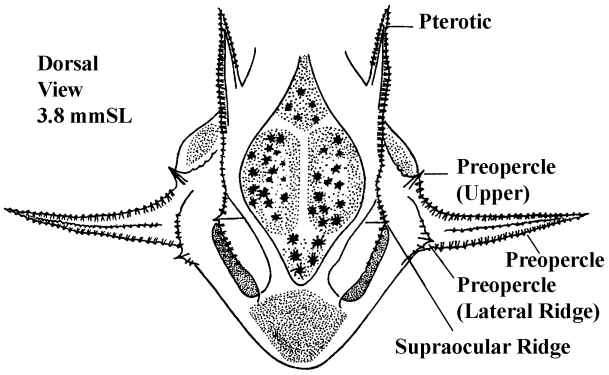
Istiophoridae

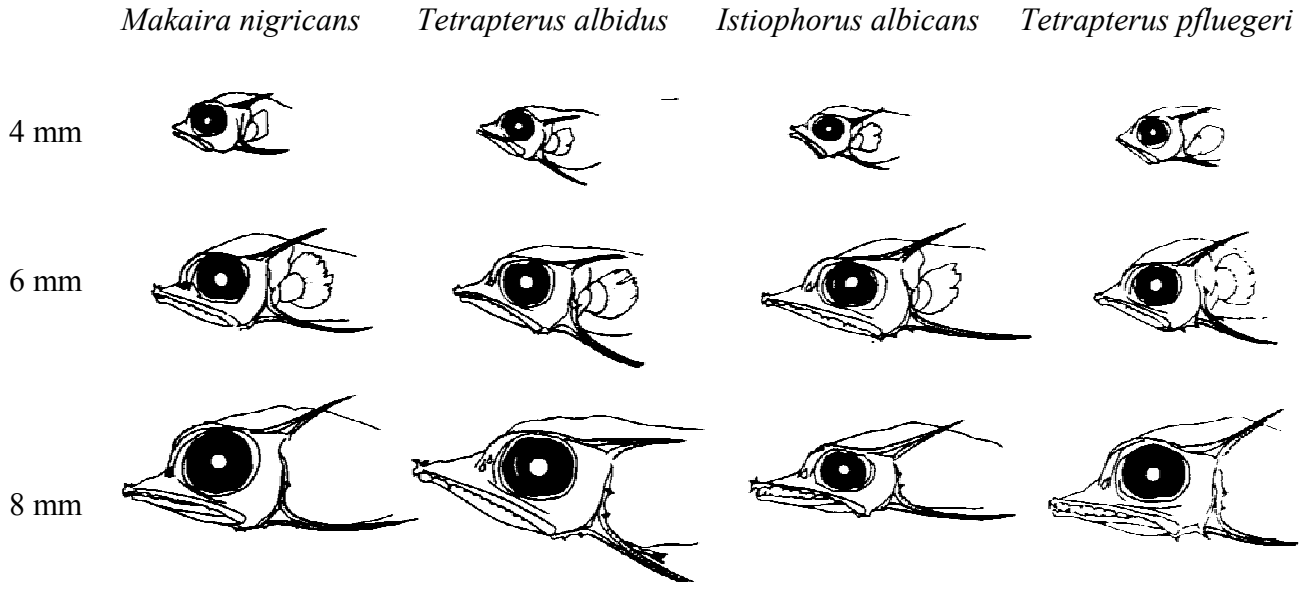
General larval characters: Prominent pterotic and preopercle spines develop at ca. 3 mm; both become quite long by 6–7 mm; preopercle spine eventually extends beyond anus; pterotic shortens in larvae >8 mm; both spines stop growing at ca. 11–12 mm and their lengths decrease relative to body length in larger larvae and juveniles. Larvae also have serrated ridges on dentary and articular bones.

Figure after Gehringer (1956), terminology modified.



Admittedly by some authors (e.g. Richards, 1975), the identification of istiophorid larvae can be more art than science. The observations contained in the table on the following page are all fraught with variation introduced by preservation method, fixed position of the head or body, or simply the subjectivity of the character. They are presented here only because they represent general observations that have been made by various workers. Suggested further avenues of research include quantification of serrations on the pterotic spine, preopercle spine, dentary and articular ridges.

The schematic figures below portray head profiles in various sizes of Indo-Pacific istiophorid larvae, labeled with their presumed Atlantic-Ocean counterparts (Ueyanagi, 1974b). Note relative differences in head depth, snout length and spine orientation.



As this monograph was in press, a report was published that tested the use of seasonal, morphological and pigment characters to correctly identify the larvae of four istiophorid species from the western Atlantic (Luthy *et al*., 2005). Molecular techniques were used to confirm identifications based on date of capture, lower jaw pigment pattern, and ratios of snout length to eye diameter. A key is presented, which combined with a separate canonical variates analysis allowed 92% of subject larvae to be correctly identified. See Luthy *et al*. (2005) for details.

Istiophoridae

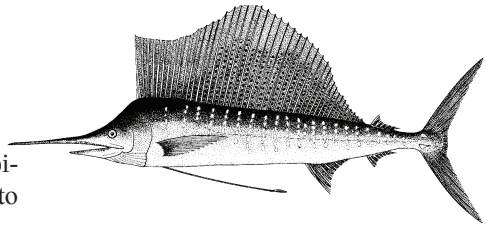
Larval Characters in istiophorid species pairs[1] (Ueyanagi, 1974a; 1974b; Richards, 1975). See schematic figures on previous page. Spine characters are best expressed in larvae <12–13 mm; meristic characters, dorsal fin shape and lateral line characters are best expressed in larvae >20 mm; pigment characters pertain to Pacific specimens and may not always be applicable to Atlantic congeners. Also refer to note box on opposite page.

Pacific species Atlantic species	*M. mazara* *M. nigricans*	*T. audax* *T. albidus*	*T. angusirostris* *T. pfluegeri*	*I. platypterus* *I. albicans*
Common names	Pacific blue marlin Atlantic blue marlin	Striped marlin White marlin	Shortbill spearfish Longbill spearfish	Pacific sailfish Atlantic sailfish
Lower jaw pigment	Confined to tip	Several spots	Undescribed	Present
Gular pigment	Absent or 1 on midline	Absent or 1 spot	None, or 1 spot on midline	Several spots on midline and laterally
Branchiostegal pigment	Absent	Absent or 1 spot	1 to several spots	Absent
Head profile	Moderate jaws, deep head; snout tip below mid-eye	Moderate jaws, deep head; snout tip high (at or above mid-eye)	Moderate jaws, deep head; snout tip below mid-eye	Londer jaws, shallower head; snout tip below mid-eye
Eye diameter/snout length	Large eye, short snout (>9 mm)	Longer snout	Longer snout	Longer snout
Orbit	Anterior edge projects forward	Edge not projecting	Edge not projecting	Edge not projecting
Pterotic spine	Oblique from base; >4 mm tip extends well above dorsal	<4 mm slightly oblique, then runs parallel to dorsum; tip does not extend above dorsal profile	Similar to that of *M. nigricans*	Oblique from base; tip extends well above dorsal profile (longer than in other species)
Preopercle spine (s)	Curves downward	Inclided sharply downward (parallel with line formed by gape)	Shorter than in. *M. nigricans*, inclined further downward; secondary spines well developed	Oriented about parallel to ventral profile but not as curved as in *M. nigricans*
1st dorsal fin rays[2]	41–43 + 6–7	38–46 + 5–6	44–50 + 6–7	42–47 + 6–7
1st dorsal fin shape	Anterior part highest	Anterior part highest	Anterior part highest	Posterior part highest
Lateral line	Complex, with branches (>14 mm)	Simple	Simple	Simple

[1] Ueyanagi (1974b) determined that larval characters did not differ within these species-pairs. However, variation in all of these characters should be tested further.

[2] Ranges compiled from Nakamura (1968) and Merrett (1971)

Istiophorus albicans (Latreille, 1804)
Istiophoridae
Atlantic sailfish



Range: Widely distributed throughout Atlantic Ocean in temperate and tropical waters; in western North Atlantic from Gulf of Maine (rarely) to South America, including Gulf of Mexico and Caribbean Sea

Habitat: Both coastal and oceanic waters, usually between the surface and the thermocline; highly migratory

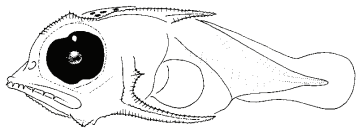
Spawning: Probably during warmer months; spawning by pairs or single female and one to several males

Eggs:
- Pelagic, spherical, buoyant
- Diameter: 1.3 mm
- Chorion: clear, transparent
- Oil globule: single

Larvae:
- Body moderately stubby, with large head and bulky gut
- Snout pointed, both jaws elongate during development
- Mouth large, gape extending well beyond eye; teeth well developed
- Preanus length 65–80% SL
- Flexion occurs at about 6.0 mmSL
- Sequence of fin ray formation: C – D, A – P_1, P_2
- Head spines prominent, form before fin rays; see checklist below
- Pigmentation includes large spots on top of head, spreading to dorsal snout and body; pigment on body generally heavier anterior to level of anus; few gular spots

Meristic Characters

Myomeres:	24
Vertebrae:	24
Dorsal fin rays:	42–47 + 6–7
Anal fin rays:	XI–XV + 6–7
Pectoral fin rays:	17–20
Pelvic fin rays:	3
Caudal fin rays:	11–12+9+8+11–12
Supraneurals:	none



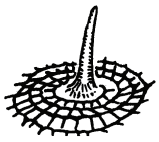
A. 3.6 mmNL

Head spine checklist:

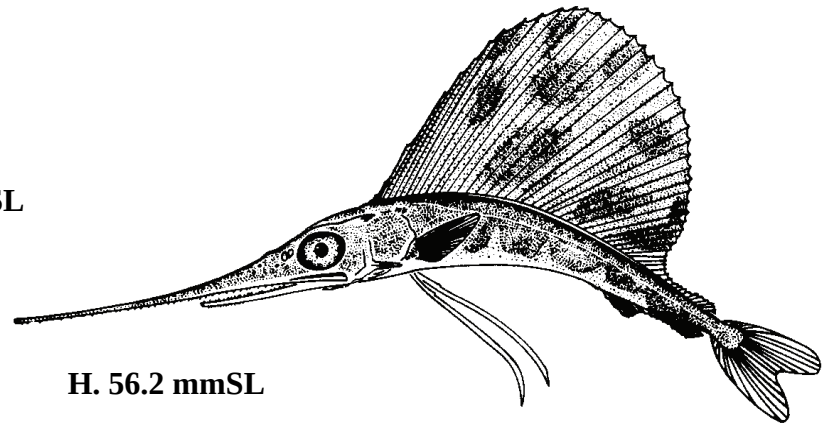
Supraoccipital: none
Preopercle: prominent spines on posterior edge and lateral ridge; long, 3-edged, serrated spine at angle
Supraocular: spiny ridge forms early
Pterotic: prominent, serrated, 3-edged spine forms early; confluent with supraocular ridge
Dentary: spiny ridge from short distance behind symphysis to similar ridge on articular
Articular: short spiny ridge appears as continuation of dentary ridge

Early Juvenile:

Dermal spines (Fig. I) cover preopercle, opercle and most of body beginning at about 43.0 mm; each spine arises from irregular plate



I. 101.0 mmSL

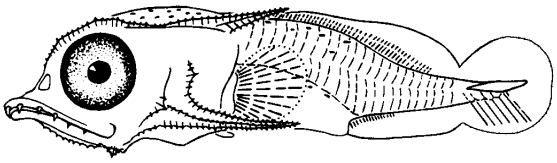


H. 56.2 mmSL

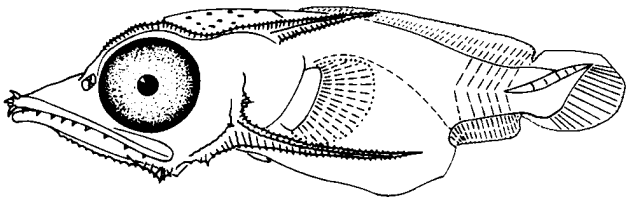
Figures: Adult: Nakamura, 2002B; **A–I**: Gehringer, 1956 (**B** and **C** modified; **A**, **D–F** redrawn)

References: Gehringer, 1956; Ueyanagi, 1963; 1964; 1974a; 1974b; Richards, 1975; 1989

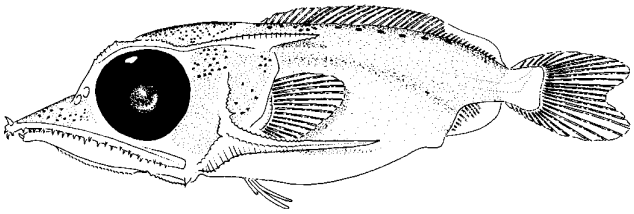
Istiophorus albicans



B. 4.7 mmNL

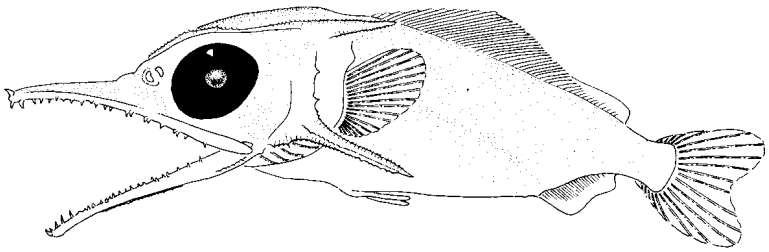


C. 5.6 mmNL

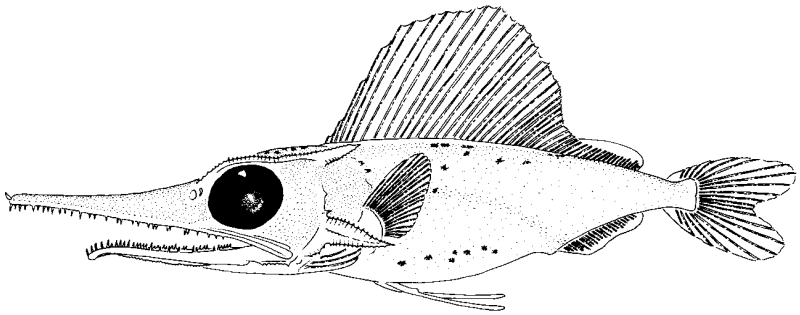


D. 8.1 mmSL

Note: This species is considered by some authors to be conspecific with the Indo-Pacific *Istiophorus platypterus* (Shaw and Nodder, 1791). Illustrated larvae were collected in the Atlantic Ocean.

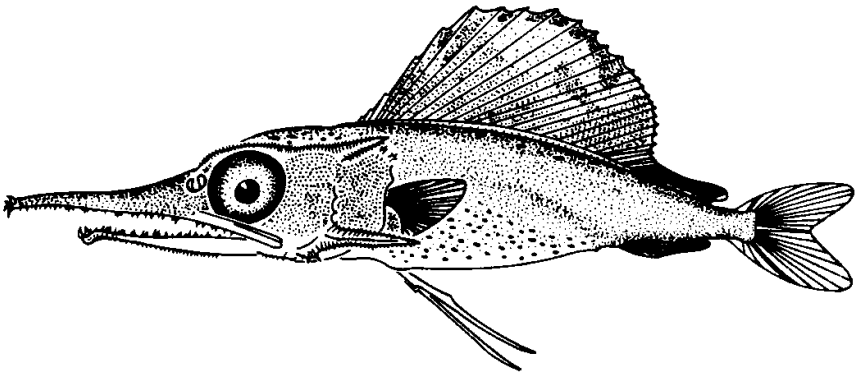


E. 11.3 mmSL



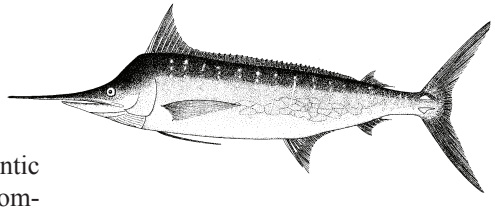
F. 18.2 mmSL

Compare to larvae with similar head spination in the families Dactylopteridae and Holocentridae.



G. 20.9 mmSL

Makaira nigricans Lacépède, 1802
Istiophoridae
(Atlantic) Blue marlin



Range: Atlantic Ocean in temperate to tropical waters; in the western Atlantic from Gulf of Maine (rarely) to latitude 40°S off South America; commonly occurs in central parts of Gulf of Mexico, Caribbean Sea and Brazil Current

Habitat: Pelagic in oceanic waters, usually between the surface and the thermocline and in surface temperatures of 22°–30°C; highly migratory

Spawning: Not well described; probably during warmer months (Jul–Sep); most spawning probably occurs well south of 35°N, but larvae have been collected in study area (e.g. MCZ 84428, 84429, 84430)

Eggs:
- Pelagic, transparent, spherical
- Diameter: 1.0 mm

Meristic Characters	
Myomeres:	24
Vertebrae:	11 + 13 = 24
Dorsal fin rays:	41–43 + 6–7
Anal fin rays:	XIII–XV + 6–7
Pectoral fin rays:	18–21
Pelvic fin rays:	I, 3
Caudal fin rays:	9+8 (PrC)
Supraneurals:	none

Larvae:
- Body moderately stubby, with large head and bulky gut
- Snout pointed, both jaws become moderately elongate during development (<1.5 times diameter of orbit)
- Mouth large, gape extending well beyond eye; teeth well developed
- Preanus length 70–75% SL
- Flexion occurs at unknown size (possibly 4–7 mm)
- Sequence of fin ray formation: unknown (probably similar to sequence in *Istiophorus albicans*)
- Head spines prominent, form before fin rays; see checklist below
- Pigmentation includes series of spots on top of head and over gut; pigment on body generally heavier anterior to level of anus; caudal peduncle and fin unpigmented; in most pelagic specimens, dorsal part of body blue with white venter

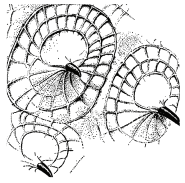
Head spine checklist:

Supraoccipital: none
Preopercle: prominent spines on posterior edge and lateral ridge; long, 3-edged, serrated spine at angle
Supraocular: ridge with low spines forms early
Pterotic: prominent, serrated, 3-edged spine forms early; confluent with supraocular ridge
Dentary: spiny ridge from short distance behind symphysis to similar ridge on articular
Articular: short, spiny ridge

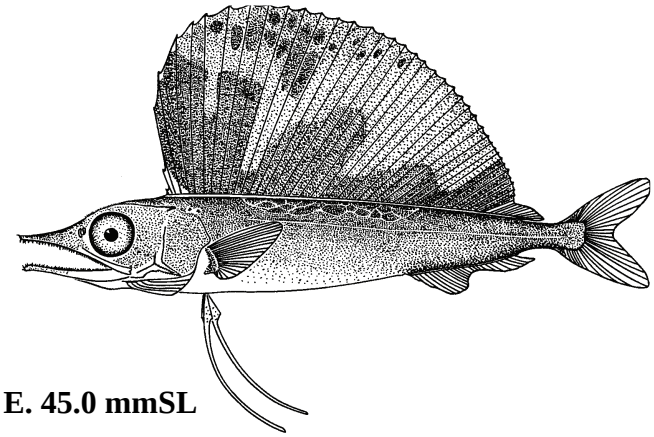
Early Juvenile:

Dermal spines (resembling those of *Istiophorus platypterus* from the Pacific Ocean, Fig. F) uniformly distributed over body with irregularly sized patches above lateral line

Note pigment pattern on dorsal fin and complex, branched lateral line



F. 84 mm

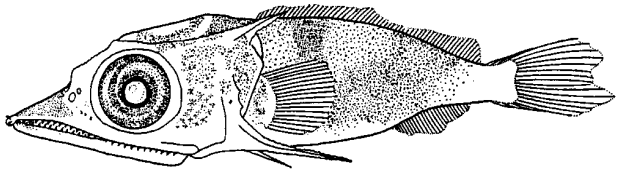


E. 45.0 mmSL

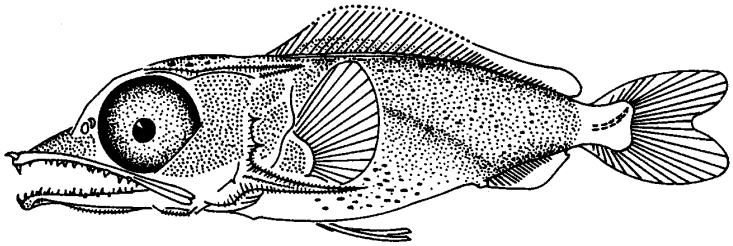
Figures: Adult: Nakamura, 2002b; **A**, **D**: Martha M. Howbert (Bartlett and Haedrich, 1968); **B–C**, **E**: Gehringer, 1956; **F**: Beebe, 1941

References: Beebe, 1941; Gehringer, 1956; Bartlett and Haedrich, 1968; Eschmeyer and Bullis, 1968; Rivas, 1975; Ueyanagi, 1963; 1964

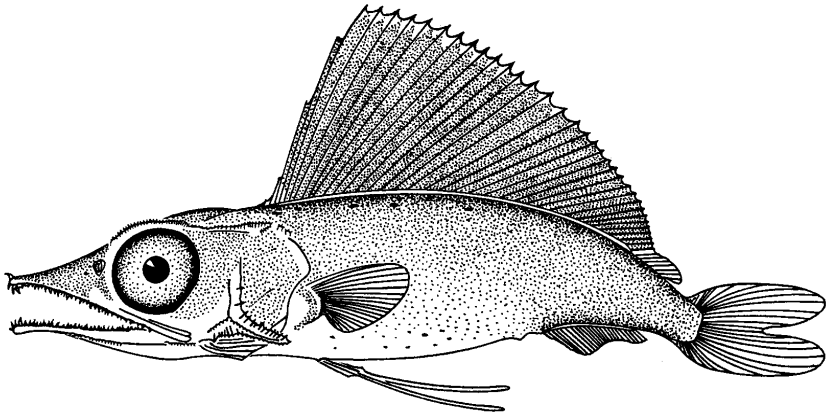
Makaira nigricans



A. 7.2 mmSL

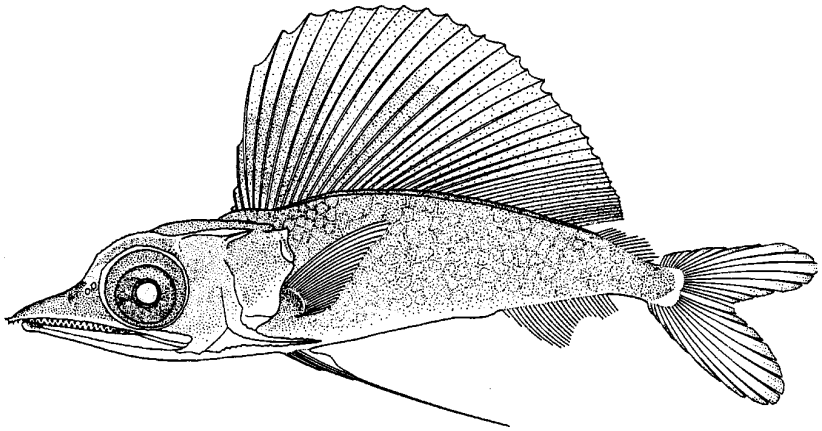


B. 11.3 mmSL



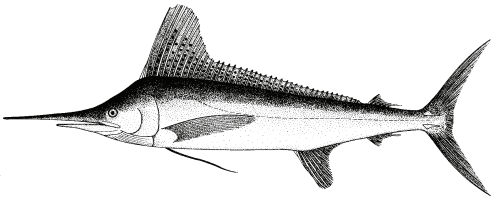
C. 21.0 mmSL Snout not as elongate as in larval *Istiophorus albicans*

Larvae in figures A and D collected in South Atlantic Ocean off Brazil



D. 22.1 mmSL

Tetrapterus albidus Poey, 1860
Istiophoridae
(Atlantic) white marlin



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

Habitat: Pelagic in oceanic waters, usually between the surface and the thermocline and in surface temperatures of 21–29°C; highly migratory

Spawning: Poorly described, but possibly strongest in spring; spawning concentrations off Bahamas, Cuba, Greater Antilles

Meristic Characters

Myomeres:	24
Vertebrae:	12 + 12 = 24
Dorsal fin rays:	38–46 + 5–6
Anal fin rays:	XII–XVII + 5–6
Pectoral fin rays:	18–21
Pelvic fin rays:	I, 3
Caudal fin rays:	9+8 (PrC)
Supraneurals:	none

Eggs:
- Undescribed

Larvae:
- Description based on putative larvae, similar to those of *Istiophorus albicans* (see note on figure page)
- Body moderately stubby, with large head and bulky gut
- Snout pointed, both jaws elongate during development (see note on figure page)
- Mouth large, gape extending well beyond eye; teeth well developed
- Preanus length about 80% SL
- Flexion occurs at about 6.0 mmSL
- Sequence of fin ray formation: C – D, A – P_1, P_2
- Head spines prominent, form before fin rays; see checklist below
- Pigmentation includes large spots on top of head, spreading to dorsal snout and body; pigment on body generally heavier anterior to level of anus; spots on gular membrane few or absent; branchiostegal membrane usually unpigmented

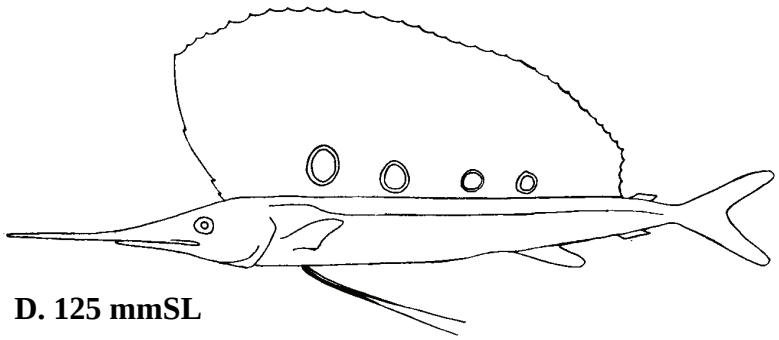
Head spine checklist:

Supraoccipital: none
Preopercle: prominent spines on posterior edge and lateral ridge; long, 3-edged, serrated spine at angle, inclined sharply downward
Supraocular: spiny ridge forms early
Pterotic: prominent, serrated, 3-edged spine forms early; confluent with supraocular ridge
Dentary: spiny ridge from short distance behind symphysis to similar ridge on articular
Articular: short spiny ridge appears as continuation of dentary ridge

Note: 1. Dermal spines presumably cover body in late larvae and juveniles, but these structures are undescribed

Early Juvenile:

Series of 4 large ocelli along base of dorsal fin rays may be replaced with 4 dark smudges

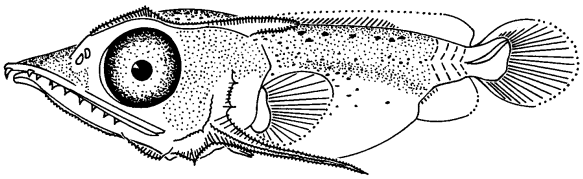


D. 125 mmSL

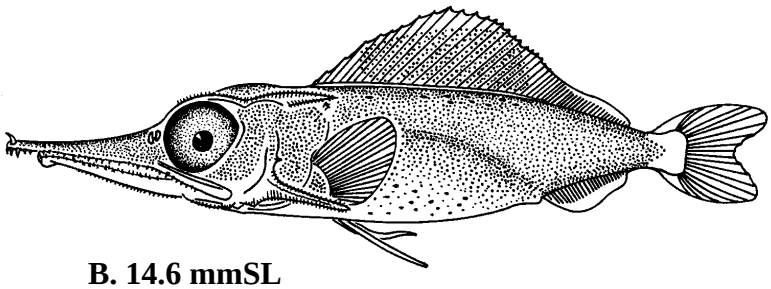
Figures: Adult: Nakamura, 2002b; **A–C**: Gehringer, 1956 (A modified); **D**: deSylva, 1963b

References: Gehringer, 1956; deSylva, 1963b; Ueyanagi, 1963; 1964; 1974a; 1974b; Mather *et al.*, 1975; Richards, 1975; 1989

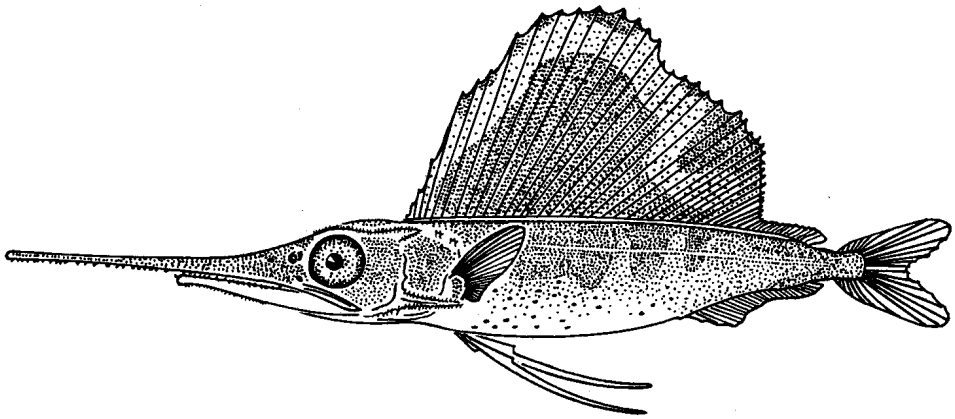
Tetrapterus albidus



A. 6.4 mmSL



B. 14.6 mmSL



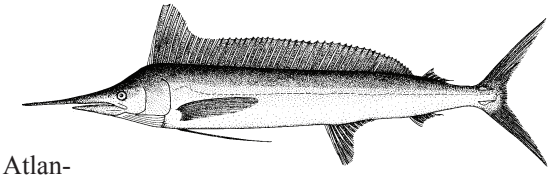
C. 38.8 mmSL

Note on identification of istiophorid larvae. Several summary reports have attempted to update progress on the ontogeny of billfishes, worldwide (e.g. Richards, 1974; Ueyanagi, 1974a; 1974b; Fritzsche, 1978; Richards, 1989). Many of these reports contain evaluations of certain character suites and suggestions for future analyses. Confusion continues, however, largely because of similarities between the taxa, but also because of the limited number of characters that have been examined. Complete osteological development studies are lacking, at least at the level at which *Xiphias gladius* has been studied (Potthoff and Kelley, 1982).

The larvae illustrated above were included in a series described as *Istiophorus americanus* (= *I. albicans*) by Gehringer (1956). These 3 specimens were re-identified as *Tetrapterus albidus* by Ueyanagi (1959), but Richards (1989) admonished that larvae could not reliably be separated from those of *I. albicans*. A potentially valuable character concerns the position of the upper jaw tip relative to mid-eye (above that level in *T. albidus*, below that level in *I. albicans*) but this character needs to be tested further.

Also refer to series of larvae 4.4–20.3 mmSL described in Richards and Luthy (2006).

Tetrapterus pfluegeri Robins and deSylva, 1963
Istiophoridae
Longbill spearfish



Range: Atlantic Ocean in temperate to tropical waters; in the western Atlantic from southern New England and New Jersey to Brazil; also off South Africa in the eastern Atlantic Ocean

Habitat: Pelagic in oceanic waters, usually between the surface and thermocline; highly migratory

Spawning: Nov–May with a peak in late winter

Eggs: – Undescribed

Meristic Characters

Myomeres:	24
Vertebrae:	12 + 12 = 24
Dorsal fin rays:	44–50 + 6–7
Anal fin rays:	XIII–XVII + 6–7
Pectoral fin rays:	17–21
Pelvic fin rays:	I, 3
Caudal fin rays:	9+8 (PrC)
Supraneurals:	none

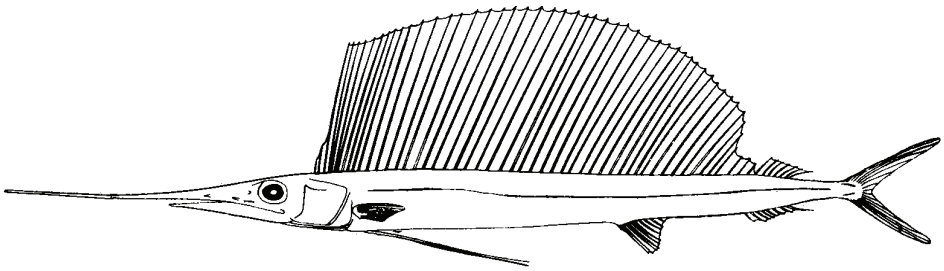
Larvae:
- – Incompletely described; description based on a single larva and a presumed resemblance to the larvae of the Pacific *T. angusirostris* (Ueyanagi, 1974b)
- – Body moderately stubby, with large head and bulky gut
- – Snout pointed, both jaws elongate during development
- – Mouth large, gape extending well beyond eye; teeth well developed
- – Preanus length about 80% SL
- – Flexion occurs at unknown size
- – Sequence of fin ray formation: C – D, A – P_1, P_2 (based on congeners)
- – Head spines prominent, form before fin rays; see checklist below
- – Pigmentation includes large spots on top of head, spreading to dorsal snout and body; pigment on body generally heavier anterior to level of anus; gular spots single or absent; 1 to several spots on branchiostegal membrane

Head spine checklist:

Supraoccipital: none
Preopercle: prominent spines on posterior edge and lateral ridge; long, 3-edged, serrated spine at angle; well-developed secondary spines on ascending limb of preopercle
Supraocular: spiny ridge forms early
Pterotic: prominent, serrated, 3-edged spine forms early; confluent with supraocular ridge
Dentary: spiny ridge from short distance behind symphysis to similar ridge on articular
Articular: short spiny ridge appears as continuation of dentary ridge

Note: 1. Dermal spines presumably cover body in late larvae and juveniles, but these structures are undescribed

Juvenile:



B: 368 mm

Figures: Adult: Nakamura, 2002b; **A**: Ueyanagi, 1974b; **B**: Robins and deSylva, 1963
References: Ueyanagi, 1963; 1964; 1974a; 1974b; Robins, 1975; Richards, 1975; 1989

Tetrapterus pfluegeri

A. 8.3 mmTL

(Identification putative, based on resemblance
to larvae of Pacific Ocean congener)

Scombridae

General larval characters:

- Body moderately deep, head large, snout produced, jaws well developed and may be elongate
- Head spines on 5 bones vary between genera (see table on opposite page)
- Myomere number relatively high (e.g. 31–66)
- Vertebral number is usually stable within a species (range is narrow)
- Sequence of fin ray formation: caudal fin rays first to form (with 9+8 PrC rays); D_1 spines then form before D_2 fin rays (reverse in *Scomber*); followed by anal fin rays, then P_2 and P_1
- Pelvic fin formula always I, 5
- Pectoral fin rays begin dorsally, development proceeds ventrally; number of fin rays is important
- Gap between anus and anal fin origin (except in *Acanthocybium*)
- Finlets present posterior to dorsal and anal fins; become discernible in late larvae and early juveniles
- Full complement of fin rays usually present by 15 mmSL
- Pigmentation somewhat variable, but important in some loci (see table on opposite page)
- Head pigment always present (except in some preflexion larvae); pigment in front of eyes present in *Euthynnus*, absent in *Auxis*
- Ventral pigment on tail in early larvae coalesces in later larvae, then number of spots increases again and dorsal pigment added to tail

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Larvae of the genus *Thunnus*:

- Pigmentation varies and may be unreliable; osteological characters are critical for accurate identification
- Osteological characters in larvae >6.0 mmSL in the genus *Thunnus* are included in table below. (Also see relationship between dorsal fin pterygiophores and interneural spaces (Potthoff, 1974.) Note Column 4 and 5 headings differ.

Character	*T. thynnus*	*T. alalunga*	*T. atlanticus*	*T. obesus* *T. albacares*
Precaudal + caudal vertebrae	18+21 (95%)	18+21 (97%)	19+20 (98%)	18+21 (85%)
1st closed haemal arch	Vert. # 10 (88%)	Vert. # 10 (99%)	Vert. # 11 (94%)	Vert. # 11 (93%)
Gill rakers on lower limb and total 1st arch	17–20 34–43	14–16 25–31	11–13 19–25	14–16 – 14–16 25–31 – 26–34

Number of pigment spots in *Thunnus* larvae 3–10 mmSL; some characters may be subjective. Also see species accounts

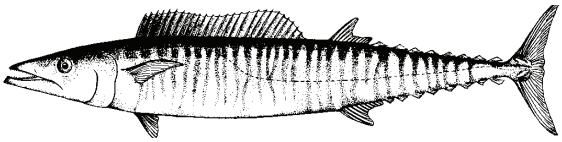
Body area	*T. thynnus*	*T. alalunga*	*T. albacares*	*T. obesus* *T. atlanticus*
Body dorsum	1–2	None	None	None
Lateral line	2 (some) or none	None	None	None
Tail venter	1–4	None	None	1 or more
Internal	1–2 or none	None	None	None
Jaw tips	2 or a few	Upper > 5 mm Lower > 9 mm	Upper > 6 mm Lower > 4.5 mm	Upper few > 5 mm Lower 0–2 < 4 mm

Scombridae

Selected developmental characters in 8 genera of Scombridae from the study area.
Synthesized by Okiyama and Ueyanagi (1978) or compiled from several sources

Character	*Scomber*	*Auxis*, *Euthynnus*, *Katsuwonus* *Thunnus*	*Sarda*	*Scomberomorus*	*Acanthocybium*
Myomeres	31	39–41	50–55	41–53	62–66
Dorsal fin	D_2 forms first	D_1 forms first	D_1 forms first	D_1 forms first	D_1 forms first
Head/SL ratio	< 1/3	> 1/3	> 1/3	> 1/3	> 1/3
Snout shape	Rounded	Pointed	Elongate	Elongate	Very elongate
Jaws	Equal in size	Equal in size	Equal/unequal	Equal/unequal	Upper longer
Premaxillary teeth	Minute	Large	Large	Large	Large
Venter	Space between anus and anal fin origin	Space between anus and anal fin origin	Space between anus and anal fin origin	Space between anus and anal fin origin	Anus adjacent to anal fin origin
Head Spines					
Supraoccipital	Absent	Absent	Absent	Present	Absent
Preopercle	Absent	Present	Present	Present	Present
Supraocular	Absent	Absent	Crest present	Crest present	Absent
Pterotic	Absent	Absent	Absent	Present	Absent
Posttemporal	Absent	Present	Present	Present	Absent
Pigment					
Dorsal body	Heavy	Light	Light	Heavy	Light
Postanus	Extensive	Present (but few spots or absent in *Thunnus* and *Katsuwonus*	Extensive	Extensive	Extensive
Cleithral symphysis	Yes (*S. scombrus*)	Yes (*Auxis* and *Euthynnus*)	Yes Yes	Yes Yes	Yes Yes
	No (*S. colias*)	No (*Katsuwonus* and *Thunnus*)			

Acanthocybium solandri (Cuvier, 1832)
Scombridae
Wahoo



Range: Worldwide in tropical and subtropical waters; in the western North Atlantic from Cape Hatteras and Bermuda throughout the Caribbean Sea; migratory in the Gulf Stream; larvae occur very rarely in study area, possibly transported north in the Gulf Stream

Habitat: Epipelagic in waters well away from coast; solitary or occurs in loose aggregations

Spawning: Off Cuba, Yucatan Peninsula and Florida; May–Oct, with peak in June

Eggs: – Undescribed

Meristic Characters

Myomeres:	62–64
Vertebrae:	30–32 + 31–33 = 62–64
Dorsal fin rays:	XXIII–XXVII, 11–16
Dorsal finlets:	7–10
Anal fin rays:	11–14
Anal finlets:	7–10
Pectoral fin rays:	22–26
Pelvic fin rays:	I, 5
Caudal fin rays:	9+8 (PrC)
Supraneurals:	none

Larvae:
- Body elongate throughout development
- Body depth increases from 6% SL in preflexion larvae to 8–10% SL at 9–10 mm
- Head large, shallow, with jaws becoming very elongate (upper longer than lower)
- Gut not as compact and triangular as in other scombrid larvae; preanus length increases from 60% SL to about 73% SL at about 10 mm; anus forms initially at anal fin origin
- Flexion occurs at about 6.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2, P_1
- Head spines moderately developed on preopercle; see checklist below
- Pigment includes 1 or 2 spots on ventral edge near caudal peduncle and scattered spots on snout; upper surface of gut with distinct spots; dorsal and ventral edge of tail pigmented near sites of developing fin rays; dorsal spines become pigmented <10 mm; scattered spots on top of head; cleithral symphysis unpigmented

Head spine checklist:

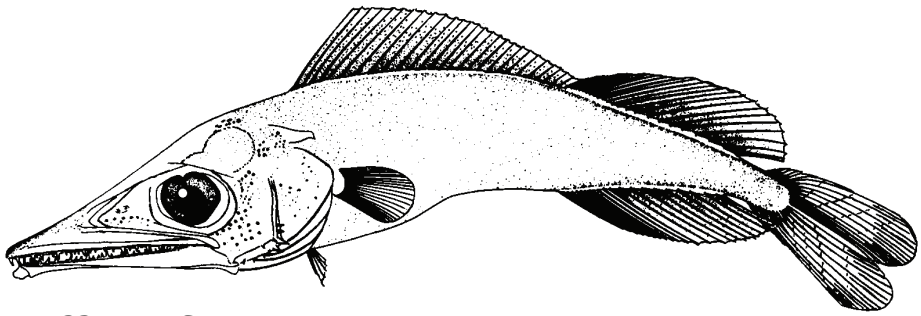
Supraoccipital: none
Preopercle: 2–6 moderate spines on edge and 2 on lateral ridge; angle spine not greatly exaggerated
Supraocular: none
Pterotic: none
Posttemporal: none

Note: 1. In other scombrid larvae, anus forms in anterior part of body and migrates to anal fin origin as gut elongates

Early Juvenile:

About 20 bars form across body at about 27 mm

Dorsal and anal finlets not yet obvious

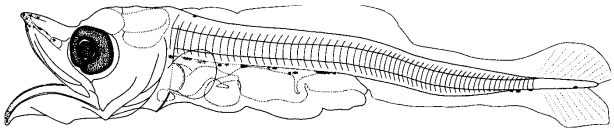


H. 23.7 mmSL

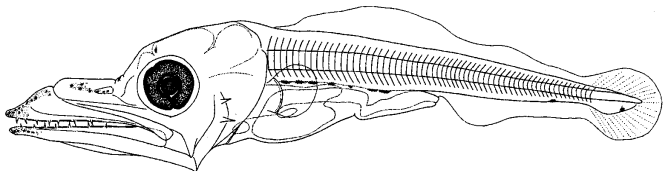
Figures: Adult: Collette, 2002q; **A–G**: Matsumoto, 1967; **H**: Strasburg, 1964

References: Matsumoto, 1967; Wollam, 1969; Collette and Nauen, 1983; Collette *et al.*, 1984b; Collette, 2002q

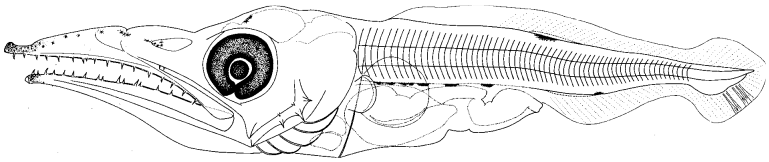
Acanthocybium solandri



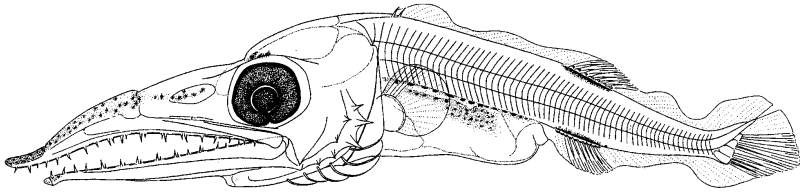
A. 3.4 mmNL



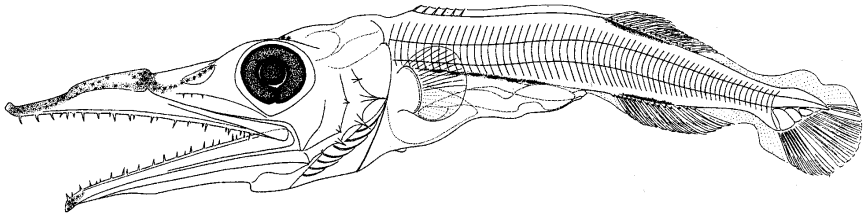
B. 4.4 mmNL



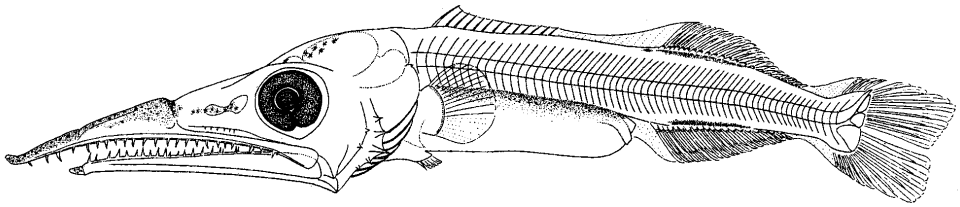
C. 5.8 mmNL



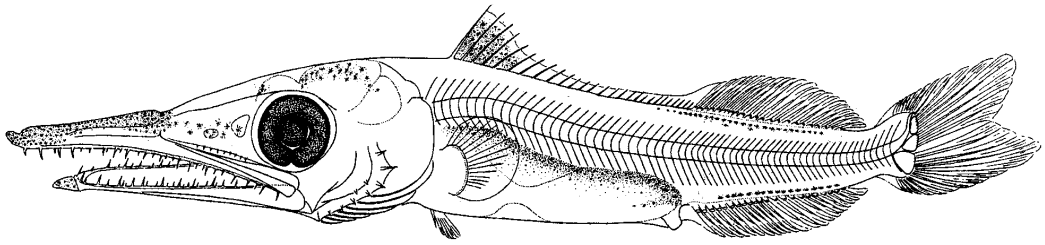
D. 6.8 mmSL



E. 8.4 mmSL

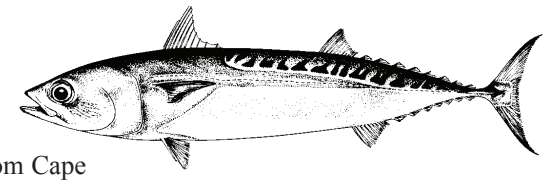


F. 10.7 mmSL



G. 13.2 mmSL

Auxis rochei (Risso, 1810)
Scombridae
Bullet tuna



Range: Worldwide in warm waters; in the western North Atlantic from Cape Cod to Argentina, including Gulf of Mexico and Caribbean Sea; precise distribution relative to that of *Auxis thazard* not well described

Habitat: Epipelagic, neritic and oceanic; also near islands

Spawning: Feb–Aug off southeast United States and Gulf of Mexico; batches may peak in different time periods

Meristic Characters

Myomeres:	39
Vertebrae:	20+19=39
Dorsal fin rays:	XX–XXII, 10–12
Dorsal finlets:	8
Anal fin rays:	11–14
Anal finlets:	7
Pectoral fin rays:	23–25
Pelvic fin rays:	I, 5
Caudal fin rays:	15+9+8+16
Supraneurals:	none

Eggs:
- Pelagic, spherical
- Diameter: 0.82–1.10 mm
- Chorion: transparent
- Yolk: homogeneous
- Oil globule: single, 0.24–0.29 mm in diameter

Larvae:
- Body moderately elongate, becoming deeper with development
- Head somewhat bigger than in *Scomber* larvae; fairly blunt profile, combined with relatively short jaws, results in characteristic "*Auxis*-look"
- Gut a compact, triangular mass; preanus length increases from 37–50% SL
- Flexion occurs at 4.5–6.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2, P_1
- Low numbers of dorsal fin rays discernible at about 7–8 mm
- Head spines moderately developed; see checklist below
- Pigment includes spots on top of head, especially on posterior midbrain (but not extending to area in front of eyes), a spot at cleithral symphysis, a row of spots on venter of tail, including 1–2 on venter of caudal peduncle, 1–2 spots on dorsum of caudal peduncle in larger larvae; lateral surface of caudal peduncle usually unpigmented

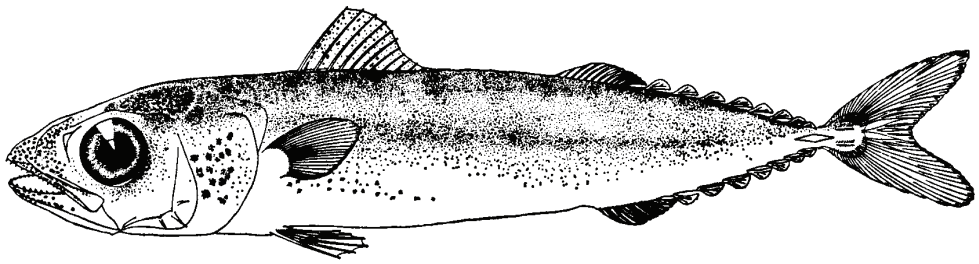
Head spine checklist:

Supraoccipital: none
Preopercle: well developed spines on edge and lateral ridge; angle spine longer
Supraocular: none
Pterotic: none
Posttemporal: 2–3 spines in larger larvae

Note: 1. Larvae coincide with "Type II" larvae described by Matsumoto (1958; 1959)

Early Juvenile:

Note wide space between dorsal fins

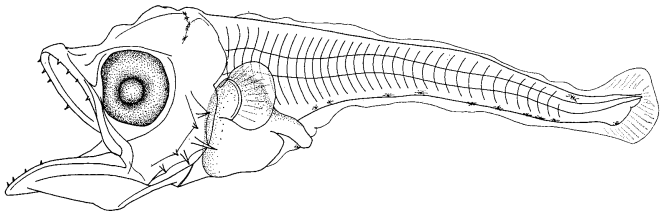


E. 39.0 mmSL

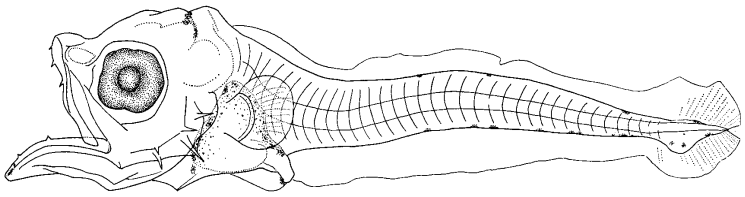
Figures: Adult: Collette, 2002q; **A–D**: Matsumoto, 1959; **E**: Matsumoto, 1961

References: Matsumoto, 1958; 1959; 1961; Potthoff and Richards, 1970; Collette and Nauen, 1983; Collette *et al.*, 1984b; Collette, 2002q

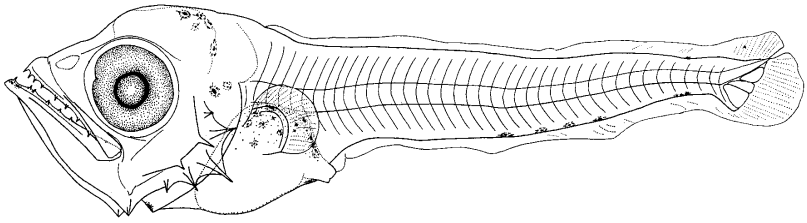
Auxis rochei



A. 3.5 mmNL

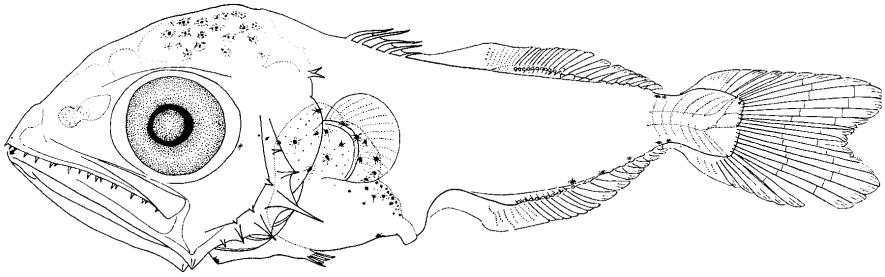


B. 3.7 mmTL



C. 5.2 mmTL

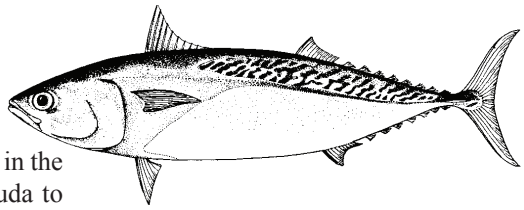
Spots on lateral caudal peduncle usually absent, but may appear in larvae 5.7-5.9 mm



D. 7.2 mmFL

Pelvic fins unpigmented (compare to *Sarda sarda*)

Auxis thazard (Lacepède, 1800)
Scombridae
Frigate mackerel



Range: Worldwide in warm waters, but probably rare in Atlantic Ocean; in the western North Atlantic known from North Carolina and Bermuda to Venezuela and several islands in Caribbean Sea; precise distribution relative to that of *Auxis rochei* not well described

Habitat: Epipelagic, neritic and oceanic; also near islands

Spawning: Undescribed in Atlantic waters

Eggs: – (See egg characters of *A. rochei*; those of *A. thazard* may be similar)

Meristic Characters

Myomeres:	39
Vertebrae:	20+19=39
Dorsal fin rays:	XX–XXII, 10–12
Dorsal finlets:	8
Anal fin rays:	11–14
Anal finlets:	7
Pectoral fin rays:	23–25
Pelvic fin rays:	I, 5
Caudal fin rays:	15+9+8+16
Supraneurals:	none

Larvae:
- Body moderately elongate, becoming deeper with development
- Head somewhat bigger than in *Scomber* larvae; fairly blunt profile, combined with relatively short jaws, results in characteristic "*Auxis*-look"
- Gut a compact, triangular mass; preanus length increases from 37–50% SL
- Flexion occurs at 4.5–6.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2, P_1
- Low numbers of dorsal fin rays discernible at about 7–8 mm
- Head spines moderately developed; see checklist below
- Pigment includes spots on top of head, especially on posterior midbrain (but not extending to area in front of eyes), a spot at cleithral symphysis, a row of spots on venter of tail, including 1–2 on venter of caudal peduncle, 1–2 spots on dorsum of caudal peduncle in larger larvae; lateral surface of caudal peduncle usually pigmented with few spots that expand to a short streak that eventually internalizes

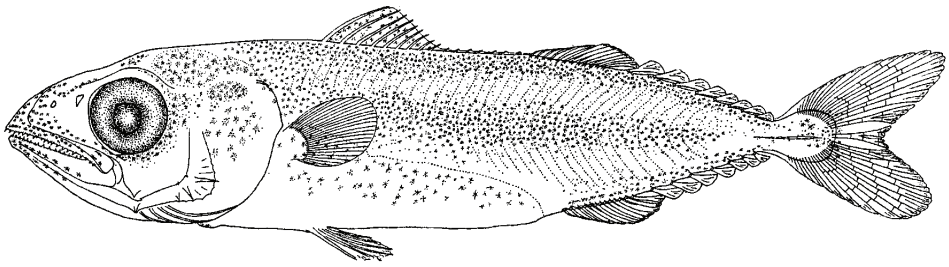
Head spine checklist:

Supraoccipital: none
Preopercle: well developed spines on edge and lateral ridge; angle spine longer
Supraocular: none
Pterotic: none
Posttemporal: 2–3 spines in larger larvae

Note: 1. Larvae coincide with "Type I" larvae described by Matsumoto (1958; 1959)

Early Juvenile:

Note wide space between dorsal fins

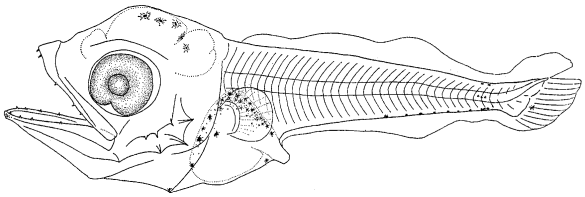


G. 25.0 mmSL

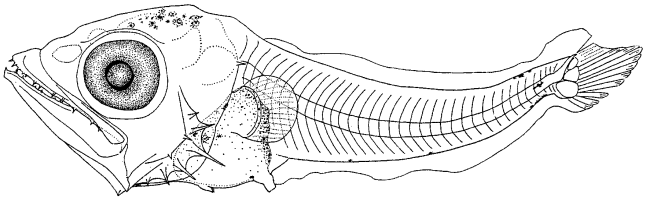
Figures: Adult: Collette, 2002q; **A–G**: Matsumoto, 1959

References: Matsumoto, 1958; 1959; 1961; Potthoff and Richards, 1970; Collette and Nauen, 1983; Collette *et al*., 1984b; Collette, 2002q

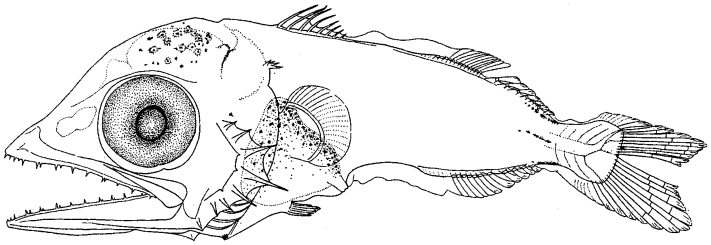
Auxis thazard



A. 4.5 mmNL

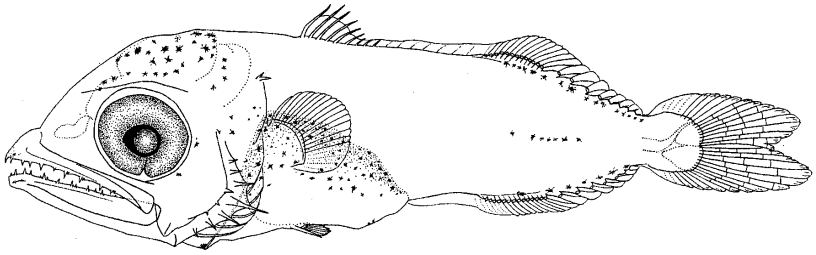


B. 5.5 mmTL



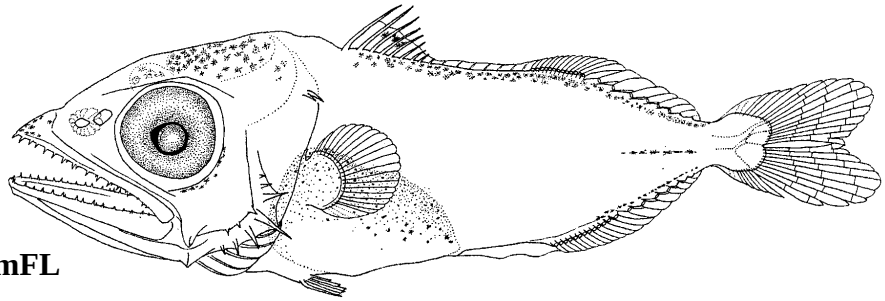
Midbrain pigment expands anteriorly but does not extend to area in front of eyes

C. 7.1 mmFL

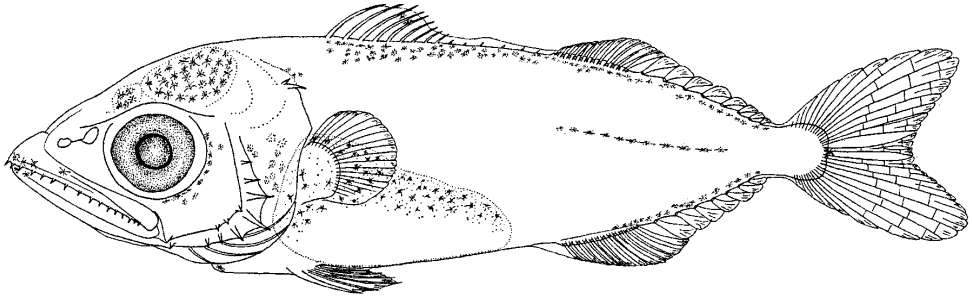


D. 9.7 mmFL

1st dorsal fin lightly pigmented

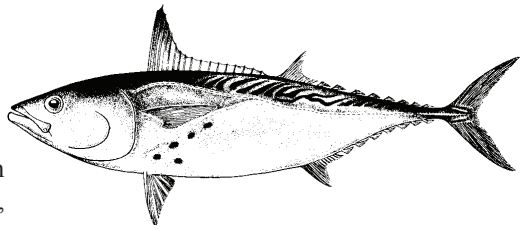


E. 11.2 mmFL



F. 13.2 mmFL Pelvic fins unpigmented (compare to *Sarda sarda*)

Euthynnus alleteratus (Rafinesque, 1810)
Scombridae
Little tunny



Range: Atlantic Ocean in tropical and subtropical waters; in the western North Atlantic from New England to Brazil, including Bermuda, Gulf of Mexico and Caribbean Sea

Habitat: Epipelagic in neritic waters, often in coastal waters; may school with like-sized individuals of other species

Spawning: Apr–Nov in several batches, usually in very warm water

Meristic Characters

Myomeres:	39
Vertebrae:	19–20+19–20=39
Dorsal fin rays:	XIII–XVII, 11–13
Dorsal finlets:	8
Anal fin rays:	11–15
Anal finlets:	7
Pectoral fin rays:	25–29
Pelvic fin rays:	I, 5
Caudal fin rays:	15–16+9+8+14–16
Supraneurals:	none

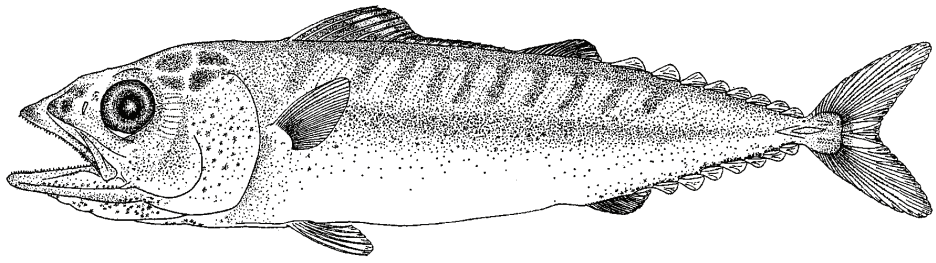
Eggs:
- Pelagic, spherical
- Diameter: 0.84–1.08 mm
- Chorion: smooth, transparent
- Yolk: homogeneous
- Oil globule: single, 0.28 mm in diameter

Larvae:
- Body moderately stubby (deeper than comparably sized *Auxis*)
- Head large, with large, pointed snout and jaws; gape reaching beyond mid-point of eye
- Gut a compact, triangular mass; preanus length increases from about 50% SL to about 70% SL
- Flexion occurs at 5.5–7.5 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_1, P_2
- Head spines moderately developed; see checklist below
- Pigment includes early forming spots on lower jaw and tip of upper jaw; spots on top of head expand anteriorly to area in front of eyes; a spot at cleithral symphysis; row of spots on venter of tail, over developing anal fin, decrease in number; single caudal fin base spot present through development

Head spine checklist:

Supraoccipital: none
Preopercle: well developed spines on edge and lateral ridge; angle spine slightly longer
Supraocular: none
Pterotic: none
Posttemporal: 1 or 2 spines present

Early Juvenile:

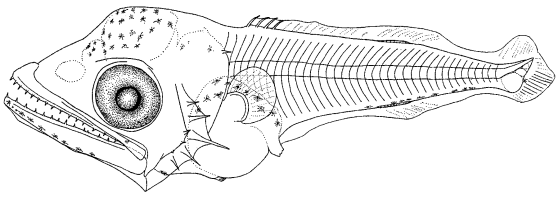


G. 58.0 mmSL

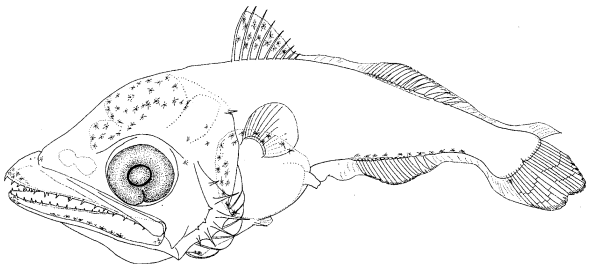
Figures: Adult: Collette and Nauen, 1983; **A–G**: Matsumoto, 1959

References: Matsumoto 1958; 1959; 1961; Potthoff and Richards, 1970; Collette and Nauen, 1983; Collette *et al*., 1984b; Collette, 2002q

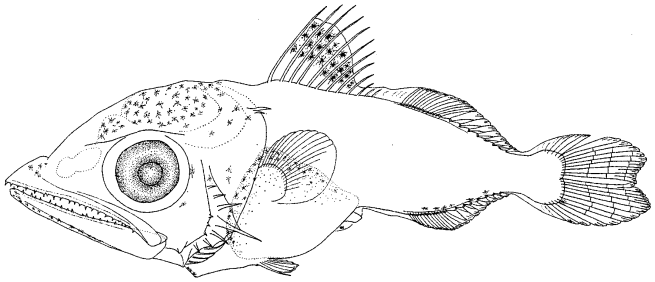
Euthynnus alleteratus



A. 5.5 mmNL

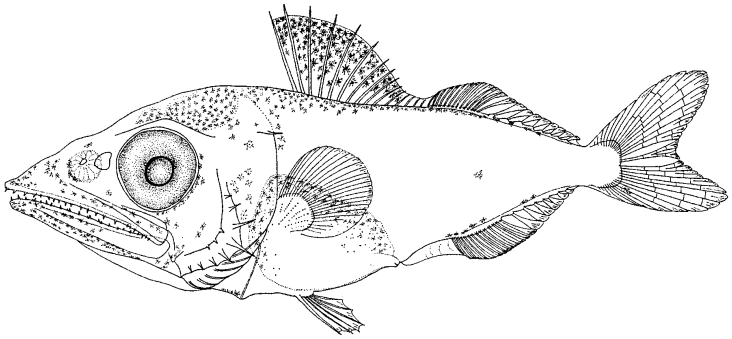


B. 7.5 mmTL

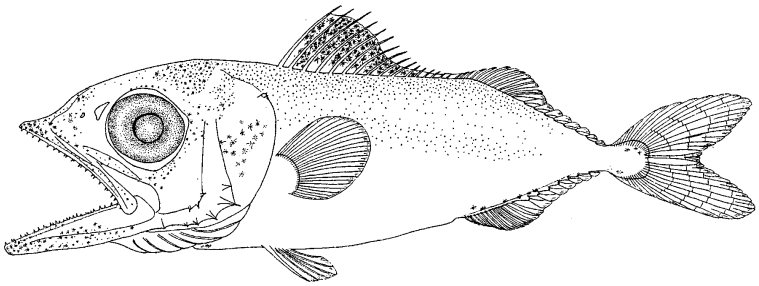


C. 9.3 mmFL

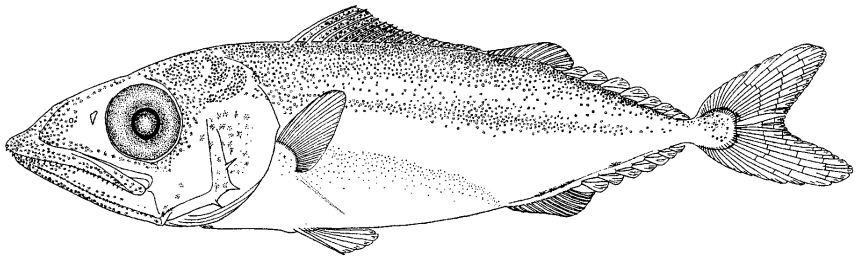
1st dorsal fin
well pigmented



D. 12.0 mmFL

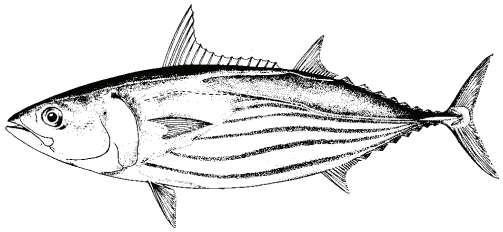


E. 18.5 mmFL



F. 26.0 mmFL Pelvic fin unpigmented (compare to *Sarda sarda*)

Katsuwonus pelamis (Linnaeus, 1758)
Scombridae
Skipjack tuna



Range: Worldwide in tropical and subtropical waters; in the western Atlantic Ocean from Nova Scotia and Cape Cod (during summer) to Argentina

Habitat: Epipelagic in outer continental shelf and oceanic waters; often found near convergences or upwellings, usually above the thermocline (but to a maximum of 260 m during the day); forms large schools, sometimes mixed with *Thunnus* species

Spawning: Year-round in tropical waters, mostly during summer in temperate zone (e.g. North Carolina and south)

Meristic Characters

Myomeres:	41
Vertebrae:	20 + 21 = 41
Dorsal fin rays:	XIV–XVI, 14–16
Dorsal finlets:	7–9
Anal fin rays:	14–16
Anal finlets:	7–8
Pectoral fin rays:	26–28
Pelvic fin rays:	I, 5
Caudal fin rays:	16–17+9+8+17–18
Supraneurals:	none

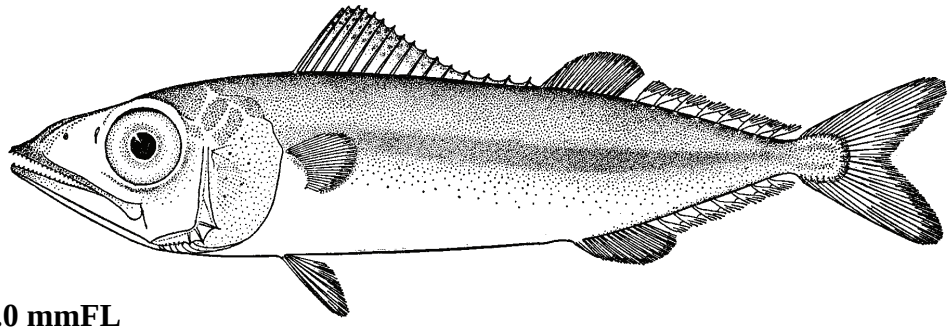
Eggs:
- Pelagic, spherical
- Diameter: 0.93–1.09 mm
- Chorion: transparent
- Oil globule: Single, 0.22–0.27 mm in diameter

Larvae:
- Body moderately stubby, becomes deeper with development, then elongates in juveniles
- Head very large, with large, pointed snout and jaws; gape reaches beyond mid-point of eye
- Gut a compact, triangular mass; preanus length increases from about 50% SL to about 70% SL
- Flexion occurs at about 6.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2, P_1
- Head spines moderately developed on preopercle; see checklist below
- Pigment includes single spot on ramus of lower jaw; spots on spiny dorsal fin confined to outer edge of membrane; 1 to very few spots along anal fin base; usually a prominent spot on venter of caudal peduncle; dorsal pigment on body, under 1st dorsal fin, forms >9.0 mm, then spreads posteriorly; no midlateral pigment until >11 mmTL; no pigment on cleithral symphysis and none on venter anterior to anus or on isthmus

Head spine checklist:

Supraoccipital: none
Preopercle: 4–9 moderate spines on edge and 2–3 on lateral ridge; angle spine slightly longer
Supraocular: none
Pterotic: none
Posttemporal: 1 or 2 spines present

Early Juvenile:

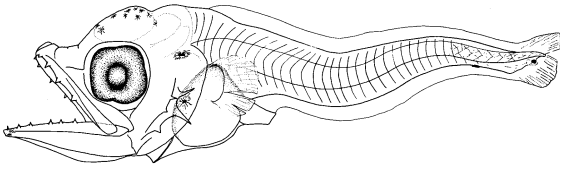


H. 27.0 mmFL

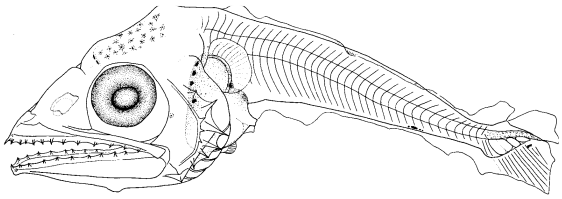
Figures: Adult: Collette, 2002q; **A–G**: Matsumoto, 1958; **H**: Wade, 1950

References: Matsumoto, 1958; 1959; 1961; Potthoff and Richards, 1970; Collette and Nauen, 1983; Collette *et al.*, 1984b; Collette, 2002q

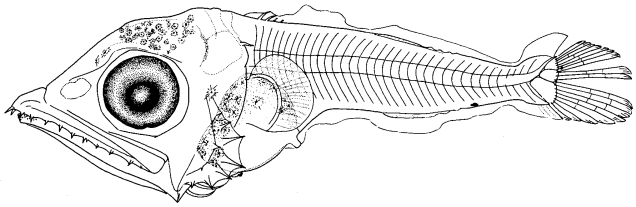
Katsuwonus pelamis



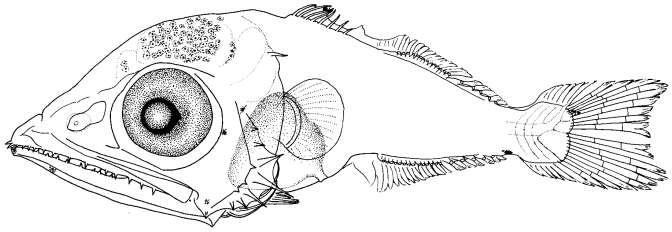
A. 3.6 mmNL



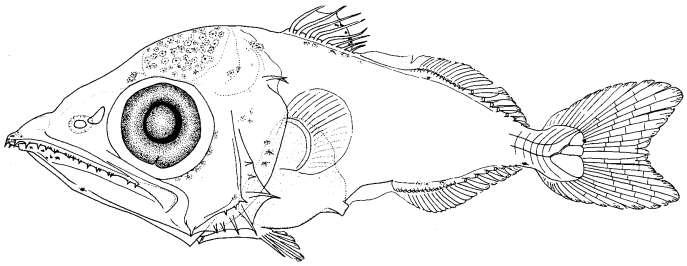
B. 5.4 mmTL



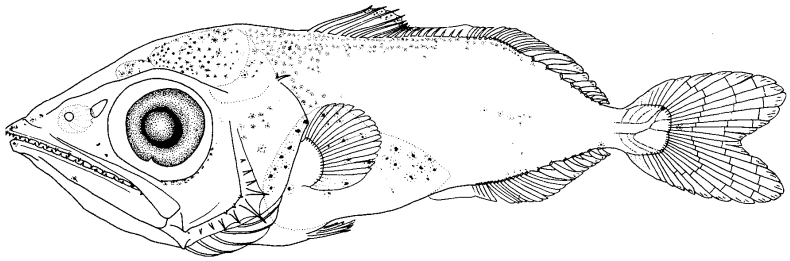
C. 6.7 mmTL



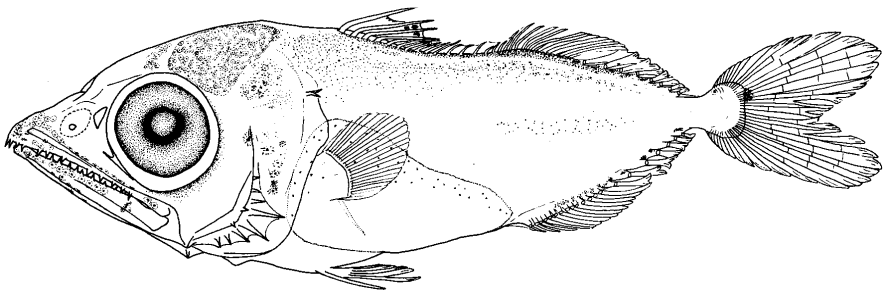
D. 7.1 mmTL



E. 8.8 mmTL

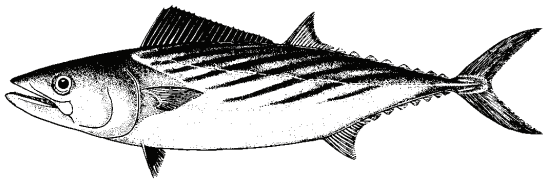


F. 10.9 mmTL



G. 14.5 mmTL

Sarda sarda (Bloch, 1793)
Scombridae
Atlantic bonito



Range: Atlantic ocean in temperate and tropical waters; in the western Atlantic from Nova Scotia (and Gulf of St. Lawrence) to Florida and northern Gulf of Mexico; rare in Caribbean Sea, but few records off northern South America; becomes more common again south of the Amazon River

Habitat: Epipelagic in continental shelf waters; often schools near surface

Spawning: Jun–Jul in study area; winter south of Cape Hatteras

Eggs:
- Pelagic, spherical
- Diameter: 0.84–1.08 mm
- Chorion: smooth, transparent
- Yolk: homogeneous
- Oil globule: single, 0.28 mm in diameter
- Perivitelline space: narrow

Meristic Characters

Myomeres:	50–55
Vertebrae:	26–28+23–27 = 50–55
Dorsal fin rays:	XX–XXIII, 13–18
Dorsal finlets:	7–9
Anal fin rays:	14–16
Anal finlets:	6–8
Pectoral fin rays:	23–26
Pelvic fin rays:	I, 5
Caudal fin rays:	9+8 (PrC)
Supraneurals:	none

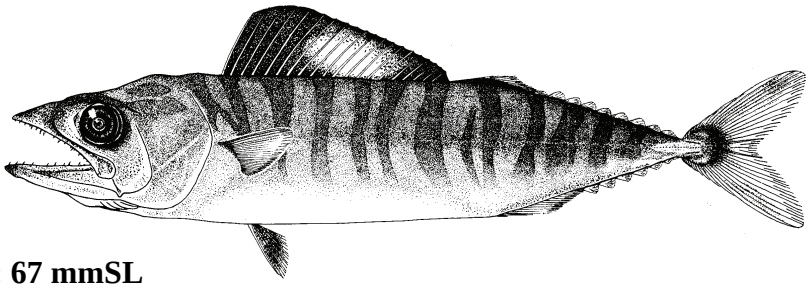
Larvae:
- Body moderately elongate, deepest through pectoral region
- Head large with pointed snout and jaws; gape extends well beyond mid-point of eye; teeth well-developed
- Gut a compact, triangular mass; preanus length increases from about 50% SL to >60% SL
- Flexion occurs at 6.0–7.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines well developed; see checklist below
- Pigment includes series of large spots along venter of tail, some of which become embedded in musculature; 1 or 2 melanophores cover tip of urostyle and hypural bones at base of caudal fin; top of head and opercles well-pigmented; spot at cleithral symphysis, tip of snout, lower jaw tip and along ramus of lower jaw; D_1 and P_2 fins well pigmented; most pigment on dorsum forms in juvenile stage

Head spine checklist:

Supraoccipital: low crest with single spine
Preopercle: several strong spines on edge and few on lateral ridge; angle spine longest
Supraocular: crest with several strong spines
Pterotic: none
Posttemporal: 2–3 strong spines present

Note: 1. Larvae resemble those of *Scomberomorus maculatus* and the myomere counts are also similar, but the latter lacks pigment at caudal fin base and any ventral melanophores present do not become embedded as in *Sarda sarda* larvae

Juvenile:

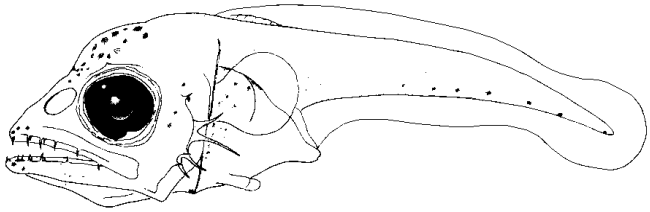


E: 67 mmSL

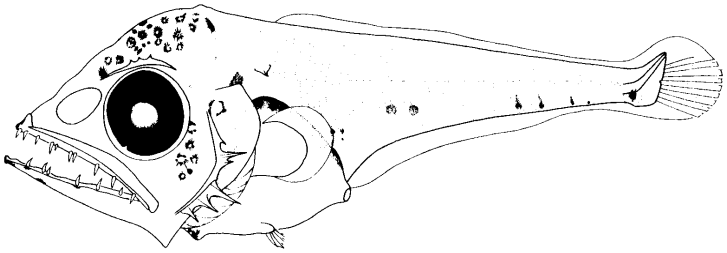
Figures: Adult: Collette, 2002q; **A**, **C–D**: Fahay, 1983; **B**: Jack Javech (Collette *et al*., 1984b); **E**: S. Hillsdon (Klawe and Shimada, 1959)

References: Collette and Nauen, 1983; Collette *et al*., 1984b; Richards, 1989; Collette, 2002q

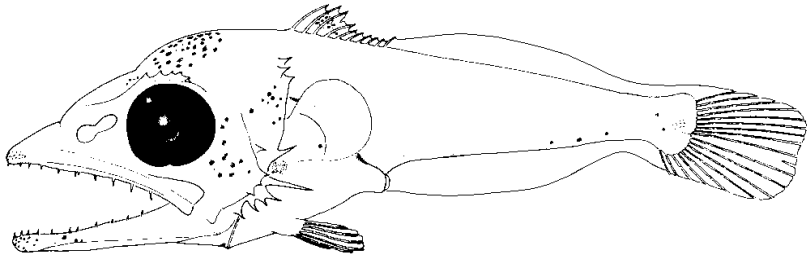
Sarda sarda



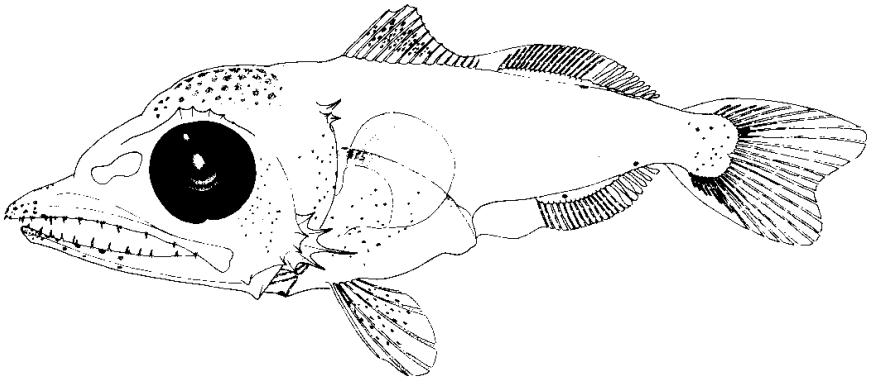
A. 5.3 mmSL



B. 6.4 mmSL

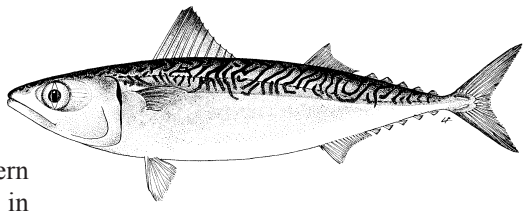


C. 9.8 mmSL



D. 10.0 mmSL

Scomber colias Gmelin, 1789
Scombridae
Atlantic chub mackerel



Range: Atlantic Ocean in temperate to tropical waters; in the western North Atlantic from Nova Scotia to Argentina, but uncommon in Gulf of Mexico and Caribbean Sea; distinct from the Indo-Pacific *Scomber japonicus* Houttuyn, 1782

Habitat: Epipelagic in warm, continental shelf waters, usually close to coast; forms schools according to size

Spawning: Occurs winter and spring south of study area, off coast of S.E. United States, usually over the outer half of continental shelf; eggs occur in surface temperatures of 20–25.4°C; larvae very rare in southern part of study area, but may be expected in Gulf Stream or Slope Sea waters, transported from spawning areas

Meristic Characters

Myomeres:	31
Vertebrae:	14 + 17 = 31
Dorsal fin rays:	IX–XIII, 11–12
Dorsal finlets:	5
Anal fin rays:	I, 11–14
Anal finlets:	5
Pectoral fin rays:	19–22
Pelvic fin rays:	I, 5
Caudal fin rays:	10–11+9+8+10–12
Supraneurals:	none

Eggs:
- Pelagic, spherical
- Similar to eggs of *Scomber scombrus*, but yolk more heavily pigmented

Larvae:
- Body moderately elongate, becoming more stubby with growth; deeper than comparably sized *S. scombrus*
- Head moderate, profile and snout well rounded; jaws moderate, mouth barely reaches anterior edge of eye
- Teeth prominent >4.0 mm to juvenile stage
- Gut a compact, triangular mass; preanus length increases from about 50% SL to >60% SL
- Flexion occurs at about 5.0–7.0 mm
- Sequence of fin ray formation: $C - D_2$, $A - D_1 - P_2$, P_1 (note D_2 forms before D_1; reverse in other scombrids)
- Head spines absent; see checklist below and other scombrid species
- Pigment prominent at several loci; see table below for acquisition schedule compared to *S. scombrus*

Head spine checklist:

Supraoccipital: none
Preopercle: none
Supraocular: none
Pterotic: none
Posttemporal: none

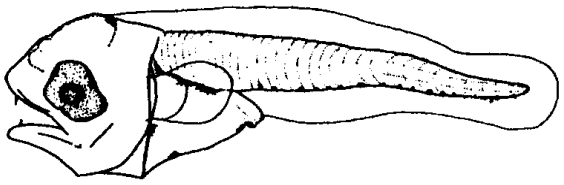
Pigment acquisition in larvae of *Scomber*

Location	*Scomber scombrus*	*Scomber colias*
Forebrain	3.7 mm (some); 5.7 mm (all)	5.2 mm (some); 8.7 mm (all)
Hindbrain	Present at all sizes	3.5 mm (some); 5.5 mm (all)
Snout	4.3 mm (some); 6.3 mm (all)	5.2 mm (some); 10.5 mm (all)
Cleithral symphysis	3.7 mm (some); 8.0 mm (all)	Absent at all sizes
Lower jaw tip	4.6 mm (some); 6.2 mm (all)	8.3 mm (some); 11.7 mm (all)
Dorsum of body	Present in all >2.6 mm	5.0 mm (some); 7.0 mm (all)

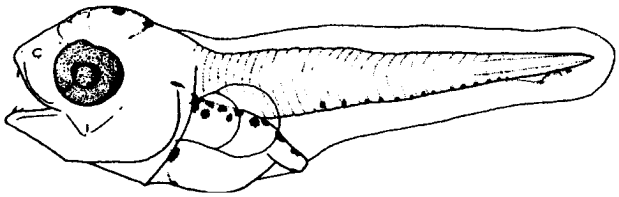
Figures: Adult: Collette, 2002q; **A–F**: Berrien, 1978

References: Berrien, 1978; Collette and Nauen, 1983; Collette *et al*., 1984b; Collette, 2002q

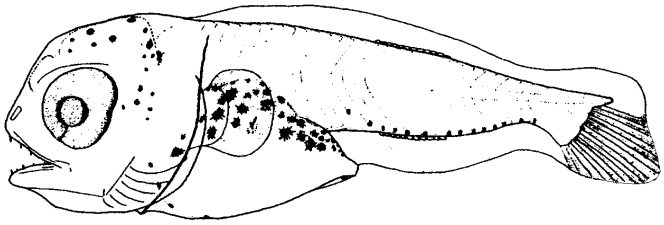
Scomber colias



A. 2.9 mmNL



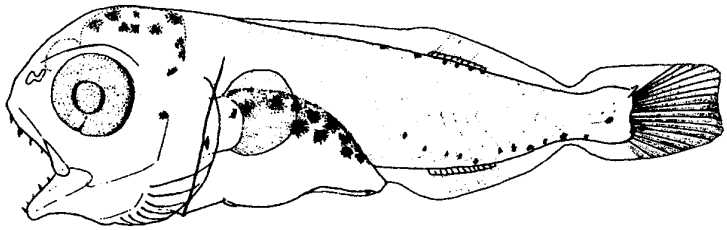
B. 3.8 mmNL



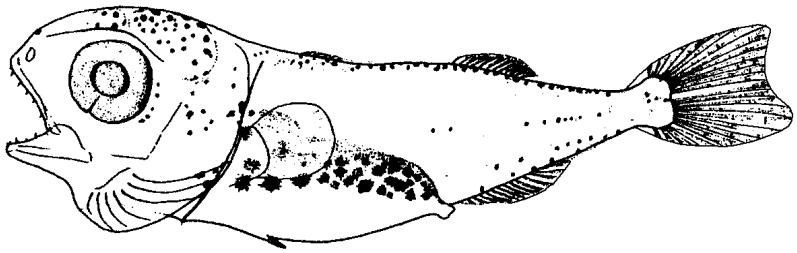
C. 5.3 SL

Preanus length increases sooner in these larvae than in those of *S. scombrus*; levels off at >60% SL in both species at about 20 mm

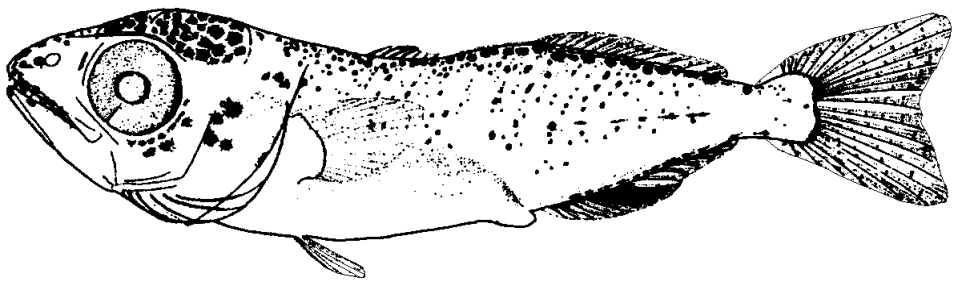
Pigment at cleithral symphysis lacking at all sizes



D. 7.3 mmSL

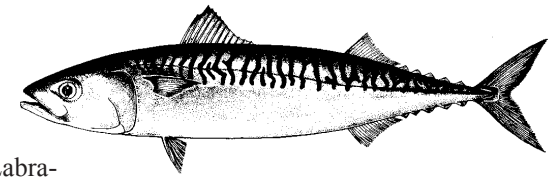


E. 11.3 mmSL



F. 14.7 mmSL

Scomber scombrus Linnaeus, 1758
Scombridae
Atlantic mackerel



Range: North Atlantic Ocean; in the western North Atlantic from Labrador to Cape Lookout, North Carolina; a well separated population occurs in eastern North Atlantic Ocean and Mediterranean Sea

Habitat: Epi- and mesopelagic in cold or temperate, continental shelf waters; forms schools according to size; winters in deeper waters

Spawning: Spring and summer, begins in southern part of range and occurs progressively later to the north; mostly over shoreward half of continental shelf

Meristic Characters

Myomeres:	31
Vertebrae:	13 + 18 = 31
Dorsal fin rays:	XII–XVII, 11
Dorsal finlets:	5
Anal fin rays:	II, 11
Anal finlets:	5
Pectoral fin rays:	19–21
Pelvic fin rays:	I, 5
Caudal fin rays:	10–11+9+8+10–12
Supraneurals:	none

Eggs:
- Pelagic, spherical
- Diameter: 1.0–1.3 mm
- Chorion: smooth, transparent
- Yolk: homogeneous
- Oil globule: single, 0.26–0.37 mm in diameter

Larvae:
- Body moderately elongate, becoming more stubby with growth; slimmer than comparably sized *S. colias*
- Head moderate, profile and snout well rounded; jaws moderate, mouth barely reaches anterior edge of eye
- Teeth prominent >4.0 mm to juvenile stage
- Gut a compact, triangular mass; preanus length increases from about 40% SL to >60% SL
- Flexion occurs at about 5.0–7.0 mm
- Sequence of fin ray formation: C – D_2, A – D_1 – P_2, P_1 (note D_2 forms before D_1; reverse in other scombrids)
- Head spines absent; see checklist below and other scombrid species
- Pigment prominent at several loci; see table below for acquisition schedule compared to *S. colias*

Head spine checklist:

Supraoccipital: none
Preopercle: none
Supraocular: none
Pterotic: none
Posttemporal: none

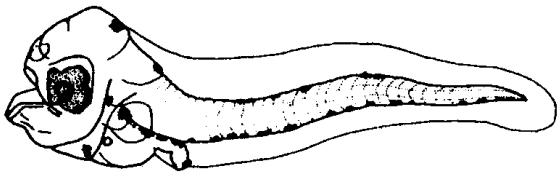
Pigment acquisition in larvae of *Scomber*

Location	*Scomber scombrus*	*Scomber colias*
Forebrain	3.7 mm (some); 5.7 mm (all)	5.2 mm (some); 8.7 mm (all)
Hindbrain	Present at all sizes	3.5 mm (some); 5.5 mm (all)
Snout	4.3 mm (some); 6.3 mm (all)	5.2 mm (some); 10.5 mm (all)
Cleithral symphysis	3.7 mm (some); 8.0 mm (all)	Absent at all sizes
Lower jaw tip	4.6 mm (some); 6.2 mm (all)	8.3 mm (some); 11.7 mm (all)
Dorsum of body	Present in all >2.6 mm	5.0 mm (some); 7.0 mm (all)

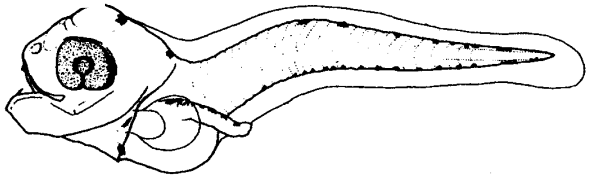
Figures: Adult: Collette and Nauen, 1983; **A–F**: Berrien, 1978

References: Berrien, 1978; Collette and Nauen, 1983; Collette *et al*., 1984b; Collette, 2002q

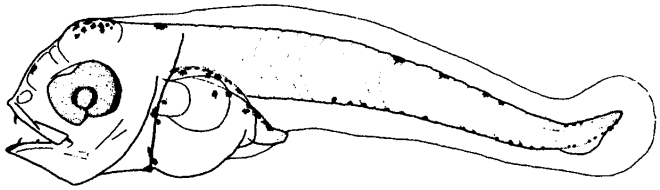
Scomber scombrus



A. 2.9 mmNL

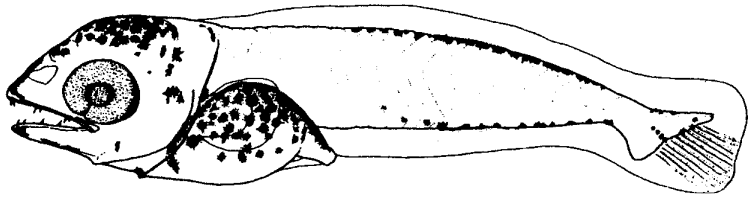


B. 3.8 mmNL

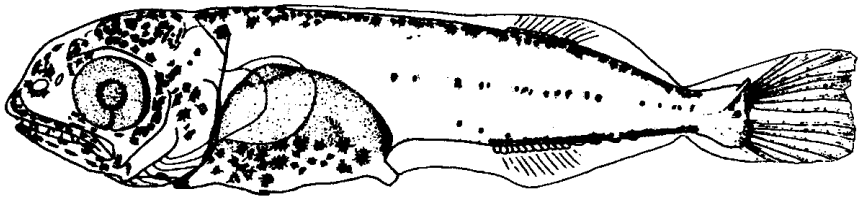


C. 4.8 mmNL

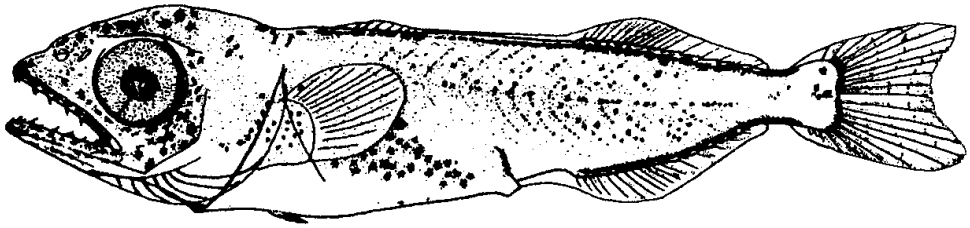
Sebastes larvae (Scorpaenidae) are similar but lack teeth <9.0 mm and have full array of head spines. Also see note on *Brosme brosme* (Gadidae) page regarding eggs.



D. 7.2 mmSL

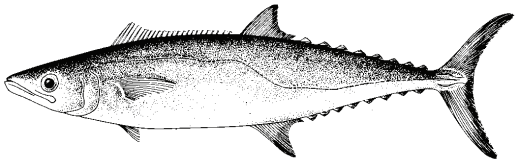


E. 11.7 mmSL



F. 15.1 mmSL

Scomberomorus cavalla (Cuvier, 1829)
Scombridae
King mackerel



Range: Western North Atlantic Ocean from Massachusetts to Brazil, including parts of Gulf of Mexico and eastern Caribbean Sea; occurs north of Florida only during warmer months; larvae frequently collected in study area, probably transported by Gulf Stream

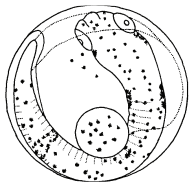
Habitat: Epipelagic over continental shelves; sometimes associated with offshore reefs; forms large schools of similar-sized individuals

Spawning: Year-round (Brazil) or Apr–Nov with peaks; May–Sep (western Gulf of Mexico); Jul–Aug (northeastern Caribbean Sea)

Meristic Characters

Myomeres:	41–43
Vertebrae:	16–17+24–26=41–43
Dorsal fin rays:	XII–XVIII, 15–18
Dorsal finlets:	7–10
Anal fin rays:	16–20
Anal finlets:	7–10
Pectoral fin rays:	21–23
Pelvic fin rays:	I, 5
Caudal fin rays:	11–13+9+8+11–13
Supraneurals:	none

Eggs:
- Pelagic, spherical
- Diameter: 0.90–0.98 mm
- Chorion: smooth
- Yolk: homogeneous
- Oil globule: single, 0.30–0.32 mm in diameter

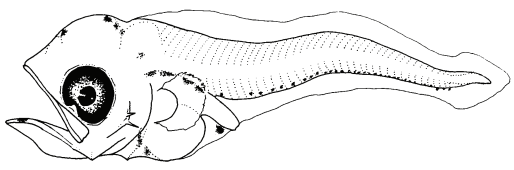


Larvae:
- Body moderately elongate, deepest through pectoral region, with elongate snout and jaws
- Head large, 33–40% SL; large mouth with prominent teeth; upper jaw may be longer than lower
- Gut a compact, triangular mass; preanus length >50% SL
- Flexion occurs at about 4.0–6.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines conspicuous; see checklist below
- Pigment spots at tip of snout, tip of lower jaw, on ramus of lower jaw, on preanal finfold anterior to anus, on cleithral symphysis; row of pigment along venter of tail decreases from 29–30 spots to 4 or 5 spots >8.0 mmSL; spots on dorsum of body spread to form a saddle >8.0 mmSL; fin pigment in later larvae restricted to D_1

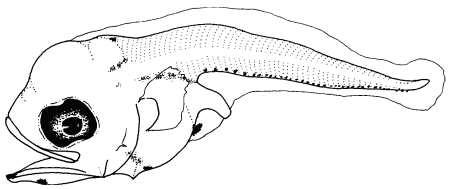
Head spine checklist:

Supraoccipital: crest composed of a single protuberance
Preopercle: up to 10 prominent spines on edge, few smaller spines on lateral ridge; angle spine much longer than others (and the longest angle spine in the family)
Supraocular: prominent crest present
Pterotic: small spine
Posttemporal: several prominent spines

Note: 1. Small larvae not likely to be collected in study area. However, preflexion larvae may be distinguished from those of *Scomberomorus maculatus* by presence of melanophores on midbrain and on each lower jaw ramus



Scomberomorus cavalla, 2.3 mmNL

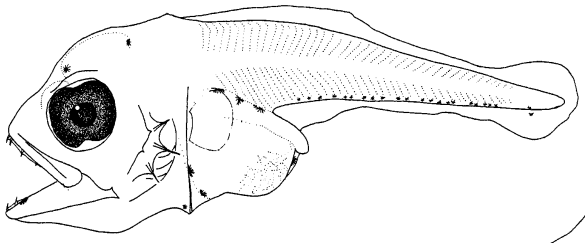


Scomberomorus maculatus, 2.1 mmNL

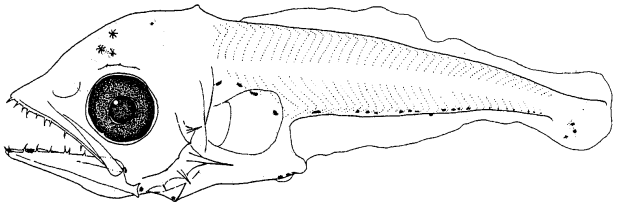
Figures: Adult: Collette, 2002q; Egg: Mayo, 1973; preflexion larvae: Richardson and McEachran, 1981; **A–G**: Wollam, 1970

References: Wollam, 1970; Collette and Russo, 1979; Collette and Nauen, 1983; Collette *et al*., 1984b; Collette, 2002q

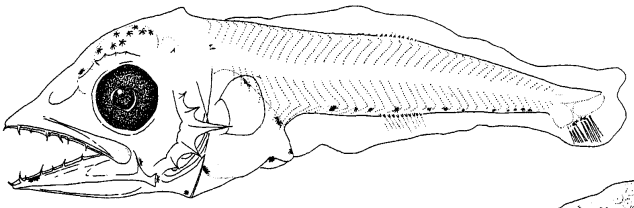
Scomberomorus cavalla



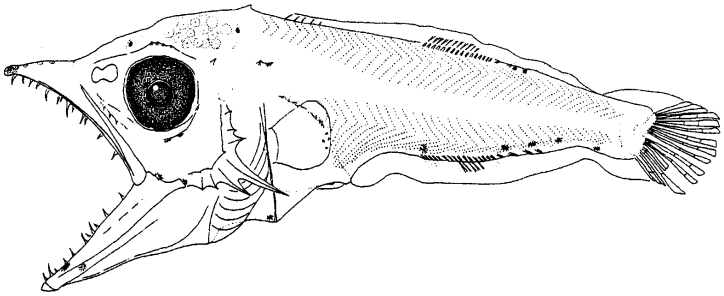
A. 3.3 mmSL



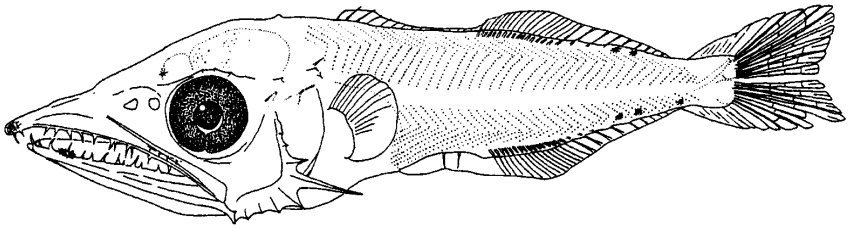
B. 4.7 mmSL



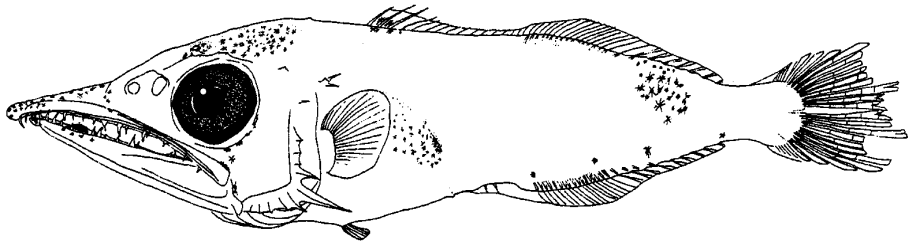
C. 5.6 mmSL



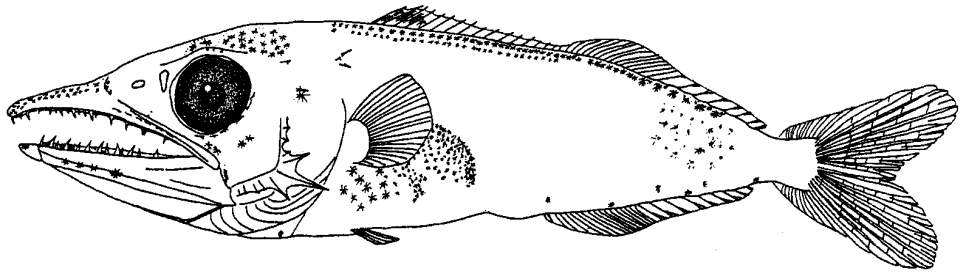
D. 7.6 mmSL



E. 10.0 mmSL

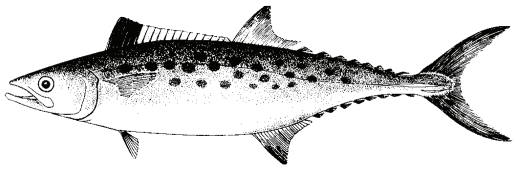


F. 13.1 mmSL



G. 17.0 mmSL

Scomberomorus maculatus (Mitchill, 1815)
Scombridae
Atlantic Spanish mackerel



Range: Western North Atlantic Ocean from Gulf of Maine to Florida and Gulf of Mexico from Florida to Yucatán Peninsula

Habitat: Epipelagic in continental shelf waters; forms large schools and may enter estuarine waters

Spawning: Spring–summer; Apr (off Carolinas); Aug–Sep in study area

Eggs:
- Pelagic, spherical
- Diameter: 1.02–1.27 mm
- Chorion: smooth, transparent
- Yolk: homogeneous
- Oil globule: single, 0.25 mm
- Perivitelline space: narrow

Meristic Characters

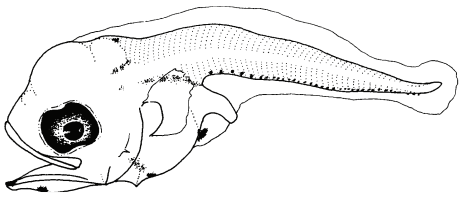
Myomeres:	51–53
Vertebrae:	21–22 + 30–31 = 51–53
Dorsal fin rays:	XVII–XIX, 17–20
Dorsal finlets:	7–9
Anal fin rays:	17–20
Anal finlets:	7–10
Pectoral fin rays:	20–23
Pelvic fin rays:	I, 5
Caudal fin rays:	11–13+9+8+11–13
Supraneurals:	none

Larvae:
- Body moderately elongate, deepest through pectoral region, with elongate snout and jaws
- Head large, 33–40% SL; large mouth with prominent teeth; upper jaw may be longer than lower
- Gut a compact, triangular mass; preanus length >50% SL
- Flexion occurs at about 4.0–6.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines conspicuous; see checklist below
- Pigment spots at tip of snout, tip of lower jaw and on gular membrane between the dentaries; spots on preanal finfold anterior to anus and on cleithral symphysis; row of pigment along venter of tail decreases from 22–41 spots; midline pigment begins at about 13 mmSL; dorsum pigment begins as line under D_1 fin; fin pigment in later larvae restricted to D_1

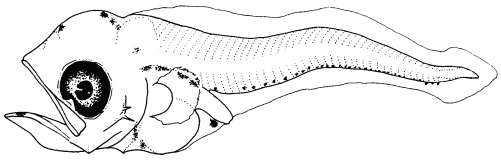
Head spine checklist:

Supraoccipital: crest composed of a single protuberance
Preopercle: up to 8 prominent spines on edge, few smaller spines on lateral ridge; angle spine longest
Supraocular: prominent crest present
Pterotic: small spine
Posttemporal: several prominent spines

Note: 1. Small larvae may be collected in study area. Preflexion larvae may be distinguished from those of *Scomberomorus cavalla* by spots at tip of lower jaw and on gular membrane, and absence of midbrain pigment



Scomberomorus maculatus, 2.1 mmNL

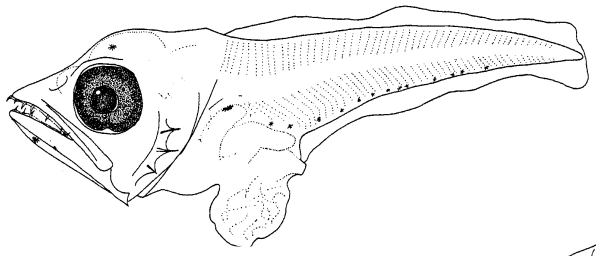


Scomberomorus cavalla, 2.3 mmNL

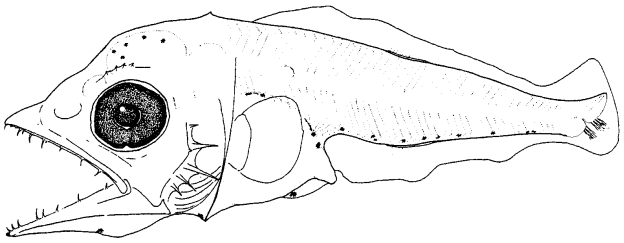
Figures: Adult: Collette, 2002q; preflexion larvae: Richardson and McEachran, 1981; **A–G**: Wollam, 1970

References: Wollam, 1970; Collette and Russo, 1979; Collette and Nauen, 1983; Collette *et al*., 1984b; Collette, 2002q

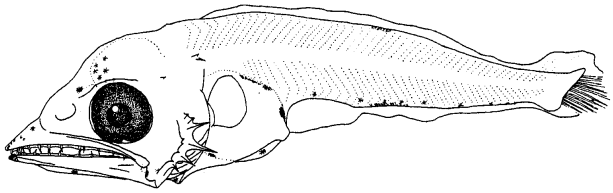
Scomberomorus maculatus



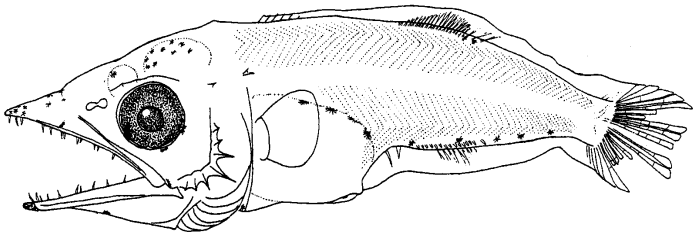
A. 3.1 mmNL



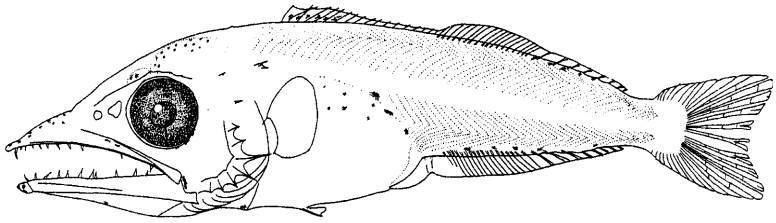
B. 4.3 mmSL



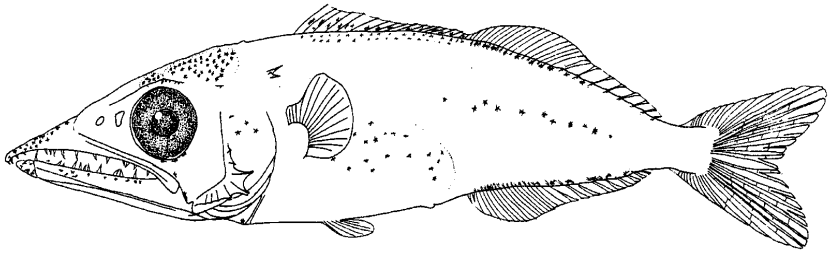
C. 5.8 mmSL



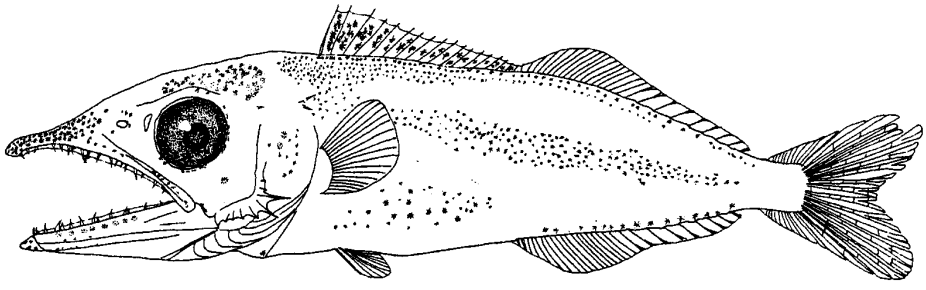
D. 7.8 mmSL



E. 9.5 mmSL

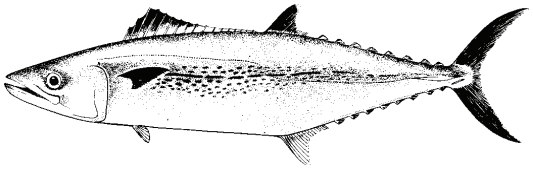


F. 13.5 mmSL



G. 17.4 mmSL

Scomberomorus regalis (Bloch, 1793)
Scombridae
Cero



Range: Western North Atlantic Ocean from Cape Cod to Brazil; most abundant in Bahamas, Cuba and West Indies

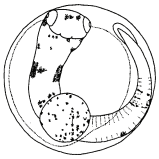
Habitat: Epipelagic in waters near coral reefs

Spawning: Year-round (Puerto Rico); undescribed elsewhere

Meristic Characters

Myomeres:	47–48
Vertebrae:	19–20 + 28–29 = 47–48
Dorsal fin rays:	XVI–XVIII, 16–19
Dorsal finlets:	7–9
Anal fin rays:	15–20
Anal finlets:	7–10
Pectoral fin rays:	20–24
Pelvic fin rays:	I, 5
Caudal fin rays:	11–13+9+8+11–13
Supraneurals:	none

Eggs:
- Pelagic, spherical
- Diameter: 1.16–1.22 mm
- Chorion: smooth
- Yolk: homogeneous
- Oil globule: single,0.34–0.36 mm in diameter

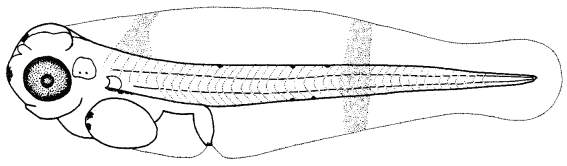


Larvae:
- Body moderately elongate, deepest through pectoral region, with elongate snout and jaws
- Head large, 30–40% SL; large mouth with prominent teeth; upper jaw may be slightly longer than lower
- Gut a compact, triangular mass; preanus length increases from 42% SL to >60% SL
- Flexion occurs at about 6.0–7.0 mmSL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines conspicuous; see checklist below
- Pigment spots at tip of snout, tip of lower jaw, and on gular membrane between the dentaries; pigment on-forebrain, midbrain and nape area; spots on preanal finfold anterior to anus and on cleithral symphysis; row of pigment spots along venter of tail decreases in number; pigment on dorsum and body midline forms at about 10 mm; fin pigment in later larvae restricted to D_1

Head spine checklist:

Supraoccipital: crest composed of a single protuberance
Preopercle: several prominent spines on edge, few smaller spines on lateral ridge; angle spine lightly longer
Supraocular: prominent crest present
Pterotic: small spine possible (undescribed)
Posttemporal: several prominent spines

Note:
1. Small larvae not likely to be collected in study area; see notes regarding preflexion larvae on *Scomberomorus cavalla* and *S. maculatus* pages. Preflexion larvae of *Scomberomorus regalis* (Fig. A–C) have more extensive pigment on brain than congeners but have lower jaw pigment pattern similar to that of *S. maculatus*.

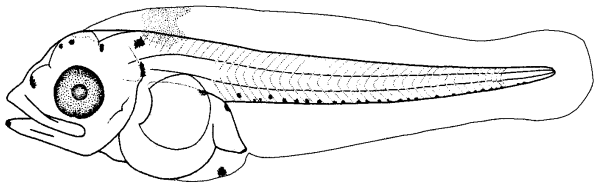


A. 3.4 mmNL

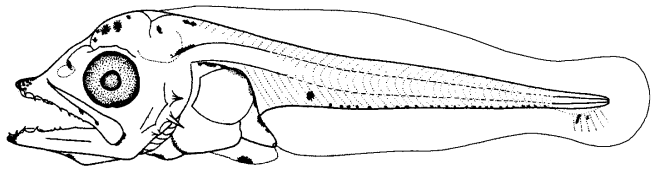
Figures: Adult: Collette, 2002q; Egg and **A–F**: Mayo, 1973 (in Richards, 1989)

References: Wollam, 1970; Mayo, 1973; Collette and Russo, 1979; Collette and Nauen, 1983; Collette *et al*., 1984b; Collette, 2002q

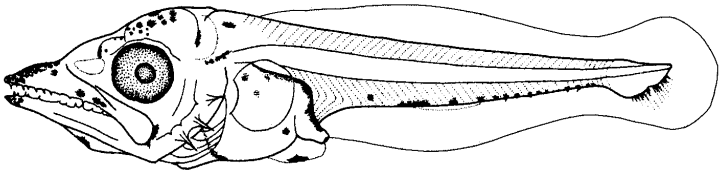
Scomberomorus regalis



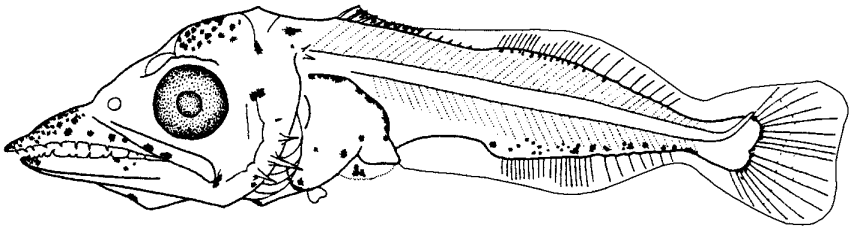
B. 4.0 mmNL



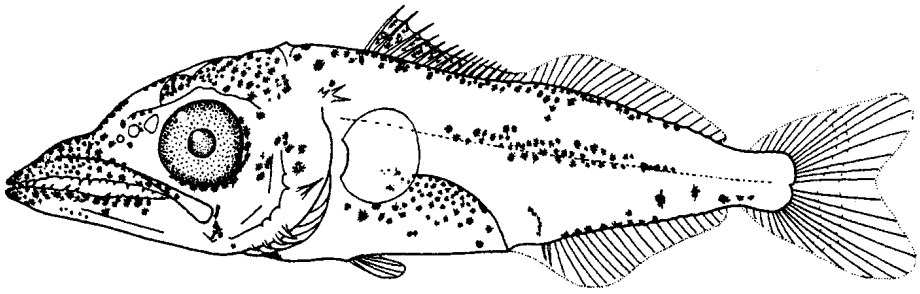
C. 4.6 mmNL



D. 6.0 mmNL

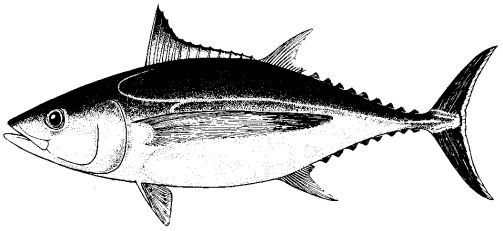


E. 7.3 mmSL



F. 10.7 mmSL

Thunnus alalunga (Bonnaterre, 1788)
Scombridae
Albacore



Range: Worldwide in temperate and tropical waters; in the western North Atlantic from New England to Brazil, including the Caribbean Sea, but absent from Gulf of Mexico

Habitat: Epi- and mesopelagic in oceanic waters; schools of smaller size classes abundant in surface waters but larger individuals often found below thermocline

Spawning: Not well described; possibly winter; a batch spawner

Meristic Characters

Myomeres:	39
Vertebrae:	18 + 21 = 39
Dorsal fin rays:	XI–XIV, 12–16
Dorsal finlets:	7–9
Anal fin rays:	11–16
Anal finlets:	7–8
Pectoral fin rays:	30–36
Pelvic fin rays:	I, 5
Caudal fin rays:	15–17+9+8+15–17
Supraneurals:	none

Eggs:
- Pelagic, spherical
- Diameter: 0.84–0.94 mm
- Chorion: transparent
- Yolk: homogeneous
- Oil globule: single, 0.24 mm in diameter

Larvae:
- Body moderately stocky, deepest through pectoral region, tapering to narrow caudal peduncle
- Head large with pointed snout and jaws; gape extends to mid-point of eye
- Gut a compact, triangular mass; preanus length increases from 40% SL to 55% SL
- Flexion occurs at 5.0–7.0 mmNL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines limited to preopercle and posttemporal; see checklist below
- Pigment on tail absent; melanophores present on midbrain, gut and tips of jaws >7.0 mm; pigment appears on D_1 at 5.0 mm

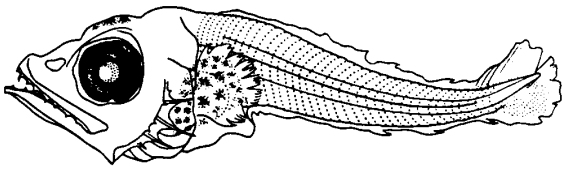
Head spine checklist:

Supraoccipital: none
Preopercle: several strong spines along edge and few smaller spines on lateral ridge
Supraocular: none
Pterotic: none
Posttemporal: 1 or 2 small spines

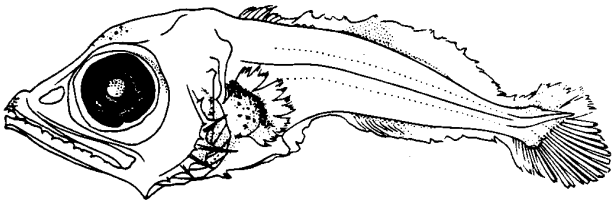
Figures: Adult: Collette, 2002q; **A–F**: Ueyanagi, 1969

References: Yabe and Ueyanagi, 1962; Matsumoto, 1958; 1962; Potthoff and Richards, 1970; Matsumoto *et al*., 1972; Richards and Potthoff, 1974; Collette and Nauen, 1983; Collette *et al*., 1984b; Richards, 1989; Collette, 2002q

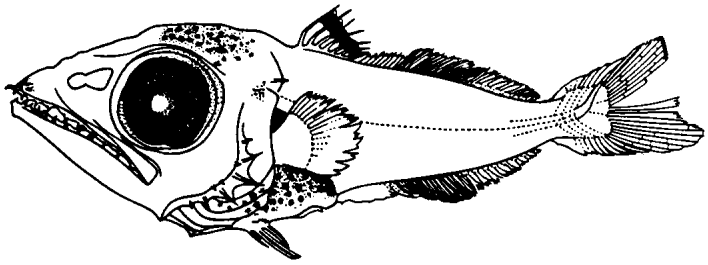
Thunnus alalunga



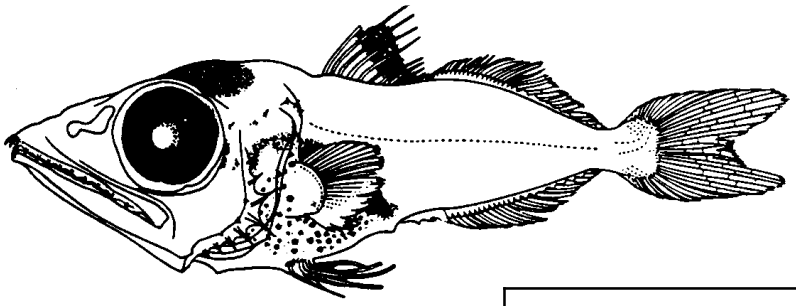
A. 4.1 mmSL



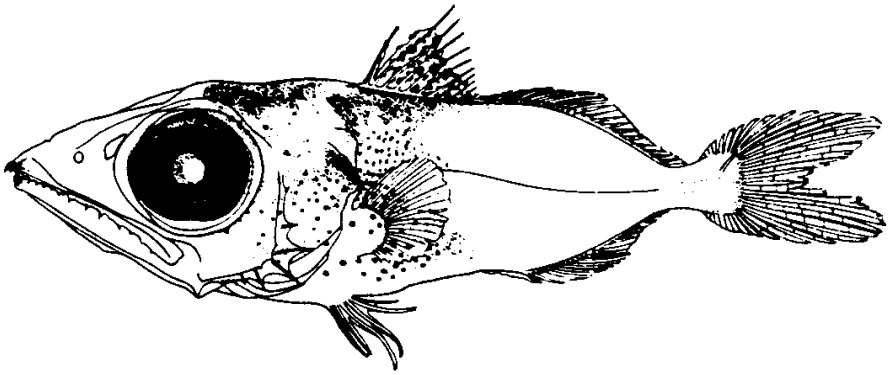
B. 5.0 mmSL



C. 7.0 mmSL

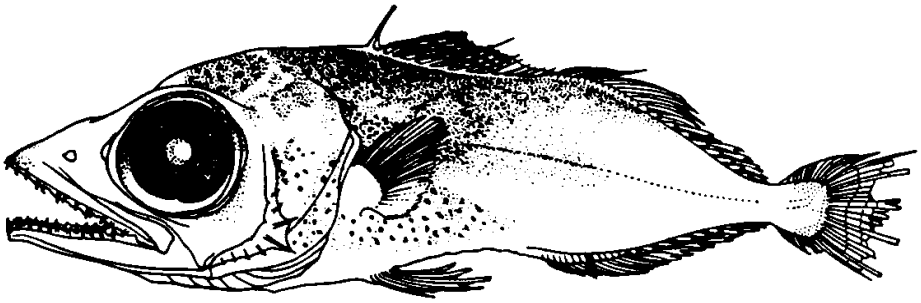


D. 9.1 mmSL



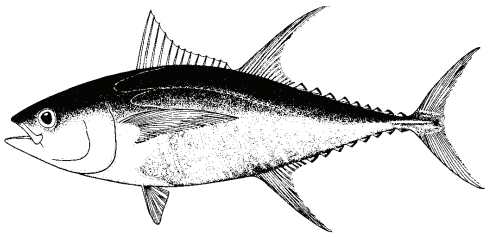
Larvae are best distinguished from those of congeners by precaudal + caudal vertebral formula, 1st closed haemal arch on centrum # 10 and pigment on head, tips of jaws (>7 mm), gut and dorsal fin (>5 mm), but none on body until all fin spines and rays are formed

E. 12.0 mmSL



F. 15.5 mmSL

Thunnus albacares (Bonnaterre, 1788)
Scombridae
Yellowfin tuna



Range: Worldwide in tropical and subtropical waters; in the western North Atlantic from about 42°N to about 10°N off South America

Habitat: Epipelagic in oceanic waters, both above and below the thermocline; often forms schools when near the surface, sometimes with porpoises

Spawning: Year-round in areas where most abundant, otherwise peaks in summer months

Meristic Characters

Myomeres:	39
Vertebrae:	18 + 21 = 39
Dorsal fin rays:	XI–XIV, 12–16
Dorsal finlets:	8–10
Anal fin rays:	11–16
Anal finlets:	7–10
Pectoral fin rays:	30–36
Pelvic fin rays:	I, 5
Caudal fin rays:	15–17+9+8+15–17
Supraneurals:	none

Eggs:
- Pelagic, spherical
- Diameter: 0.90–1.04 mm
- Oil globule: single
- Other characters undescribed

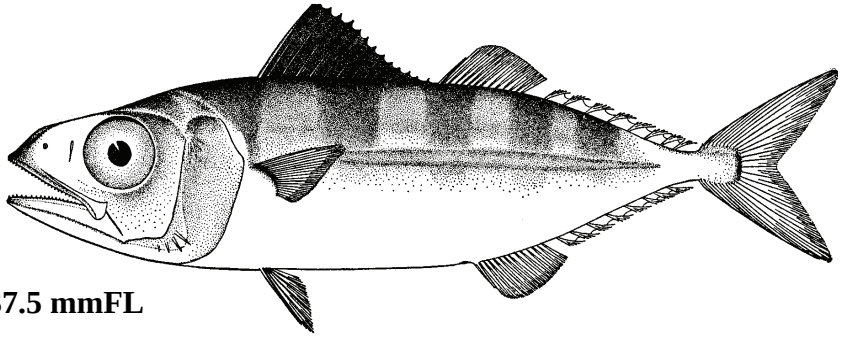
Larvae:
- Body moderately stocky, deepest through pectoral region, tapering to narrow caudal peduncle
- Head large with pointed snout and jaws; gape extends beyond mid-point of eye
- Gut a compact, triangular mass; preanus length increases from 45% SL to 55% SL
- Flexion occurs at 5.0–7.0 mmNL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines limited to preopercle and posttemporal; see checklist below
- Pigment on tail absent; melanophores present on midbrain, gut, tips of jaws and on D_1 fin >5.0 mm

Head spine checklist:

Supraoccipital: none
Preopercle: several strong spines along edge and few smaller spines on lateral ridge
Supraocular: none
Pterotic: none
Posttemporal: 1 or 2 small spines

Note: 1. Larvae share osteological characters with *Thunnus obesus*; larvae may be distinguished from those of *Thunnus obesus* on the basis of pigment characters only

Early Juvenile:

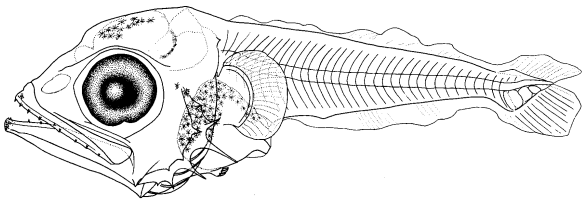


G. 37.5 mmFL

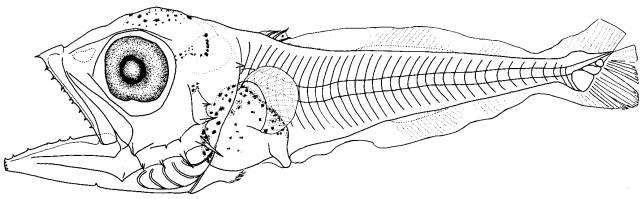
Figures: Adult: Collette, 2002q; **A–F**: Matsumoto, 1958; **G**: Wade, 1950

References: Yabe and Ueyanagi, 1962; Matsumoto, 1958; 1962; Potthoff and Richards, 1970; Matsumoto *et al.*, 1972; Richards and Potthoff, 1974; Collette and Nauen, 1983; Collette *et al.*, 1984b; Richards, 1989; Collette, 2002q

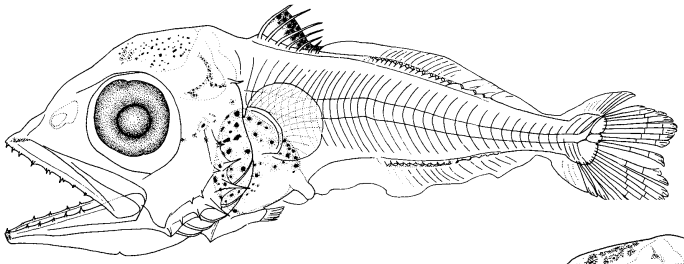
Thunnus albacares



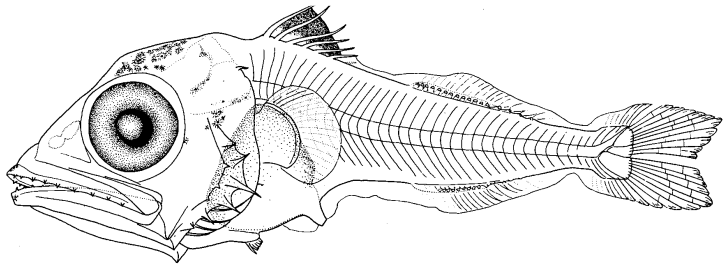
A. 5.5 mmTL



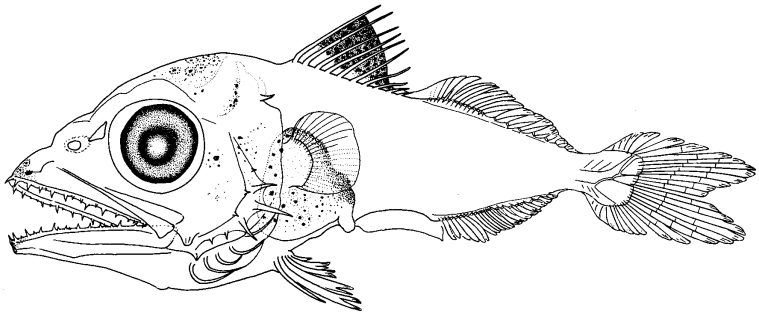
B. 6.4 mmTL



C. 7.2 mmTL

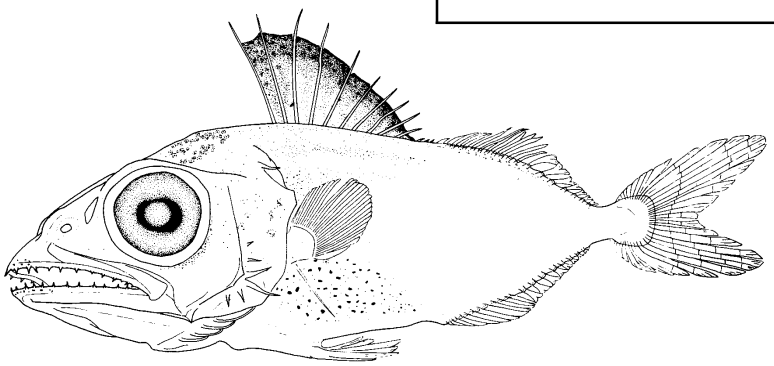


D. 8.0 mmTL



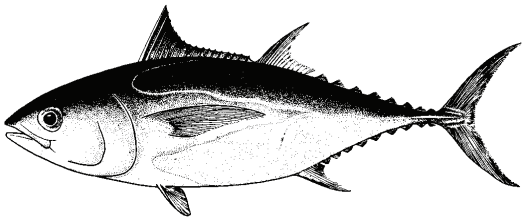
E. 9.2 mmTL

Larvae are best distinguished from those of congeners by precaudal + caudal vertebral formula, 1st closed haemal arch on centrum # 11 and pigment on head, tips of jaws, gut and dorsal fin (>5 mm), but not on body until late larval or juvenile stage



F. 14.3 mmTL

Thunnus atlanticus (Lesson, 1831)
Scombridae
Blackfin tuna



Range: Western Atlantic Ocean from near Martha's Vineyard, Massachusetts to Brazil (22°21' S), including Gulf of Mexico and Caribbean Sea

Habitat: Epipelagic in oceanic waters >20°C; forms large schools, sometimes mixed with *Katsuwonus pelamis*

Spawning: Apr–Nov, peak in May (Florida); Jun–Sep (Gulf of Mexico); probably well offshore

Meristic Characters

Myomeres:	39
Vertebrae:	19 + 20 = 39
Dorsal fin rays:	XI–XIV, 12–16
Dorsal finlets:	7–9
Anal fin rays:	11–16
Anal finlets:	6–8
Pectoral fin rays:	30–36
Pelvic fin rays:	I, 5
Caudal fin rays:	15–17+9+8+15–17
Supraneurals:	none

Eggs:
- Undescribed

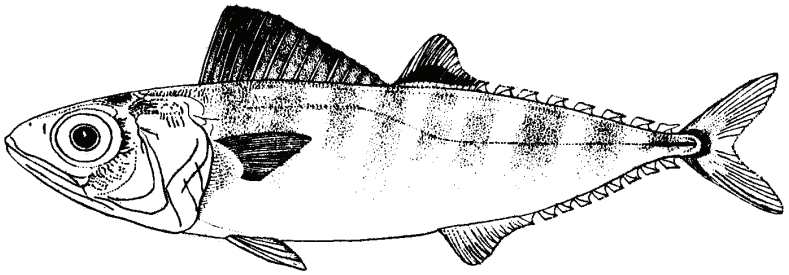
Larvae:
- Body moderately stocky, deepest through pectoral region, tapering to narrow caudal peduncle
- Head large with pointed snout and jaws; gape extends to, or slightly beyond, mid-point of eye
- Gut a compact, triangular mass; preanus length increases from 40% SL to 55% SL
- Flexion occurs at 5.0–7.0 mmNL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines limited to preopercle and posttemporal; see checklist below
- Pigment on tail restricted to a few very tiny spots on venter (or absent in one larval morph); pigment also occurs on midbrain, gut, tips of jaws; fin pigment on D_1 >5.0 mm

Head spine checklist:

Supraoccipital: none
Preopercle: several strong spines along edge and few smaller spines on lateral ridge
Supraocular: none
Pterotic: none
Posttemporal: 1 or 2 small spines

Note:
1. Two larval morphs apparently occur, one with tiny ventral melanophores on tail, one lacking pigment on tail

Early Juvenile:

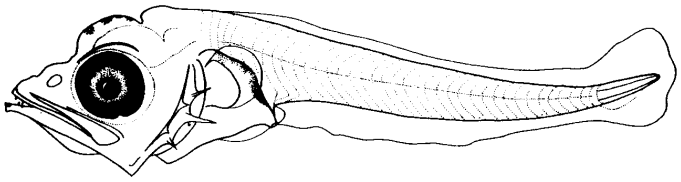


D. 65 mmSL

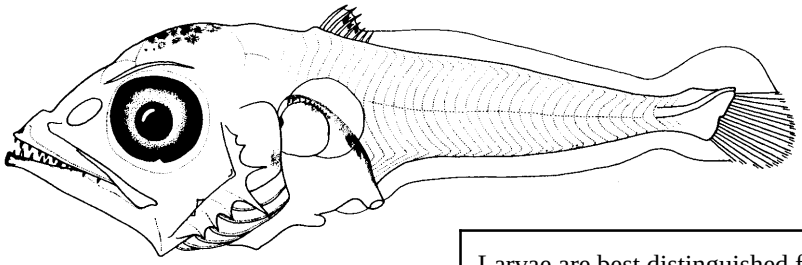
Figures: Adult: Collette, 2002q; **A–C**: Richards, 1989; **D**: Fowler, 1944

References: Yabe and Ueyanagi, 1962; Matsumoto, 1958; 1962; Potthoff and Richards, 1970; Matsumoto *et al*., 1972; Richards and Potthoff, 1974; Collette and Nauen, 1983; Collette *et al*., 1984b; Richards, 1989; 2006c; Collette, 2002q

Thunnus atlanticus

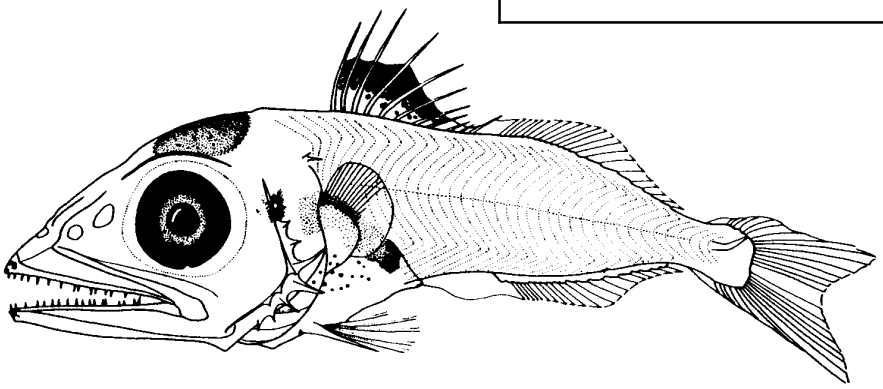


A. 5.1 mmML



B. 6.0 mmSL

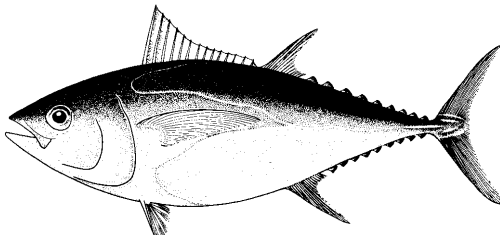
Larvae are best distinguished from those of congeners by precaudal + caudal vertebral formula, 1st closed haemal arch on centrum # 11 and pigment characters (e.g. tiny spots on venter of tail in larvae >5.0 mmSL)



C. 8.5 mmSL

Note: Larvae illustrated in Fig. A-C, are based on a template used for all species of *Thunnus*, with pigment patterns overlain that are species-specific (Richards1989; 2006c)

Thunnus obesus (Lowe, 1839)
Scombridae
Bigeye tuna



Range: Worldwide in tropical and subtropical waters; in the western Atlantic from 42°N to Argentina, including Gulf of Mexico and Caribbean Sea

Habitat: Epi- and mesopelagic in oceanic waters in depths from near-surface to 250 m; often closely associated with the thermocline

Spawning: Poorly described in western Atlantic

Meristic Characters

Myomeres:	39
Vertebrae:	18 + 21 = 39
Dorsal fin rays:	XI–XIV, 12–16
Dorsal finlets:	8–10
Anal fin rays:	11–16
Anal finlets:	7–10
Pectoral fin rays:	30–36
Pelvic fin rays:	I, 5
Caudal fin rays:	15–17+9+8+15–17
Supraneurals:	none

Eggs: – Undescribed

Larvae:
- Body moderately stocky, deepest through pectoral region, tapering to narrow caudal peduncle
- Head large with pointed snout and jaws; gape extends to midpoint of eye
- Gut a compact, triangular mass; preanus length increases from 40% SL to 55 % SL
- Flexion occurs at 5.0–7.0 mmNL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines limited to preopercle and posttemporal; see checklist below
- Pigment spots (1 or 2) present posteriorly on venter of tail; pigment also occurs on midbrain, gut, tips of jaws and on D_1 fin in larvae >5.0 mm

Head spine checklist:

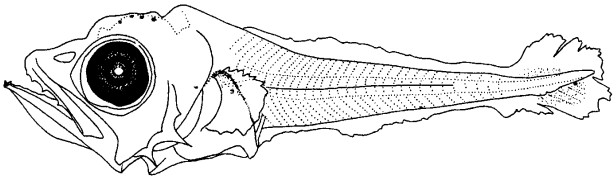
Supraoccipital: none
Preopercle: several strong spines along edge and few smaller spines on lateral ridge
Supraocular: none
Pterotic: none
Posttemporal: 1 or 2 small spines

Note: 1. Larvae share osteological characters with *Thunnus albacares*; larvae may be distinguished from those of *Thunnus albacares* on the basis of pigment characters only

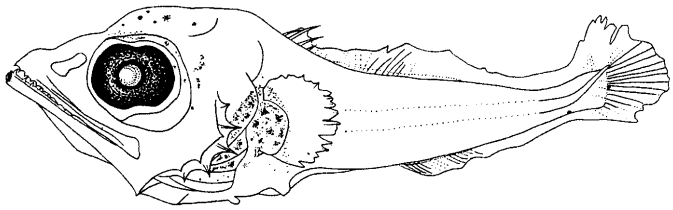
Figures: Adult: Collette, 2002q; **A–B**, **D–E**: Okiyama, 1988; **C**: Matsumoto, 1962

References: Yabe and Ueyanagi, 1962; Matsumoto, 1958; 1962; Potthoff and Richards, 1970; Matsumoto *et al.*, 1972; Richards and Potthoff, 1974; Collette and Nauen, 1983; Collette *et al*., 1984b; Richards, 1989; Collette, 2002q

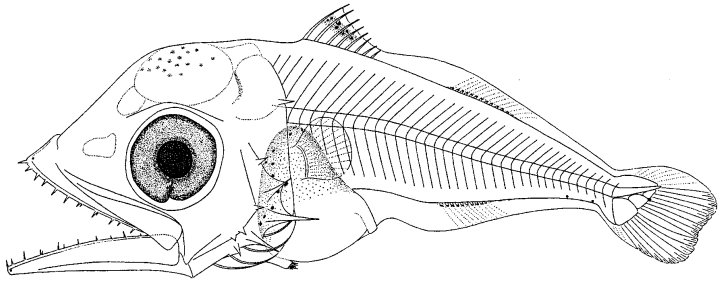
Thunnus obesus



A. 4.1 mmTL

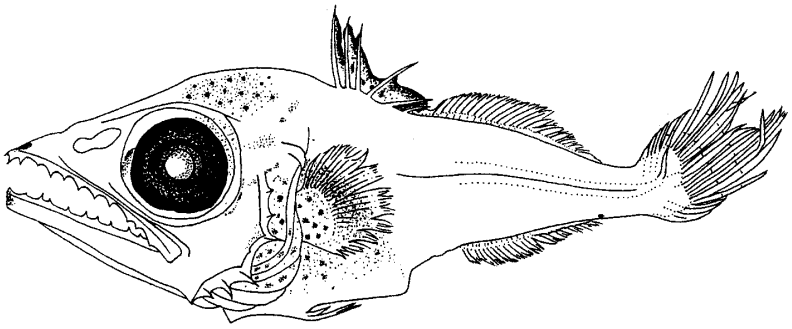


B. 5.5 mmTL

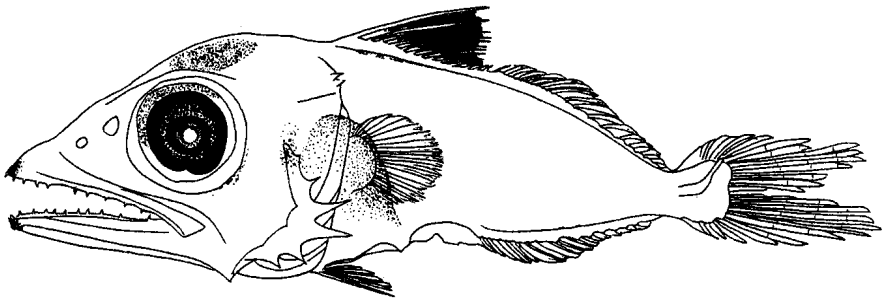


C. 6.1 mmTL

Larvae are best distinguished from those of congeners by precaudal + caudal vertebral formula, 1st closed haemal arch on centrum # 11 and pigment on head, tips of jaws, gut, dorsal fin (>5 mm), and venter of tail

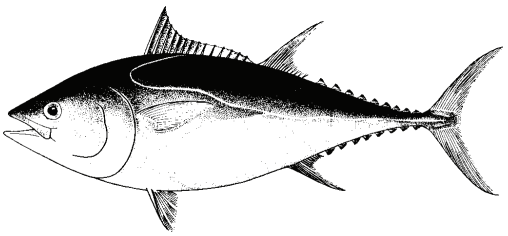


D. 7.7 mmTL



E. 9.9 mmTL

Thunnus thynnus (Linnaeus, 1758)
Scombridae
Atlantic bluefin tuna



Range: North Atlantic Ocean from Labrador and Newfoundland to northeastern Brazil, including Gulf of Mexico and Caribbean Sea; also eastern Atlantic and Mediterranean Sea with a small population off South Africa. (Replaced in the North Pacific by *Thunnus orientalis*, once considered a subspecies of *T. thynnus*.)

Habitat: Epipelagic, usually in oceanic waters but approaching coastal waters seasonally; younger stages form schools by size, often mixed with other scombrid species

Meristic Characters

Myomeres:	39
Vertebrae:	18 + 21 = 39
Dorsal fin rays:	XI–XIV, 12–16
Dorsal finlets:	8–10
Anal fin rays:	11–16
Anal finlets:	7–9
Pectoral fin rays:	30–36
Pelvic fin rays:	I, 5
Caudal fin rays:	15–17+9+8+15–17
Supraneurals:	none

Spawning: Spring-summer (Gulf of Mexico)

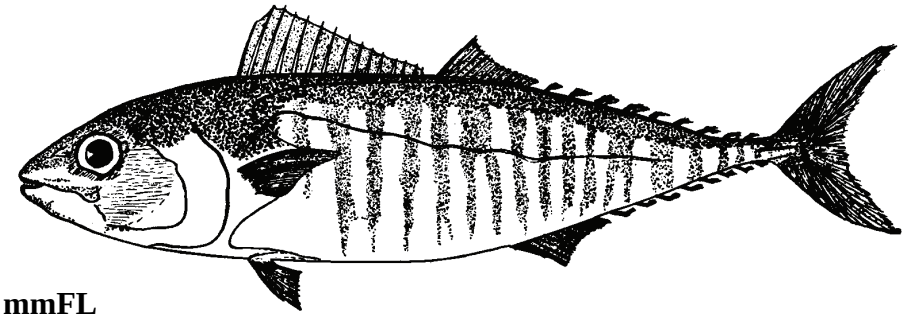
Eggs:
- Pelagic, spherical
- Diameter: 1.00–1.12 mm
- Chorion: transparent
- Yolk: homogeneous
- Oil globule: single, 0.25–0.28 mm in diameter

Larvae:
- Body moderately stocky, deepest through pectoral region, tapering to narrow caudal peduncle
- Head large with pointed snout and jaws; gape extends to mid-point of eye or slightly beyond
- Gut a compact, triangular mass; preanus length increases from about 40% SL to about 55% SL
- Flexion occurs at 5.0–7.0 mmNL
- Sequence of fin ray formation: C – D_1 – D_2, A – P_2 – P_1
- Head spines limited to preopercle and posttemporal; see checklist below
- Pigment present on dorsal and ventral surfaces of tail; pigment also occurs on midbrain, gut, tips of jaws and on D_1 fin >5.0 mm

Head spine checklist:

Supraoccipital: none
Preopercle: several strong spines along edge and few smaller spines on lateral ridge
Supraocular: none
Pterotic: none
Posttemporal: 1 or 2 small spines

Juvenile:

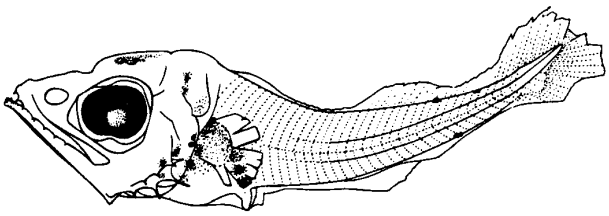


G. 212 mmFL

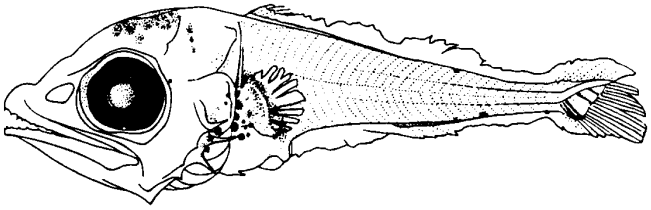
Figures: Adult: Collette, 2002q; Egg: Sanzo, 1932a; **A–F**: Yabe *et al*., 1966; **G**: Dieuzeide and Roland, 1955

References: Yabe and Ueyanagi, 1962; Matsumoto, 1958; 1962; Potthoff and Richards, 1970; Matsumoto *et al.*, 1972; Richards and Potthoff, 1974; Collette and Nauen, 1983; Collette *et al*., 1984b; Richards, 1989; 2006c; Collette, 2002q

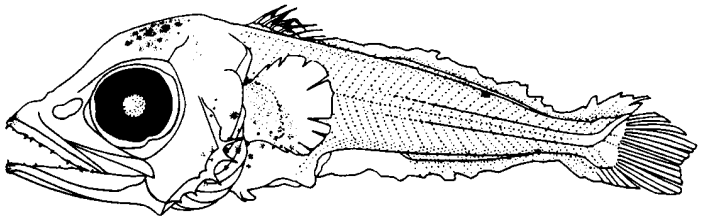
Thunnus thynnus



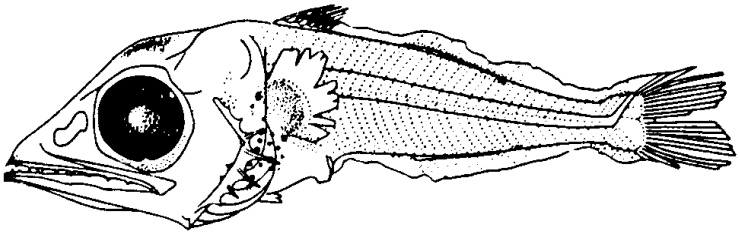
A. 4.4 mmNL



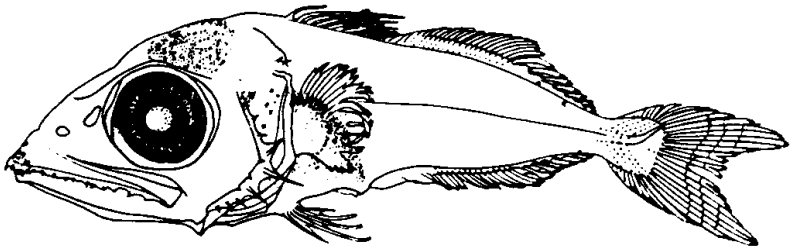
B. 5.3 mmSL



C. 6.1 mmSL

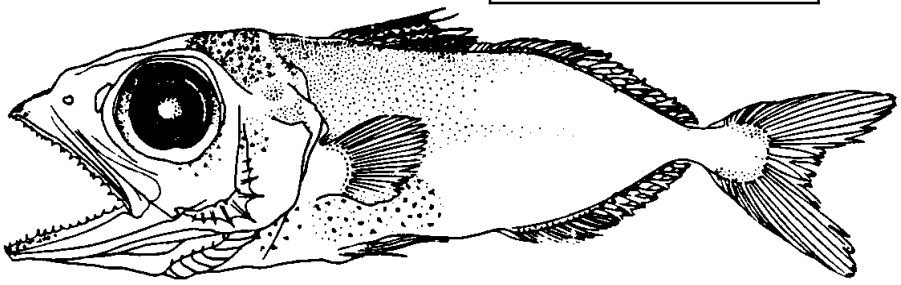


D. 6.6 mmSL



Larvae are best distinguished from those of congeners by precaudal + caudal vertebral formula, 1st closed haemal arch on centrum # 10 and pigment on head, tips of jaws, gut, dorsal fin (>5 mm), and dorsum and venter of tail

E. 9.6 mmSL



F. 16.8 mmSL