope Sea waters

**Spawning:** Feb–Apr (West Indies)

**Eggs:**
- Demersal, attached to floating objects
- Diameter: 1.20–1.45 mm
- Chorion: attachment filaments uniformly distributed
- Oil globule: none

**Larvae:**
- Hatching occurs at 5.0 mm; body moderately long
- No elongate jaw "beaks"
- Fin rays form early
- Pectoral and pelvic fin rays elongate
- Lower lobe of caudal fin longer than upper; begins to elongate at about 10 mm
- Dorsal fin pigment lacking
- Pigment in earliest larvae undescribed; pigment in later stages includes uniform scattering of large spots over head and body; gut darkly pigmented in later larvae; few, large spots on base of pectoral fin; caudal fin is only pigmented fin through most of development, until P$_1$ and P$_2$ fins acquire pigment at about 8.0 mm

**Note:**
1. The presence of a single, median, mandibular barbel on chin is diagnostic. Juveniles of other exocoetids have paired chin barbels or none.

**Juvenile:**

**Meristic Characters**
- Myomeres: 44–47
- Vertebrae: 44–47
- Dorsal fin rays: 11–13
- Anal fin rays: 8–9
- Pectoral fin rays: 12–14
- Pelvic fin rays: 6
- Caudal fin rays: 7+8 (principal)

**Figures:** Adult: Parin, 2002a; Egg: Breder, 1927; A–C: Kovalevskaya, 1982; D: Staiger, 1965

**References:** Breder, 1927; Bruun, 1935; Staiger, 1965; Kovalevskaya, 1982
Cypselurus comatus

A. 11.2 mmSL

B. 17.2 mmSL
**Exocoetus obtusirostris** Günther, 1866
**Exocoetidae**
Oceanic two-wing flyingfish

**Range:** Tropical Atlantic Ocean; in the western North Atlantic as far north as 40°N, including Gulf of Mexico and Caribbean Sea

**Habitat:** Epipelagic in open ocean waters

**Spawning:** Eggs spawned in small batches (420–890 eggs per batch)

**Eggs:**
- Pelagic, spherical
- Diameter: 2.8–2.9 mm
- Chorion lacks attachment filaments

**Larvae:**
- Hatching occurs at <4.0 mm
- Body slender, head large with blunt "forehead"
- No elongate jaw "beaks", no mandibular barbels on lower jaw
- Fin rays form early; pectoral fin rays last to form
- Pectoral fin rays begin to elongate at about 10 mm
- Pelvic fin origin far forward; pelvic fin rays do not elongate
- Lower lobe of caudal fin longer than upper; begins to form <10 mm
- Dorsal fin pigment light; few spots form on posterior part of fin
- Pigment includes dense scattering of spots over much of head and body in early larvae; pigment becomes more dense on dorsum in later stages; pectoral fins lightly pigmented

**Note:**
1. Juveniles are evenly pigmented on the body, without bold bars; dorsal and anal fins have black smudge posteriorly; pelvic fins mostly blackish, origin closer to pectoral fin than to anal fin; pectoral fins transparent

**Early Juvenile:**

---

**Meristic Characters**

<table>
<thead>
<tr>
<th>Character</th>
<th>Value</th>
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<tbody>
<tr>
<td>Myomeres</td>
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<tr>
<td>Vertebrae</td>
<td>42–45</td>
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<tr>
<td>Dorsal fin rays</td>
<td>12–14</td>
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<td>Anal fin rays</td>
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<td>Pectoral fin rays</td>
<td>15–17</td>
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<tr>
<td>Pelvic fin rays</td>
<td>6</td>
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<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

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**Figures:** Adult: Parin, 2002a; A–D: Kovalevskaya, 1964; E: Parin, 2002a

**References:** Kovalevskaya, 1964; 1982; Parin and Gorbunova, 1964; Collette *et al.*, 1984a; Parin and Shakhovskoy, 2000; Parin, 2002a
Early Stages of Fishes in the Western North Atlantic Ocean

Exocoetus obtusirostris

A. 4.3 mmSL

B. 10.1 mmSL

C. 18.5 mmSL

Note
“humpbacked” appearance

D. 61.5 mmSL
Exocoetus volitans Linnaeus, 1758
Exocoetidae
Tropical two-wing flyingfish

Range: Worldwide in tropical waters; in the western North Atlantic Ocean as far north as 35° 57'N, 73° 13'W; very abundant in open ocean waters, rare in Gulf of Mexico

Habitat: Epipelagic in open ocean waters; rarely neritic

Spawning: Year-round; eggs spawned in small batches (330-420 eggs per batch); spawns well offshore, based on distribution of small larvae

Eggs:
- Pelagic, spherical
- Diameter: 1.7–2.0 mm
- Chorion lacks attachment filaments

Larvae:
- Hatching occurs at about 3.5 mm, flexion underway, fin rays formed
- No elongate jaw "beaks", no mandibular barbels on lower jaw
- Fin rays form early; pectoral fin rays last to form
- Pectoral fin rays begin to elongate at about 10 mm
- Pelvic fin origin far forward; pelvic fins do not elongate
- Lower lobe of caudal fin longer than upper; begins to form at about 10 mm
- Dorsal fin pigment absent through development
- Pigment includes scattering of spots over much of head and body in early larvae, with a more dense accumulation of pigment forming across the body between dorsal and anal fins in larger stages; dense cluster of pigment forms over distal part of pectoral fin
- Transformation occurs at 13–16 mm, when all fin rays are formed and pectoral fin is elongate

Note: 1. Juveniles are pale with about 4 darker bars crossing body; dorsal and anal fins have dark smudge on posterior parts; pectoral fins are dusky with clear edge; pelvic fins are clear; pelvic fin origin much closer to pectoral fin than to anal fin

Juvenile:

H. 79.2 mmSL


References: Kovalevskaya, 1964; 1982; Collette et al., 1984a; Hunte et al., 1995; Parin and Shakhovskoy, 2000; Parin, 2002a

Meristic Characters

<table>
<thead>
<tr>
<th>Character</th>
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<tr>
<td>Myomeres</td>
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<tr>
<td>Vertebrae</td>
<td>43–45</td>
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<tr>
<td>Dorsal fin rays</td>
<td>13–15</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>12–14</td>
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<tr>
<td>Pectoral fin rays</td>
<td>14–16</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>
Early Stages of Fishes in the Western North Atlantic Ocean

Exocoetus volitans

A. 3.7 mmSL

B. 4.3 mmSL

C. 6.4 mmSL

D. 9.8 mmSL

E. 11.5 mmSL

F. 17.7 mmSL

G. 26.4 mmSL
Hirundichthys affinis (Günther, 1866)
Exocoetidae
Fourwing flyingfish

Range: Western Atlantic Ocean as far north as 35°N; abundant in Caribbean Sea and Gulf of Mexico; also eastern tropical Atlantic (see Note 2); target of important commercial fishery in eastern Caribbean Sea

Habitat: A neritic, or neritic-oceanic, epipelagic species

Spawning: Year-round with peak Mar–Jul; maturity reached at about 190 mm

Eggs: – Demersal, attached to floating objects or on benthic substrates
– Diameter: 1.6–1.9 mm (ovarian)
– Chorion equipped with 8–11 long attachment filaments originating at one pole of egg (with a central, thicker filament reaching 40 mm long) and a bundle of shorter, finer filaments at opposite pole

Larvae: – Hatching occurs at <4.0 mm, caudal fin rays formed
– No elongate jaw "beaks"
– Fin rays form early
– Pectoral and pelvic fin rays elongate
– Lower lobe of caudal fin longer than upper; begins to elongate at about 12–14 mm
– Dorsal fin pigment light; dark edged in larger juveniles
– Pigment in early stages includes heavy covering of distinct melanophores over head and body; more extensive pigment over gut; opercle pigmented, but no separate, distinct spots as in larvae of Hirundichthys speculiger; pigment on underside of head light, few spots near lower jaw tip; late larvae develop pigment on edges of pectoral and pelvic fins

Note: 1. Juveniles pale; pectoral and pelvic fins crossed by bands; pelvic fins long, with origin closer to anal fin than to pectoral fin; dorsal fin not particularly high, outer margin dark

2. This species just reaches southern limit of study area; juveniles possible in Gulf Stream north of 35°N

Juvenile:

H. Size Unknown

Meristic Characters
Myomeres: about 45–47
Vertebrae: 45–47
Dorsal fin rays: 10–12
Anal fin rays: 11–13
Pectoral fin rays: 16–18
Pelvic fin rays: 6
Caudal fin rays: 7+8 (PrC)

References: Bruun, 1935; Breder, 1938; Evans, 1961; Lewis et al., 1962; Belyanina, 1994; Oxenford et al., 1995a; 1995b; Hunte et al., 1995; Parin, 2002a

Figures: Adult and H: Parin, 2002a; A–G: Belyanina, 1994
**Hirundichthys affinis**

A. 4.6 mmSL

B. 8.2 mmSL

C. 14.0 mmSL (Ventral Head)

D. 14.0 mmSL

Larvae and juveniles very slim-bodied

E. 21.2 mmSL

F. 37.5 mmSL (Ventral Head)

G. 37.5 mmSL
**Hirundichthys rondeletii** (Valenciennes, 1846)

**Exocoetidae**

Blackwing flyingfish

**Range:** Worldwide in Atlantic, Pacific, Indian oceans and Mediterranean Sea; in the western North Atlantic between 42°N and 28°N; also northern parts of Gulf of Mexico

**Habitat:** Epipelagic in open ocean waters

**Spawning:** Winter-spring in Pacific; undescribed in Atlantic

**Eggs:**
- Demersal, attached to floating objects or vegetation
- Diameter: 1.4–1.5 mm
- Chorion equipped with 90–100 attachment filaments arising from one pole, a single filament arising from opposite side of egg

**Larvae:**
- Hatching occurs at <4.0 mm
- No elongate jaw "beaks", no mandibular barbels
- Fin rays form early
- Pectoral fin rays begin to elongate at about 6.0 mm
- Lower lobe of caudal fin longer than upper; begins to elongate at about 12.0 mm
- Dorsal fin pigment absent until juvenile stage
- Pigment in early larvae includes scattering of spots over much of head and body; later larvae develop few vague bars across body

**Note:**
1. Juveniles pale with few, vague bars crossing body; dorsal fin black at tips of rays; pectoral fin mostly black, with clear edge; pelvic fins long and mottled, with origin closer to anal fin than to pectoral fin

**Meristic Characters**

<table>
<thead>
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<th>Character</th>
<th>Range</th>
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</thead>
<tbody>
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<tr>
<td>Vertebrae</td>
<td>45-46</td>
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<tr>
<td>Dorsal fin rays</td>
<td>10-12</td>
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<tr>
<td>Anal fin rays</td>
<td>11-13</td>
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<tr>
<td>Pectoral fin rays</td>
<td>16-19</td>
</tr>
<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7±8 (PrC)</td>
</tr>
</tbody>
</table>

**Figures:**

- Adult: Bruun, 1935; A, B, E, F: Kovalevskaya, 1980; Eggs and C: Kovalevskaya, 1972; D: Okiyama, 1988
- References: Kovalevskaya, 1972; 1980; Okiyama, 1988; Collette *et al.*, 1984a; Amaoka *et al.*, 1992; Watson, 1996k; Parin, 2002a
Hirundichthys rondeletii

A. 4.3 mmSL

B. 6.5 mmSL

C. 11.2 mm

D. 12.8 mmSL

Larvae and juveniles very slim-bodied

E. 22.0 mmSL
Hirundichthys speculiger (Valenciennes, 1846)
Exocoetidae
Mirrorwing flyingfish

Range: Worldwide in Atlantic, Pacific and Indian oceans; in the western North Atlantic as far north as 40°N, not including Gulf of Mexico or western Caribbean Sea

Habitat: Epipelagic in open ocean waters

Spawning: Year-round

Eggs: Demersal, attached to floating objects
  - Diameter: 1.53–1.87 mm (maximum: 2.2 mm)
  - Chorion equipped with cluster of 7–20 attachment filaments arising from one pole, a single, long, thick filament arising from opposite pole

Larvae: Hatching occurs at about 3.6 mm
  - No elongate jaw "beaks", no mandibular barbels
  - Fin rays form early
  - Pectoral and pelvic fin rays begin to elongate at sizes <10 mmSL
  - Lower lobe of caudal fin longer than upper; begins to elongate at about 10 mmSL
  - Dorsal fin pigment absent in larval stages
  - Pigment in early stages includes light scattering of spots over body, with circular cluster on top of head; 3 prominent spots on opercle; cluster of spots on middle of caudal peduncle; late larvae develop pigment on edges of pectoral and pelvic fins

Note: 1. Juveniles pale; pectoral and pelvic fins mottled with dark spots and bands; pelvic fins long, with origin closer to anal fin than to pectoral fin; dorsal fin low, outer margin darkly pigmented

Juvenile:

G. 58.0 mmSL

Meristic Characters
Myomeres: about 45–47
Vertebrae: 45–47
Dorsal fin rays: 10–13
Anal fin rays: 11–13
Pectoral fin rays: 17–20
Pelvic fin rays: 6
Caudal fin rays: 7+8 (PrC)

References: Kovalevskaya, 1972; Collette et al., 1984a; Chen 1987; 1988; Amaoka, et al., 1992; Belyanina, 1994; Parin, 2002a
Early Stages of Fishes in the Western North Atlantic Ocean

*Hirundichthys speculiger*

A. 5.5 mmSL

B. 5.5 mmSL (Ventral Head)

C. 9.2 mmSL

Note prominent spots on opercle visible in ventral views of head

D. 14.5 mmSL

E. 14.5 mmSL (Ventral Head)

Larvae and juveniles very slim-bodied

F. 21.4 mmSL
**Parexocoetus hillianus** (Gosse, 1851)

**Exocoetidae**

Sailfin flyingfish

**Range:** Atlantic Ocean, mostly in tropical waters; in the western North Atlantic from 40°N to northern Brazil; very common in Caribbean Sea and Lesser Antilles, less common in Gulf of Mexico, Gulf Stream, and western Sargasso Sea

**Habitat:** Epipelagic in open ocean waters

**Spawning:** Much of year off coast of U.S.; in 2 pulses (Mar–Aug and Sep–Jan) in Caribbean Sea; may spawn close to shore

**Eggs:**
- Demersal, attached to floating objects

**Larvae:**
- Hatching occurs at <4.0 mm; fin rays form early
- No elongate jaw "beaks" (except *Parexocoetus brachypterus brachypterus* forms small, lower jaw beak by 18 mm, Figs. J, K)
- Pair of short, mandibular barbels form in larvae; length about equal to eye diameter in late larvae, longer in older juveniles (Fig. I)
- Pectoral fins become moderately elongate; pelvic fins do not
- Lower lobe of caudal fin longer than upper; begins to elongate at about 9 mm
- Dorsal fin pigment begins as shading in mid-fin, spreads to include most of fin
- Pigment in early stages includes scattered spots that follow myosepta outlines

**Note:**
1. This species is treated as *Parexocoetus brachypterus hillianus* (or simply *P. brachypterus*) by recent authors, but most recently as *P. hillianus* by Parin (2002a). It is very closely related to the Pacific form, *P. brachypterus brachypterus*, therefore the early stages of the latter subspecies are included for comparison.

**Juvenile:**

**Meristic Characters**

<table>
<thead>
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<th>Character</th>
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<tbody>
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<tr>
<td>Vertebrae</td>
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<tr>
<td>Dorsal fin rays</td>
<td>9–14</td>
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<td>Anal fin rays</td>
<td>10–14</td>
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<td>11–13</td>
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<tr>
<td>Pelvic fin rays</td>
<td>6</td>
</tr>
<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

**Figures:**

- **Adult:** Parin, 2002a; **A–D:** Chen, 1987; **E–H:** Hildebrand and Cable, 1930; **I:** Parin, 2002a; **J–K:** Betsy Washington (Collette et al., 1984a)
- **References:** Hildebrand and Cable, 1930; Imai, 1959; Lewis, 1961; Fahay, 1975; Collette et al., 1984a; Okiyama, 1988; Oxenford et al., 1995b

**I. Size unknown**

Note very high, darkly pigmented dorsal fin, moderate sized pelvic fin originating closer to anal fin than to pectoral fin
Early Stages of Fishes in the Western North Atlantic Ocean

**Parexocoetus hillianus**

Series described as *Parexocoetus brachypterus brachypterus* (Chen, 1987)

A. 6.5 mmSL  
B. 8.9 mmSL  
C. 13.6 mmSL  
D. 16.5 mmSL

Series described as *Parexocoetus mesogaster* (Hildebrand and Cable, 1930)

E. 5.0 mmTL  
F. 11.0 mmTL  
G. 18.0 mmTL  
H. 36.0 mmTL

The larvae described by Hildebrand and Cable (1930) were collected off North Carolina where *P. hillianus* is the only member of the genus that occurs. They share several characters with the closely related Pacific series described by Chen (1987) and are most likely larvae of *P. hillianus*. 
**Prognichthys occidentalis** Parin, 1999
**Exocoetidae**
Western bluntnose flyingfish

**Range:** Western Atlantic Ocean between 40°N (juveniles in Gulf Stream) and 40°S, including Gulf of Mexico and Caribbean Sea

**Habitat:** Primarily neritic, avoiding open ocean

**Spawn:** Undescribed; small juveniles occur year-round off the coast of the southern United States

**Eggs:** Undescribed

**Larvae:**
- Undescribed
- Small juveniles occur in dark and light forms
- Pectoral and pelvic fins moderately elongate
- Lower lobe of caudal fin longer than upper
- Pigment in both forms very dense; both pectoral and pelvic fins almost black
- Juveniles are heavily pigmented on head, body and fins; pectoral fins in larger juveniles black, often with pale cross-bands

**Note:**
1. Collections of this species off the coast of the United States have been referred to as *Prognichthys gibbifrons* (e.g. Fahay, 1975) a name applied to a valid species restricted to the eastern tropical Atlantic (Parin, 1999).
2. A congener, *Prognichthys glaphyrae* Parin, 1999, occurs mostly in the cores of central oceanic gyres, including the North Atlantic, where it has been collected as far north as 32°N. Larvae and juveniles have been described by Parin (1999).

**Juvenile:**

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**Meristic Characters**

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<td>Anal fin rays</td>
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<td>Pelvic fin rays</td>
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<tr>
<td>Caudal fin rays</td>
<td>7+8 (PrC)</td>
</tr>
</tbody>
</table>

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**F. Size unknown** (illustration possibly based on same specimen as depicted in Fig. E)

**Figures:**
- Adult: Parin, 2002a; A–E: Parin, 1999; F: Parin, 2002a

**References:**
- Parin, 1999; 2002a
Prognichthys occidentalis

A. 13.2 mmSL (Dark Form)
B. 14.2 mmSL (Light Form)
C. 25.1 mmSL (Dark Form)
D. 25.3 mmSL (Light Form)
E. 67.2 mmSL