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

Suborder Family					
Species	Vertebrae	Dorsal Fin	Anal Fin	Caudal Fin	Pectoral Fin
Sphyraenoidei Sphyraenidae					
Sphyraena barracuda	24	V, I, 8–10	III, 7–9	32	11-12
Sphyraena borealis	24	V, I, 8–9	II, 8–9	35	11-12
Sphyraena guachancho	24	V, I, 9–10	I–II, 7–8	36	11-12
Scombroidei					
Scombrolabracidae					
Scombrolabrax heterolepis	30	XII, 15–16	III, 15–17	7-9+9+8+8-10	18–19
Gempylidae					
Diplospinus multistriatus	58-61	XXX-XXXVI, I, 35-41	II, 29–35	4+9+8+5	14
Gempylus serpens	51-55	XXVI–XXXII, I–II, 10–12	II+I, 10–12	8-10+9+8+9-10	12-15
Lepidocybium flavobrunneum	31-32	VIII–XII, 16–18	II, 10–14	10+9+8+10	15-17
Nealotus tripes	36–39	XIX-XXI, I, 16-19	II, 15–19	8+9+8+10	12-14
Neoepinnula americana	32	XVI, I, 17–20	II, I, 17–20	9-10+9+8+9-10	15-16
Nesiarchus nasutus	33–37	XIX-XXII, I, 19-22	II–III, 15–17	8-9+9+8+8-9	13
Promethichthys prometheus	34	XII–XIV, I, 17–21	I–II, 15–17	10-11+9+8+10	14
Ruvettus prettiosus	32	XIII–XV, 15–18	III, 12–16	10+9+8+10	14–15
Trichiuridae					
Aphanopus carbo	98–99	XXXVIII–XLI,II, 53–57	II, 44–50	Small, 9+8 (PrC)	12
Aphanopus intermedius	102-107	XL-XLIV, 54-59	II, 46–50	Small, 9+8 (PrC)	12
Benthodesmus simonyi	153-158	XLIV-XLVI, 104-110	II, 93–101	5+9+8+5	12-13
Benthodesmus tenuis	122-132	XXXIX–XLII, 79–88	II, 69–75	5+9+8+5	12-13
Evoxymetopon taeniatus	103-104	X, 77–86	II, 56	7+9+8+6-7	11-12
Lepidopus altifrons	98-107	90–96 (total)	II, 52–58	Small, 9+8 (PrC)	12
Trichiurus lepturus	162–168	III, 120–140	II, 105–108	None	I, 11–13
Xiphiidae					
Xiphias gladius	25–27	38-45, 4-5	12–16	8-10+9+8+9-11	16-19

Perciformes Suborders Sphyraenoidei and Scombroidei

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.

Suborder					
Family Species	Vertebrae	Dorsal Fin	Anal Fin	Caudal Fin	Pectoral Fin
Scombroidei					
Istiophoridae					
Istiophorus albicans	24	42-47+6-7	XI-XV+6-7	11-12+9+8+11-12	17–20
Makaira nigricans	24	41-43+6-7	XIII-XV+6-7	9+8 (PrC)	18-21
Tetrapterus albidus	24	38-46+5-6	XII–XVII+5–6	9+8 (PrC)	18-21
Tetrapterus pfluegeri	24	44-50+6-7	XIII–XVII+6–7	9+8 (PrC)	17-21
Scombridae ¹					
Acanthocybium solandri	62–64	XXIII–XXVII, 11–16	11-14	9+8 (PrC)	22-26
Auxis rochei	39	XX–XXII, 10–12	11-14	15+9+8+16	23-25
Auxis thazard	39	XX–XXII, 10–12	11-14	15+9+8+16	23-25
Euthynnus alletteratus	39	XIII–XVII, 11–13	11–15	15-16+9+8+14-16	25-29
Katsuwonus pelamis	41	XIV–XVI, 14–16	14–16	16-17+9+8+17-18	26–28
Sarda sarda	50-55	XX–XXIII, 13–18	14–16	9+8 (PrC)	23-26
Scomber colias	31	IX–XIII, 11–12	I, 11–14	10-11+9+8+10-12	19–22
Scomber scombrus	31	XII–XVII, 11	II, 11	10-11+9+8+10-12	19–21
Scomberomorus cavalla	41–43	XII–XVIII, 15–18	16–20	11-13+9+8+11-13	21-23
Scomberomorus maculatus	51-53	XVII–XIX, 17–20	17–20	11-13+9+8+11-13	20-23
Scomberomorus regalis	47–48	XVI–XVIII, 16–19	15-20	11-13+9+8+11-13	20-24
Thunnus alalunga	39	XI–XIV, 12–16	11–16	15-17+9+8+15-17	30–36
Thunnus albacares	39	XI–XIV, 12–16	11–16	15-17+9+8+15-17	30-36
Thunnus atlanticus	39	XI–XIV, 12–16	11–16	15-17+9+8+15-17	30-36
Thunnus obesus	39	XI–XIV, 12–16	11–16	15-17+9+8+15-17	30-36
Thunnus thynnus	39	XI–XIV, 12–16	11–16	15-17+9+8+15-17	30-36

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.

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

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.



Sphyraena barracuda

Sphyraena guachancho

Sphyraena borealis

Scombrolabracidae: *Scombrolabrax heterolepis* is considered by some authors to be the sole member of the perciform suborder Scombrolabracoidei (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 procurrent spur on the posteriormost, ventral procurrent 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.



Head spines in larvae of Gempylidae

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).

Suborders Sphyraenoidei and Scombroidei

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 spawn- ing
Eggs:	Pelagic, sphericalDiameter: 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)

- $-P_1$ 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:
 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:



1388

Meristic Characters Myomeres: 24 Vertebrae: 24 Dorsal fin rays: V, I, 8-10 Anal fin rays: III, 7–9 Pectoral fin rays: 11-12 Pelvic fin rays: I, 5 Caudal fin rays: 8+9+8+7 Supraneurals: /0+0/0/2/1 (see note)

Sphyraena barracuda



Sphyraena borealis DeKay, 1842 Sphyraenidae Sennet



Meristic Characters

24

24

V, I, 8-9

II, 8–9

11 - 12

I, 5

9+9+8+9

/0+0/0/2/1

(see note)

Myomeres:

Vertebrae:

Dorsal fin rays:

Pectoral fin ravs:

Anal fin rays:

Pelvic fin rays:

Caudal fin rays:

Supraneurals:

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: $C D_2$, $A D_1$, $P_1 P_2$
 - D₁ origin at about the level of P₂ origin (compare to congeners)
 - $-P_1$ fin does not reach P_2 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)



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)References:deSylva, 1963a; 1984b; Houde, 1972; G. D. Johnson, 1986; Matsuura and Suzuki, 1997; Able and Fahay, 1998; Hare *et al.*, 2001; Russell, 2002



Sphyraena borealis



Sphyraena guachancho Cuvier, 1829 **Sphyraenidae** Guanchanche



Range:	Western North Atlantic Ocean from Massachusetts (rarely) to Brazil, includ- ing Gulf of Mexico and Caribbean Sea; also eastern Atlantic
Habitat:	Occurs in schools in shallow, turbid, coastal waters, often over muddy sub- strates
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: $C D_2, A D_1, P_1 P_2$
- D₁ origin equal to, or slightly posterior to, P₂ origin
- $-P_1$ fin reaches slightly beyond P_2 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:



H. 23.3 mmSL

Meristic Characters		
Myomeres:	24	
Vertebrae:	24	
Dorsal fin rays:	V, I, 9–10	
Anal fin rays:	I–II, 7–8	
Pectoral fin rays:	11-12	
Pelvic fin rays:	I, 5	
Caudal fin rays:	10+9+8+9	
Supraneurals:	/0+0/0/2/1	
	(see note)	

Sphyraena guachancho



A. 2.5 mmNL





C. 3.7 mmNL (Ventral and Dorsal Views)

B. 3.7 mmNL



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



Meristic Characters

30

30

XII, 15-16

III, 15–17

18-19

I, 5

none

Myomeres:

Vertebrae:

Dorsal fin rays:

Pectoral fin rays:

Caudal fin rays: 7–9+9+8+8–10

Pelvic fin rays:

Supraneurals:

Anal fin rays:

- 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: $C D_2$, $A D_1 P_2 P_1$
 - 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 D_1 fin, then spreads posteriad; dense pigment on peritoneum; melanophores ncrease 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)

Scombrolabrax heterolepis



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: D_1 , $P_2 P_1 A$, $C D_2$
 - 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:



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

References: Voss, 1954; Strasburg, 1964; Nishikawa, 1982; 1987a; Collette et al., 1984b; Ozawa, 1986h; Parin and Nakamura, 2002a

Meristic Charac	ters
Myomeres:	58-61
Vertebrae:	58-61
Dorsal fin rays:	XXX–XXXVI,
	I, 35–41
Anal fin rays:	II, 29–35
Pectoral fin rays:	14
Pelvic fin rays:	I, 0 (no rays)
Caudal fin rays:	4+9+8+5
Supraneurals:	none

Diplospinus multistriatus



E. 17.4 mmSL

1398

Gempylus serpens Cuvier, 1829 Gempylidae Snake mackerel



Dorsal fin rays: XXVI-XXXII, I, 10-12

51-55

51-55

II+I, 10–12

12 - 15

I. 3–4

8-10+9+8+9-10

none

Meristic Characters

Myomeres:

Vertebrae:

Anal fin rays:

Pectoral fin rays:

Pelvic fin rays:

Caudal fin rays:

Supraneurals:

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
- Preanus 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: $D_1, P_2 P_1, C D_2, A$
- 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, midlateral 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:



G. 26.4 mmSL

Gempylus serpens



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



Early Juvenile:



G. 33.0 mmSL

Meristic Characters		
Myomeres:	31	
Vertebrae:	31-32	
Dorsal fin rays:	VIII–XII, 16–18	
Anal fin rays:	II, 10–14	
Pectoral fin rays:	15-17	
Pelvic fin rays:	I, 5	
Caudal fin rays:	10+9+8+10	
Supraneurals:	none	



1402

Nealotus tripes Johnson, 1865 Gempylidae 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: $D_1 P_1$, $P_2 C D_2$, 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:



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

Meristic Charact	ters
Myomeres:	36–39
Vertebrae:	36–39
Dorsal fin rays:	XIX–XXI, I, 16–19
Anal fin rays:	II, 15–19
Pectoral fin rays:	12-14
Pelvic fin rays:	I, 1–2
Caudal fin rays:	8+9+8+10
Supraneurals:	none

Nealotus tripes



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
- Undescribed Eggs:
- Body and head very deep, then tapers to a narrow caudal peduncle Larvae: - Snout moderately pointed; head length >40% SL until decreases to about 30% SL in juveniles
 - Mouth large, extending to about the middle of eve
 - 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 P₂ 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:



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

Meristic Characters		
Myomeres:	32	
Vertebrae:	32	
Dorsal fin rays:	XVI, I, 17–20	
Anal fin rays:	II, I, 17–20	
Pectoral fin rays:	15-16	
Pelvic fin rays:	I, 5	
Caudal fin rays:	9-10+9+8+9-10	
Supraneurals:	none	

Neoepinnula americana



Nesiarchus nasutus Johnson, 1862 Gempylidae Black gemfish



33-37

33-37

XIX-XXII, I, 19-22

II–III, 15–17

13

I, 5

8-9+9+8+8-9

none

Meristic Characters

Myomeres:

Vertebrae:

Dorsal fin rays:

Pectoral fin rays:

Pelvic fin rays:

Caudal fin rays:

Supraneurals:

Anal fin rays:

Range:	Worldwide in tropical and subtropical waters; in the western North Atlantic from Nova Scotia to Gulf of Mexico and Caribbean Sea
Habitat:	Meso- to benthopelagic in depths of 200-1,200 m; migrates vertically
Spawning:	Undescribed

Eggs: – Undescribed

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 Supraocular: 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:



G. 32.5 mmSL

Nesiarchus nasutus



F. 12.3 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 decreasesslightly 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

Figures:Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987aReferences:Nishikawa, 1982; 1987a; Gorbunova, 1982; Collette *et al.*, 1984b; Ozawa, 1986h; Parin and Nakamura, 2002a

Meristic Characters Myomeres: 34 Vertebrae: 34 Dorsal fin rays: XII-XIV, I, 17-21 Anal fin rays: I-II, 15-17 Pectoral fin rays: 14 Pelvic fin rays: I, 0 (no rays) Caudal fin rays: 10-11+9+8+10 Supraneurals: none



Ruvettus pretiosus Cocco, 1833 Gempylidae Oilfish



Meristic Characters

Myomeres: Vertebrae:

Dorsal fin rays:

Pectoral fin rays:

Pelvic fin rays:

Caudal fin rays:

Supraneurals:

Anal fin rays:

32

32

XIII-XV, 15-18

III, 12–16 14–15

I, 5

10+9+8+10

0/2/1/1/

Range:	Worldwide in tropical and subtropical waters; in the western North	1
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
 - Preanus 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 D₁ and D₂; 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 Supraocular: 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: 1. Specialized scales with hook-like projections cover body of juveniles

Early Juvenile:



Figures:Adult: Parin and Nakamura, 2002a; A–G: Nishikawa, 1987a (C reversed)References:Nishikawa, 1982; 1984; 1987a; Potthoff *et al.*, 1986; Parin and Nakamura, 2002a

Ruvettus pretiosus



Benthodesmus tenuis (Günther, 1877) Trichiuridae Slender frostfish



Range:	Isolated areas of Atlantic, Pacific and Indian oceans; in the west- ern North Atlantic known to occur off the coast of eastern United States, in the Gulf of Mexico and off Suriname	
TT 1 • 4 4		

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

Spawning: Undescribed

Eggs: – Undescribed

Meristic Characters Myomeres: 122-132 Vertebrae: 122-132 Dorsal fin rays: XXXIX-XLII, 79-88 Anal fin rays: II, 69–75 Pectoral fin rays: 12-13 Pelvic fin rays: I, 1 (tiny) Caudal fin rays: 5+9+8+5 Supraneurals: none

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: $D_1 D_2 A P_2 C$, P_1
- 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)

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

Benthodesmus tenuis



A. 8.1 mmNL (Benthosdesmus sp.)



B. 27.1 mmSL

Largehead hairtail (cutlassfish)

Trichiurus lepturus Linnaeus, 1758



- **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
 - Preanus 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		
Myomeres:	162-168	
Vertebrae:	162-168	
Dorsal fin rays:	III, 120–140	
Anal fin rays:	II, 105–108	
Pectoral fin rays:	I, 11–13	
Pelvic fin rays:	none	
Caudal fin rays:	none	
Supraneurals:	none	

1414

Trichiuridae

Trichiurus lepturus



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: Epi- 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: $C D_2$, $A D_1 P_1$ (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:



- Figures: Adult: Nakamura, 2002a; egg and A: Sanzo, 1922; B: Jack Javech (Collette *et al.*, 1984b); C, E, L: Tåning, 1955 (all redrawn); D: Arata, 1954 (redrawn) F–K: Potthoff and Kelley, 1982
- **References**: Arata, 1954; Tåning, 1955; Yasuda *et al.*, 1978; Potthoff and Kelley, 1982; Collette *et al.*, 1984b; Govoni *et al.*, 2000; 2003; 2004



Meristic Characters			
Myomeres:	24		
Vertebrae:	25-27		
Dorsal fin rays:	38 - 45 + 4 - 5		
Anal fin rays:	12-16		
Pectoral fin rays:	16–19		
Pelvic fin rays:	none		
Caudal fin rays:	8-10+9+8+9-11		
Supraneurals:	none		



Xiphias gladius



K. 188.0 mmSL