Order Siluriformes

Selected meristic characters in species belonging to the order Siluriformes, family Ariidae, whose adults or larvae have been collected in the study area. Classification sequence follows Eschmeyer, 1990. Sources: Jones *et al*. (1978); Acero (2002).

Species	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Caudal Fin Rays	Pectoral Fin Rays	Pelvic Fin Rays
Arius felis	50–52	II, 7	18–20	19–20+7+8+19–20 53-55 (total)	I, 6–10	6
Bagre marinus	53–54	I, 7	22–28	22–23+7+8+21 58–59 (total)	I, 11–14	6

Ariid catfishes are mouth-brooders, the males carrying the eggs until hatching. The large yolk sac is retained by developing larvae until they transform into juveniles. All stages are characterized by an adipose fin, lack of scales, forked caudal fin, strong spines at the origin of dorsal and pectoral fins, and 2 or 3 pairs of barbels near the mouth

Arius felis (Linnaeus, 1766)
Ariidae
Sea catfish

Range: Western North Atlantic Ocean from Cape Cod to Yucatan Peninsula, Mexico

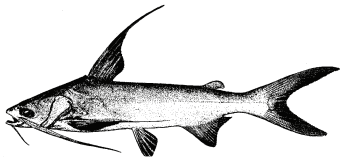
Habitat: Shallow, coastal water over sand or mud; may penetrate freshwater; tolerates high water temperatures

Spawning: Spring and summer in shallow waters

Eggs: Diameter to 14–18 mm, slightly oval, chorion thin, clear and adhesive

Larvae:
- Hatch at about 29–45 mm, with large yolk-sac, large eyes, rays well-developed (except pectoral fin)
- Three pairs of barbels form; 2 near tip of lower jaw, 1 on maxilla

Bagre marinus (Mitchill, 1815)
Ariidae
Gafftopsail catfish



Range: Western North Atlantic Ocean from Cape Cod to coast of northern South America

Habitat: Shallow waters of coastal ocean and estuaries; may penetrate freshwater; leave estuaries in fall, spend winter in ocean; during spring and summer most abundant in salinities 5–30 ppt

Spawning: Spring and summer over mudflats

Eggs: Diameter to 15–26 mm, oval to elliptical, chorion golden-yellow

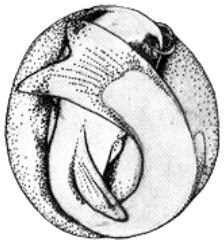
Larvae:
- Hatch at about 45 mm, with large yolk-sac, large eyes, rays well-developed (except pectoral fin)
- Two pairs of barbels form; 1 near tip of lower jaw, 1 on maxilla

Figures: *A. felis* and *B. marinus* adults: Goode, 1884; **A–B**: Merriman, 1940; **C–E**: Gudger, 1918

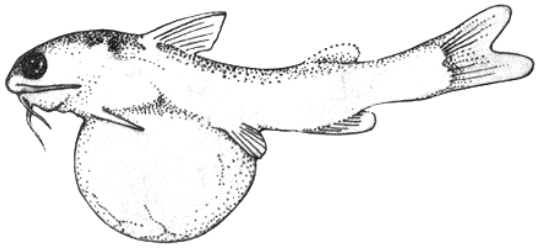
References: Jones *et al*., 1978; Acero, 2002

Order Siluriformes

Arius felis



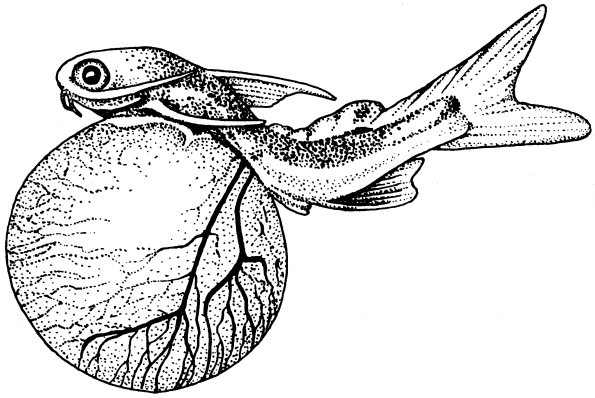
A. Egg



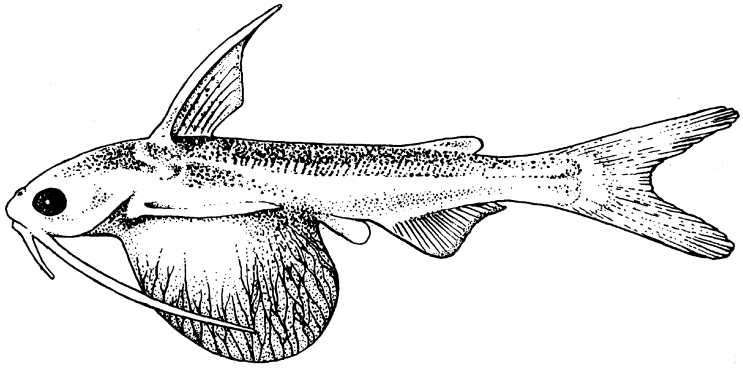
B. 40 mmTL (Yolk-sac Larva)

Bagre marinus

C. Egg



D. 45 mmTL (Yolk-sac Larva)



E. 58 mmTL (Yolk-sac Larva)

Siluriform fishes in the family Ictaluridae are primarily freshwater inhabitants, but several species commonly occur in tidal marshes. For example, *Ictalurus nebulosus* (Lesueur, 1819) is frequently collected in estuarine habitats with salinities as high as 10 ppt. Spawning occurs in freshwater habitats and development proceeds directly from yolk-sac larva to juvenile. See Jones *et al.* (1978) for summaries of early development in six species that occur in the study area.

Salmoniformes

Selected meristic characters in species belonging to the order Salmoniformes whose adults or larvae have been collected in the study area. Classification follows Ahlstrom *et al*., 1984b; Eschmeyer, 1990 (families not in sequence). Sources for meristic characters: Parr, 1960; Kawaguchi and Butler, 1984; Markle and Kreft, 1985; Kobyliansky, 1985; Markle, 1986; Matsui and Rosenblatt, 1987; McEachran and Fechhelm, 1998

Family *Species*	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Pelvic Fin Rays	Brachiostegal Rays
Argentinidae						
Argentina silus	64–67	11–13	13–17	15–18	12–13	6
Argentina striata	47–51	10–12	11–13	18–21	12–15	5
Microstomatidae						
Microstoma microstoma	45–47	11–12	8–9	8	9–11	3–4
Nansenia groenlandica	43–45	9–10	8–10	11–13	11–12	3
Nansenia longicauda	47–50	10–11	10–11	13–14	10–11	4
Nansenia oblita	42–45	10–11	9–10	10–11	10–11	4
Bathylagidae						
Bathylagichthys greyae	44–45	11–14	11–13	10–13	9–11	2
Bathylagus euryops	44–46	9–11	16–19	7–12	7–9	2
Dolicholagus longirostris	48–51	10–12	19–21	9–12	9–10	2
Melanolagus bericoides	48–53	10–11	18–22	10–12	9–10	2
Opisthoproctidae						
Dolichopteryx binocularis	57–58	15	11	14	7–9	2
Opisthoproctus grimaldii	–	12–14	8	11	10	2
Opisthoproctus soleatus	31	10–12	13–14	9–11	9(10)	2
Platytroctidae						
Barbantus curvifrons	43–45	15–21	12–15	21–24	7–8	7–8
Holtbyrnia anomala	44–47	18–22	15–19	13–17	8–10	8
Holtbyrnia innesi	46–48	18–20	15–17	16–20	9	8
Holtbyrnia macrops	46	18–21	14–18	17–20	8–10	8
Maulisia microlepis	43–45	17–21	15–18	13–18	7–9	7–9
Mentodus rostrata	47–49	20	18	17–18	9	7–8
Normichthys operosus	43–45	17–20	16–18	16–19	6–7	7–8
Sagamichthys cf. *schnakenbecki*	48–49	16–18	15–17	15–19	9–10	8
Searsia koefoedi	46–47	18–21	17–19	20–25	7–9	7–8
Osmeridae						
Mallotus villosus	64–70	12–14	19–21	18–20	8	8
Osmerus mordax	62–64	10–11	15–17	11–12	8	7
Salmonidae						
Salmo salar	58–61	10–12	8–11	14–15	9–10	(10)11–12(13)

Salmoniformes

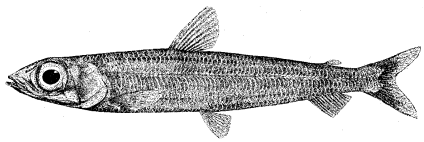
Selected meristic characters in species belonging to the order Salmoniformes, family Alepocephalidae

Family *Species*	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Pelvic Fin Rays	Brachiostegal Rays
Alepocephalidae						
Alepocephalus agassizi	(49)50–52	15–18	16–18	10–12	6–8	–
Alepocephalus cf. australis	–	–	–	–	–	–
Alepocephalus bairdii	61–65	18–22	20–26	10–13	7–9	–
Alepocephalus productus	24+26–28	17	17	10	7	–
Bajacalifornia megalops	31–32+18–20	16–18	14–16	13–16	7–9	7
Bathylaco nigricans	41–46	17–22	11–12	5–11	6–9	8–10
Bathyprion danae	51–55	24–27	24–27	10–12	8–9	10–11
Bathytroctes microlepis	36–41	15–17	15–16	10–14	8	7–8
Bathytroctes squamosus	–	17	14	11–13	8	7–8
Bellocia koefoedi	36–39	14–15	11–12	10–11	7–8	–
Bellocia michaelsarsi	38–40	12–16	9–13	15–17	7–9	7–8
Conocara macropterum	–	18–21	37–39	8–10	6–7	–
Conocara murrayi	52–54	21–23	26–28	8	6	–
Mirognathus normani	–	16–21	16–19	0	5	–
Narcetes stomias	25–28+21–23	18–20	14–17	9–11	8–9	8–9
Photostylus pycnopterus	26+18	12–15	16–19	17–20	6–7	6
Rouleina attrita	19–22+22–26	18–21	18–21	6–7	6–7	5–6
Rouleina maderensis	20–22+26–28	20–22	20–22	5–7	5–6	6
Xenodermichthys copei	16–19+30–32	27–31	26–30	7–8	6	–

Species of Salmoniformes occur worldwide, mostly in the deep-sea. Only a few larvae are known, mostly in the families Argentinidae, Bathylagidae and Opisthoproctidae. Known argentinid eggs are pelagic with distinctive pustules on the inner surface of the chorion. Described larvae in these families vary considerably. Some have stalked eyes. Fin rays uniquely develop in the finfold, then migrate to a location on body's edge.

Early stages of Alepocephalidae and Platytroctidae are mostly undescribed. Members of both families lack adipose fins (present in bathylagids), and apparently undergo direct development, rather than transforming from a distinct larva to a juvenile stage resembling the adult. Black tissue lines the mouth, branchial chamber and peritoneum. Yolk-sac larvae and juvenile platytroctids have a posteriorly directed tubule on the 'shoulder' region, described in Pacific congeners of *Holtbyrnia* and *Sagamichthys* (Matsui, 1991). The juveniles of at least 1 Pacific platytroctid undergo a nightly vertical migration in the water column. Adult alepocephalids mostly occur near-bottom in deep water. They hatch from large eggs (3–4 mm) and young stages have been collected from midwater depths. Larvae have large heads, long preanus lengths, and horizontally elongate eyes that become rounded in adults. Fin ray development is delayed, with dorsal, anal and principal caudal fin rays forming at about 30 mm, pectoral and procurrent caudal fin rays not until about 60 mm.

Argentina silus Ascanius, 1775
Argentinidae
No common name



Range: Western North Atlantic Ocean from Block Canyon and Georges Bank to Greenland, including Grand Bank and Flemish Cap; also eastern North Atlantic from Iceland to Norway and Ireland

Meristic Characters

Myomeres:	64–67
Vertebrae:	64–67
Dorsal fin rays:	11–13
Anal fin rays:	13–17
Pectoral fin rays:	15–18
Pelvic fin rays:	12–13
Caudal fin rays:	19 (PrC)

Habitat: Pelagic in depths of 140–915 (usually 137–220 m); prefer temperatures of 7–10°C

Spawning: Spring (Mar–Apr); 1 larva from study area (MCZ 94217) collected Jun; transforming specimen (MCZ 55170) collected Sep

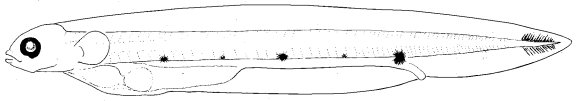
Eggs:
- Pelagic, spherical
- Diameter: 3.0–3.5 mm
- Chorion: smooth, unsculptured, with 'pustules' on inner surface
- Yolk: segmented
- Oil globules: single, 0.95–1.16 mm diameter, clustered at vegetal pole
- Perivitelline space: narrow

Larvae:
- Hatching occurs at 6–9 mm; large yolk, unpigmented eyes, no body pigment, broad finfold
- Body long and slender, with very long gut
- Branchiostegal rays: 6
- Adipose fin appears after transformation
- Flexion occurs at 28–35 mm
- Dorsal and anal fins form in finfold, them migrate to body's edge
- Caudal fin begins to ossify at about 28 mm
- Pectoral and pelvic fin rays form late
- Pigmentation includes a series of prominent melanophores arranged along the upper edge of developing gut; prominent pigment on upper and lower caudal fin base and scattered spots form on caudal fin rays; spots also occur in 'throat' region and on opercle
- Transformation occurs at >50 mm

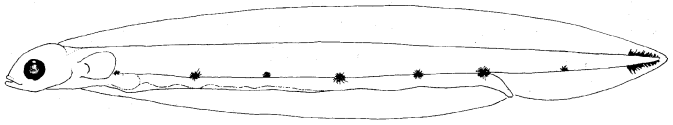
Note:
1. Large larvae superficially resemble those of *Trachinocephalus myops* (Synodontidae); they differ in positions of pelvic and dorsal fin origins, and absence of adipose fin pigment (also see Markle *et al*., 1980)
2. *Argentina striata* Goode and Bean, 1896, occurs in the western North Atlantic Ocean from Nova Scotia and Gulf of Maine to Brazil. Larvae differ from *A. silus* in pigmentation and sequence of fin formation. Vert: 47–51; D: 10–12; A: 11–13; Pectoral: 18–21; Pelvic: 12–15 (see Cohen and Atsaides, 1969)

Figures: Adult: Cohen, 1964a; **A–F**: Schmidt, 1906c (redrawn)
References: Ahlstrom *et al*., 1984b; Scott and Scott, 1988

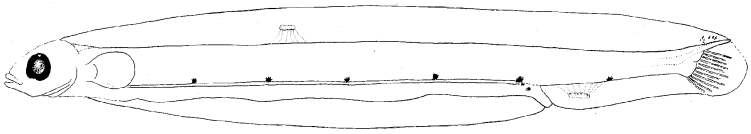
Argentina silus



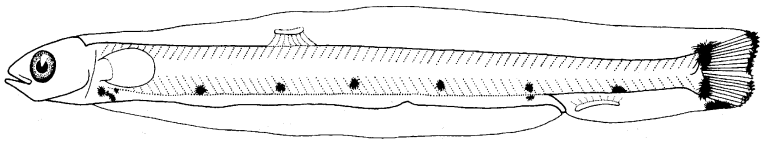
A. 16.8 mm



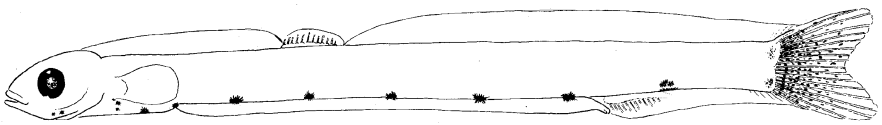
B. 19.0 mm



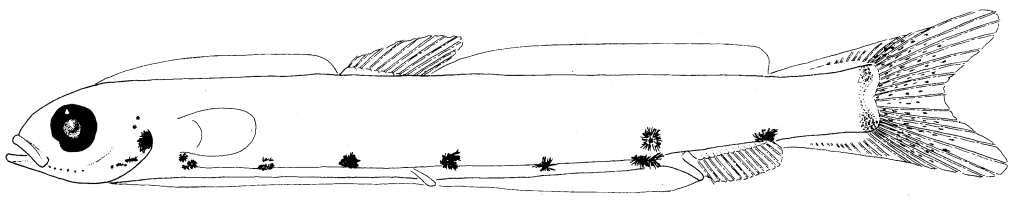
C. 28.0 mm



D. 32.5 mm

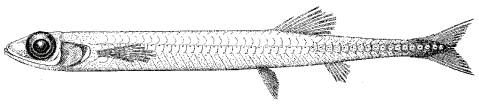


E. 39.0 mm Adipose fin not yet formed



F. 50.0 mm Pelvic fins form under posterior end of dorsal fin

Microstoma microstoma (Risso, 1810)
Microstomatidae
No common name



Meristic Characters

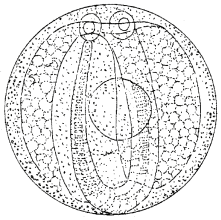
Myomeres:	45–47
Vertebrae:	45–47
Dorsal fin rays:	11–12
Anal fin rays:	8–9
Pectoral fin rays:	8
Pelvic fin rays:	9–11
Caudal fin rays:	11 + 19 + 11

Range: Western North Atlantic Ocean (Gulf of Mexico); also tropical eastern Atlantic and Mediterranean Sea

Habitat: Epi- and mesopelagic, often near surface over depths of about 1,000 m

Spawning: Undescribed; several larvae collected in study area May–Aug (e.g. MCZ 66006; MCZ 66040)

Eggs:
- Pelagic, spherical
- Diameter: 1.60–1.72 mm
- Chorion with 'pustules' on inner surface
- Yolk: segmented
- Oil globule: single, colorless, 0.48–0.52 mm in diameter
- Perivitelline space: narrow



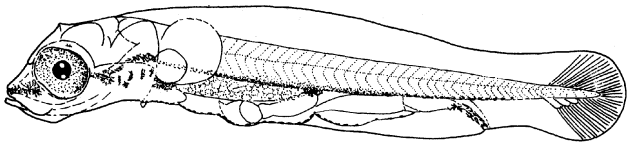
Larvae:
- Elongate body, laterally compressed early, then becomes round
- Trailing gut in early larvae
- Eye round, not oval as in *Nansenia groenlandica*
- Flexion occurs at 7–11 mm
- No adipose fin
- Sequence of fin formation: C – D, A – P_1 – P_2
- Dorsal and anal fin rays form distally in finfolds, then migrate to body's edge
- Pelvic fins located anterior to dorsal fin origin
- Pigmentation includes series of melanophores along ventral edge of body; short series of spots under developing dorsal fin becomes longer in larger larvae; head pigment forms bar behind eye; dense pigment covers body in larger larvae, following outlines of myomeres; no clear, unpigmented area over caudal peduncle as in *Nansenia*
- Transformation occurs at 17–20 mm

Note: 1. Characters above pertain to Mediterranean Sea specimens (Schmidt, 1918; Sanzo, 1931a)

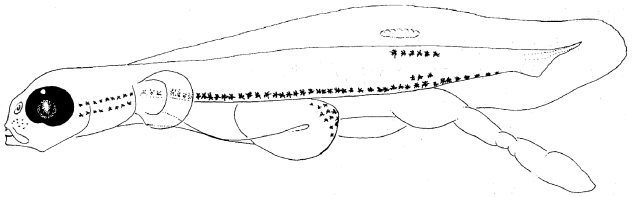
Figures: Adult: Miriam Wilson (Cohen, 1964a); Egg and **A, C–F**: Olivar and Fortuño, 1991 (redrawn from Sanzo, 1931a); **B**: Schmidt, 1918 (redrawn)

References: Schmidt, 1918; Sanzo, 1931a; Cohen, 1964a; Ahlstrom *et al.*, 1984b; Olivar and Fortuño, 1991

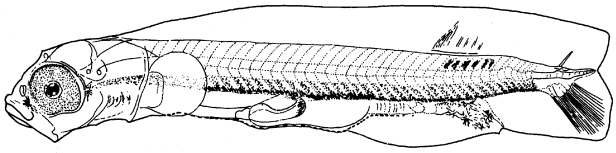
Microstoma microstoma



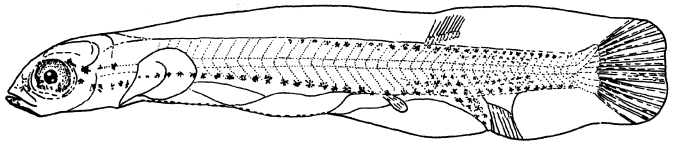
A. 6.2 mm



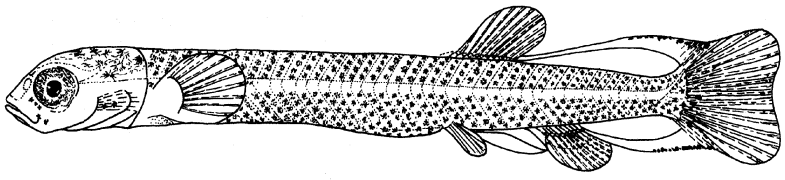
B. 7.0 mm Trailing gut only in small specimens



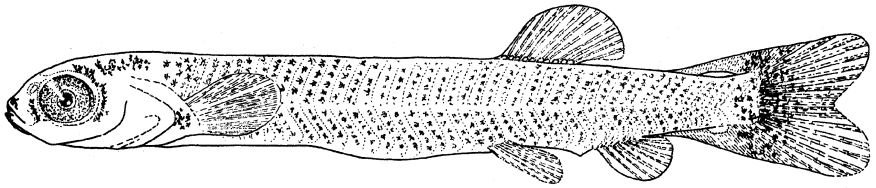
C. 7.2 mm



D. 12.6 mm Dense pigment spreads over body



E. 15.6 mm Pelvic fins form anterior to dorsal fin origin



F. 16.8 mm

Nansenia groenlandica (Reinhardt, 1840)
Microstomatidae
No common name

Meristic Characters

Myomeres:	43–44
Vertebrae:	43–45
Dorsal fin rays:	9–10
Anal fin rays:	8–10
Pectoral fin rays:	11–13
Pelvic fin rays:	11–12
Caudal fin rays:	19 (PrC)

Range: North Atlantic Ocean north of 39°N; also subpolar-temperate regions of eastern South Pacific

Habitat: Mesopelagic, occurring mostly in depths of 300–1,000 m; larvae known from slope waters south of southern New England and Georges Bank and near Hudson Canyon

Spawning: Spring–summer (eastern Atlantic)

Eggs:
- Undescribed

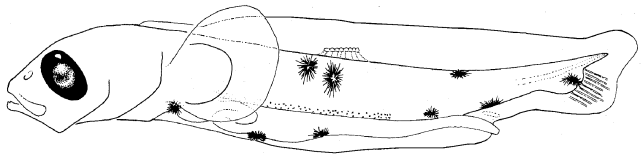
Larvae:
- Slender body with long, thick gut
- Wide finfold
- Low number of branchiostegal rays (3)
- Adipose fin forms before transformation
- Flexion complete at about 10–13 mm
- Sequence of fin ray formation: C – D, A – P_1 – P_2
- Dorsal and anal fins form distally in finfold, then migrate to body's edge
- Pelvic fin forms late
- Finfold persists after fin ray formation
- Dorsal fin origin anterior to pelvic fins
- Oval shaped eye in early larvae, becomes round
- Small terminal mouth
- Pigmentation includes 2–3 large melanophores on side under developing dorsal fin, plus several more on dorsal and ventral edges of body near level of anus; internal pigment occurs between body and developing gut; a few ventral spots on gut; a persistent spot occurs at base of caudal fin; head without pigment until late stages; overall pigment increases on sides in late larvae, leaving an unpigmented area between adipose fin and caudal fin base
- Transformation occurs at >20 mm

Note:
1. Many *Nansenia* larvae are in collections of the MCZ, not identified to species

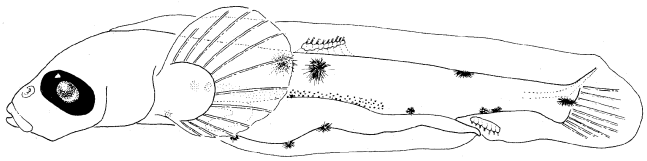
Figures: Adult: Schmidt, 1918; **A–F**: Schmidt, 1918 (**A–C**, **E** redrawn)

References: Ahlstrom *et al*., 1984b; Kawaguchi and Butler, 1984; Scott and Scott, 1988

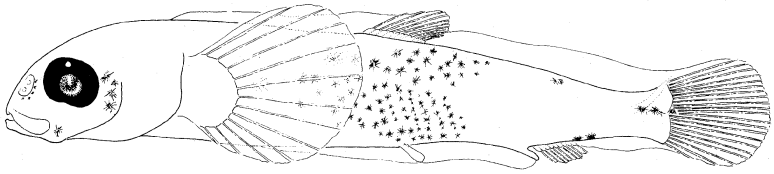
Nansenia groenlandica



A. 7.5 mm

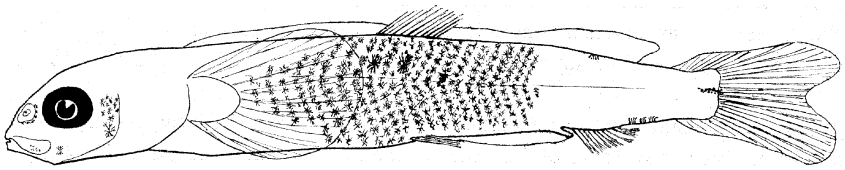


B. 10.0 mm

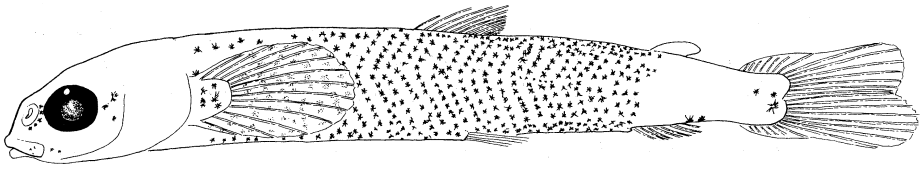


C. 13.2 mm

Pelvic fin forms under middle of dorsal fin base

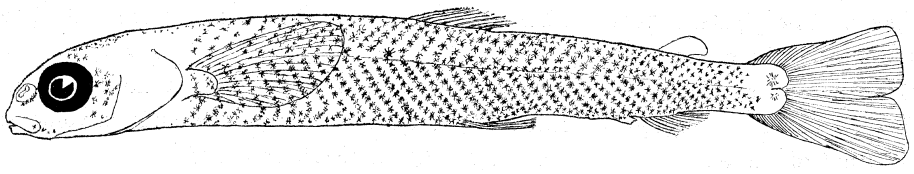


D. 18.0 mm



E. 20.5 mm

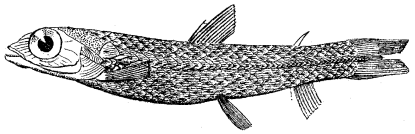
Heavy pigment over-all except adipose fin to caudal fin base



F. 27.0 mm

Pigment spreads posteriorly on body

Nansenia oblita (Facciolà, 1887)
Microstomatidae
No common name



Range: Adults only known from eastern Atlantic Ocean and Mediterranean Sea

Habitat: Mesopelagic

Spawning: Undescribed (in western Atlantic); larvae have been collected from 39°26.5' N, 53°13.2' W (open ocean south of Grand Bank)

Meristic Characters

Myomeres:	42–45
Vertebrae:	42–45
Dorsal fin rays:	10–11
Anal fin rays:	9–10
Pectoral fin rays:	10–11
Pelvic fin rays:	10–11
Caudal fin rays:	19 (PrC)

Eggs:
- Pelagic, spherical, transparent
- Diameter: 1.48–1.50 mm
- Chorion with 'pustules' on inner surface
- Oil globule single, colorless, 0.40–0.43 mm
- Perivitelline space: narrow

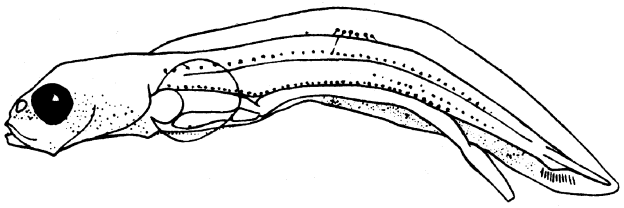
Larvae:
- Hatching occurs at about 4.0 mm, no pigment, mouth unformed
- Eye not oval as in *N. groenlandica*
- Elongate body, early larvae laterally compressed; preanus length about 75% TL; anus at about myomere #30
- Terminal end of gut may be exterilium in early larvae
- Body becomes rounded in later larvae; small, terminal mouth
- Four branchiostegal rays
- Sequence of fin ray formation: C, D, A – P_1 – P_2
- Adipose fin forms from finfold after fin rays are formed
- Pectoral fin rays form early
- Dorsal and anal fin rays form distally in finfold, then migrate to body's edge
- Pelvic fin forms late
- Pigmentation includes series of melanophores along dorsal and ventral margins of notochord; scattering of spots on head forms vague bar through eye; pigment spreads over most of body, except caudal peduncle remains unpigmented; later larvae have dense concentration of pigment at base of caudal fin
- Transformation occurs at >20 mm

Note:
1. Larval specimens held in Atlantic Reference Center (H6914; H6915)
2. Characters above pertain to Mediterranean specimens (Schmidt, 1918; Sanzo, 1931a)

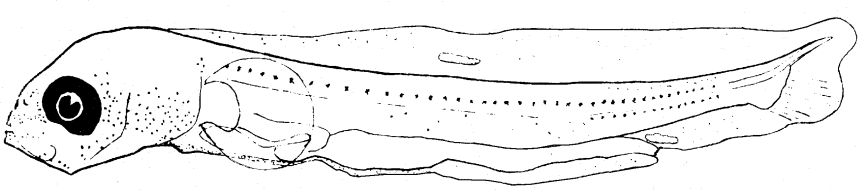
Figures: Adult: Schmidt, 1918; **A–D**: Schmidt, 1918

References: Sanzo, 1931a; Schmidt, 1918; Ahlstrom *et al.*, 1984b; Scott and Scott, 1988

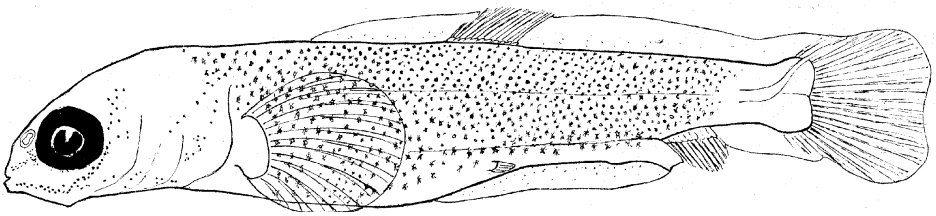
Nansenia oblita



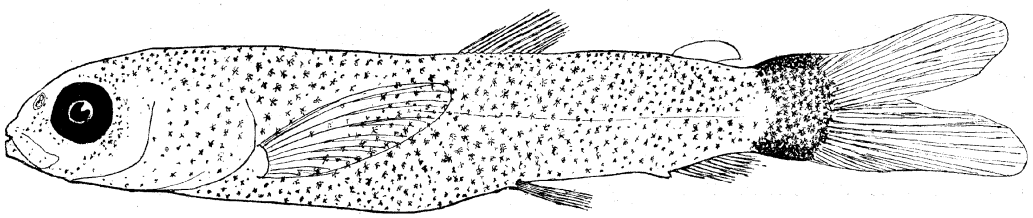
A. 7.8 mm



B. 9.0 mm Pigment in early larvae in linear series along body

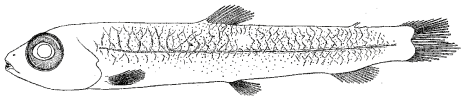


C. 13.0 mm Pelvic fin forms under middle of dorsal fin base



D. 21.0 mm Pigment spreads posteriorly on body with a dense concentration on caudal fin base

Bathylagichthys greyae (Cohen, 1958)
Bathylagidae
No common name



Range: Worldwide in tropical waters; in the western North Atlantic known from Bermuda and Caribbean Sea; a single (immature) specimen from near Browns Bank (41°49' N, 65°33' W)

Habitat: Meso- or bathypelagic, found from near surface to depths of 1,646 m

Spawning: Undescribed

Eggs: – Undescribed

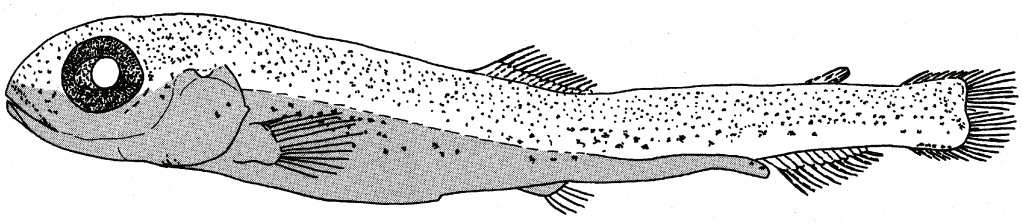
Meristic Characters

Myomeres:	44–46
Vertebrae:	44–45
Dorsal fin rays:	11–14
Anal fin rays:	11–13
Pectoral fin rays:	10–13
Pelvic fin rays:	9–11
Caudal fin rays:	19 (PrC)

Larvae:
- Body elongate, tapers slightly from level of pectoral fin to notochord tip
- Head relatively large, snout pointed; mouth small, terminal
- Head length about 21–26% SL through development
- Preanus length about 73–84% SL
- Trailing gut in early larvae; anus only slightly protruding in later larvae
- Flexion begins at about 8.0 mmNL
- Eyes oval in early larvae, become round in later larvae
- Adipose fin present after transformation
- Pelvic fin origin under middle of dorsal fin
- Pectoral fins located low on body
- Dorsal fin origin at about 50% SL
- Sequence of fin ray formation: C – P_1 – D, A, P_2
- Pigment in early larvae includes a paired series of small, conspicuous spots over anus; early development of series of spots dorsolaterally over anus; another series of spots midlaterally under dorsal fin
- Pigmentation in juveniles is heavy over-all, with a scattering of melanophores over upper head and body, and more dense, black pigment on ventral part of head and body, as far as level of anus; bases of pectoral and pelvic fins unpigmented (appear white)
- Transformation begins at about 20 mmSL

Note: 1. Description based on larvae and early juveniles collected in SE Atlantic Ocean

Juvenile:

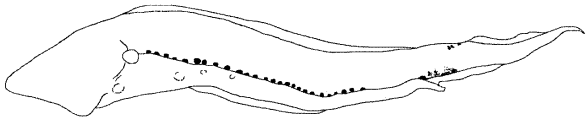


F. 28.0 mmSL

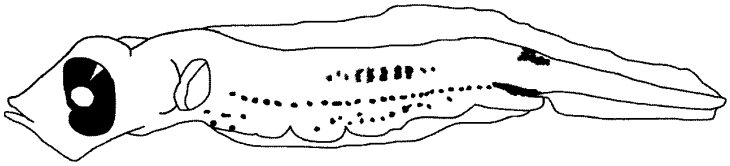
Figures: Adult: Cohen, 1958; **A–C**: John and Zelck, 2001; **D–E**: C.P. Kenaly (Kenaly and Hamilton, 2006); **F:** María-Pilar Olivar (Olivar and Fortuño, 1991)

References: Cohen, 1964a; Kobyliansky, 1986; Scott and Scott, 1988; John and Zelck, 2001; Kenaly and Hamilton, 2006

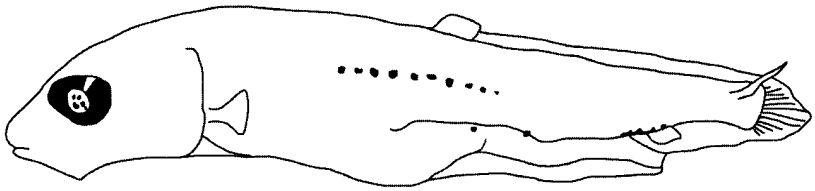
Bathylagichthys greyae



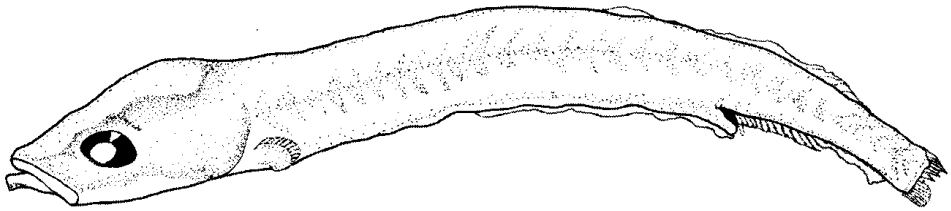
A. 3.6 mmSL



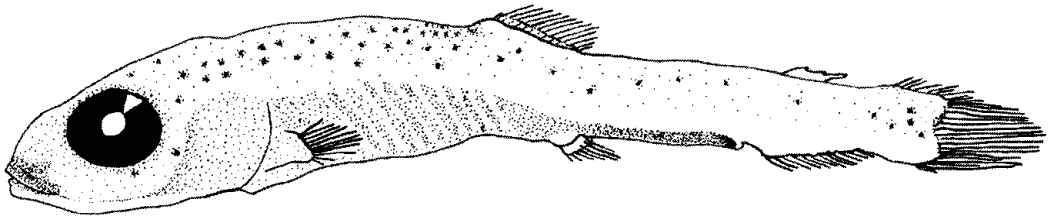
B. 4.2 mmSL



C. 7.7 mmSL

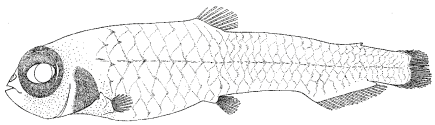


D. 20.4 mmSL, Transforming Larva



E. 28.2 mmSL, Juvenile

Bathylagus euryops Goode and Bean, 1895
Bathylagidae
Goitre blacksmelt



Range: Temperate and subarctic waters of North Atlantic Ocean; in the western North Atlantic from Davis Strait and Greenland south to Bermuda; also NE Atlantic Ocean

Habitat: Bathypelagic, found in depths of 500–1,800 m; occurs over outer continental shelf and upper continental slope areas off Labrador, Newfoundland, Grand Bank, Georges Bank and Long Island; young stages found closer to surface

Meristic Characters

Myomeres:	44–46
Vertebrae:	44–46
Dorsal fin rays:	9–11
Anal fin rays:	16–19
Pectoral fin rays:	7–12
Pelvic fin rays:	7–9
Caudal fin rays:	19 (PrC)

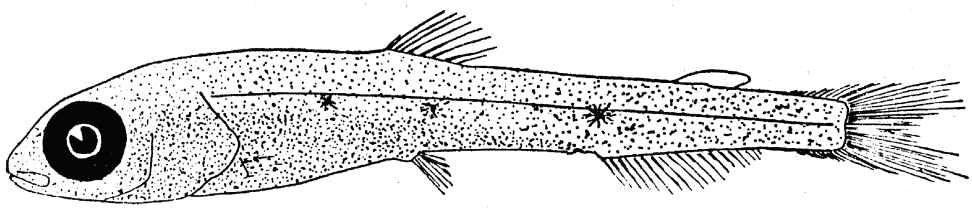
Spawning: Undescribed, possibly during spring

Eggs: – Undescribed

Larvae:
- Elongate body with small head, strongly telescopic eyes
- Mouth small, terminal
- Preanus length about 80% SL; shrinks to about 70% SL in juveniles
- Slightly trailing gut at terminus
- Wide finfolds (including preanal) in early stages
- Flexion begins at about 14 mm with formation of caudal fin rays
- Eye stalks decrease in relative length from 31% HL in preflexion stages to 25% HL in postflexion stages
- Adipose fin present
- Sequence of fin ray formation: C – A – other fin rays form after transformation
- Pelvic fin forms under middle of dorsal fin origin
- Anal fin base long (longer than length of caudal peduncle)
- Caudal fin first to form rays, pectoral fin last to form rays
- Pigmentation includes a series of large melanophores spaced along the flank and lateral surface of gut; series of small spots in branchial region, and scattering of pigment at base of caudal
- Transformation occurs at about 25.0 mm

Note: 1. Remnants of larval pigment pattern present in transforming and juvenile stages

Juvenile:

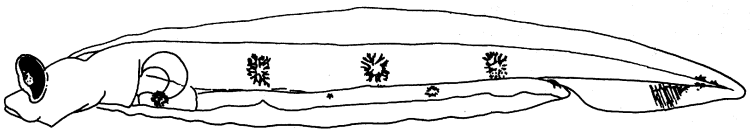


E. 31.0 mmSL

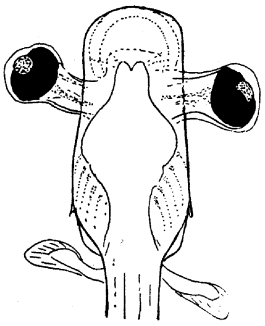
Figures: Adult: Esther Google (Cohen, 1964a); **A–B, E**: Tåning, 1931; **C**: Ahlstrom *et al.*, 1984b; **D**: C.P. Kenaly (Kenaly and Hamilton, 2006)

References: Cohen, 1964a; Ahlstrom *et al*., 1984b; Olivar and Fortuño, 1991

Bathylagus euryops

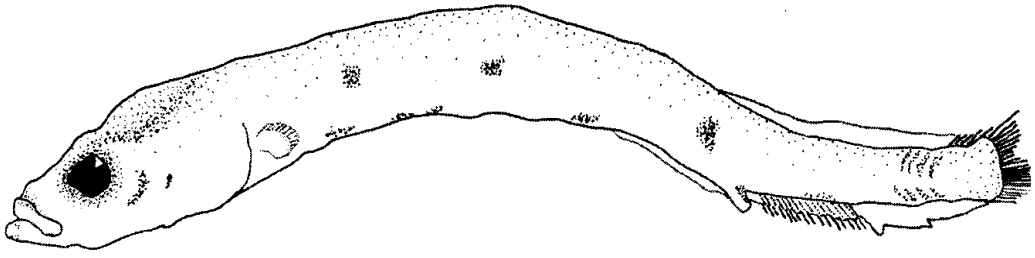


A. 14.3 mmSL



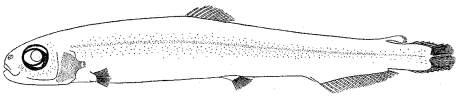
B. 14.3 mmSL
(Dorsum of Head)

C. 24.0 mmSL



D. 25.0 mmSL
(Transforming)

Dolicholagus longirostris (Maul, 1948)
Bathylagidae
No common name



Range: Worldwide in tropical to subtropical waters; in the western North Atlantic from Browns Bank to Caribbean Sea

Habitat: Meso- to bathypelagic in depths of 200–945 m; common in slope water and Gulf Stream north to Newfoundland

Spawning: Undescribed

Eggs: – Undescribed

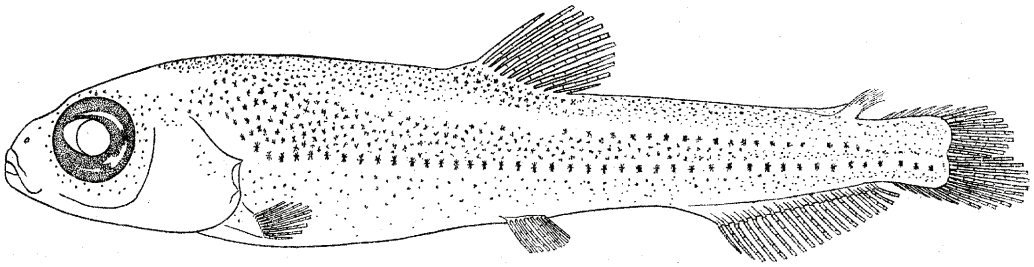
Meristic Characters

Myomeres:	48–51
Vertebrae:	48–51
Dorsal fin rays:	10–12
Anal fin rays:	19–21
Pectoral fin rays:	9–12
Pelvic fin rays:	9–10
Caudal fin rays:	19 (PrC)

Larvae:
- Elongate body, long gut, slender, pointed head and terminal mouth
- Strongly telescopic eyes, gradually pulled into head at transformation
- Sequence of fin ray formation: C – D, A – P_1, P_2
- Dorsal and anal fin rays formed in finfold, then migrate to body''s edge
- Pectoral and pelvic fin rays late–forming (at transformation)
- Pigment includes series of melanophores on lower head, along ventral edge of body, and on posterior gut; series along ventral edge becomes situated along body midline after flexion and extends forward through head as a long stripe

Note: 1. *Bathylagus compsus* (Cohen) is a junior synonym of *D. longirostris* (Kobyliansky, 1986)

Early Juvenile:



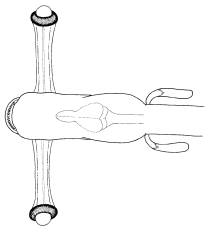
G. 44.4 mmSL

Figures: Adult: Esther Coogle (Cohen, 1964a); **A**: Henry Orr (Moser and Ahlstrom, 1996a); **B–C**: Henry Orr (Ahlstrom *et al*., 1984b); **D–F**: Beebe, 1933 (described as *B. glacialis*); **G**: Cohen, 1958

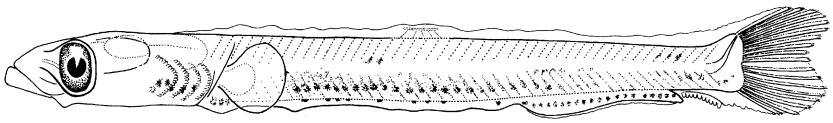
References: Cohen, 1964a; 1984b; Ahlstrom *et al*., 1984b; Kobyliansky, 1985; 1986

Dolicholagus longirostris

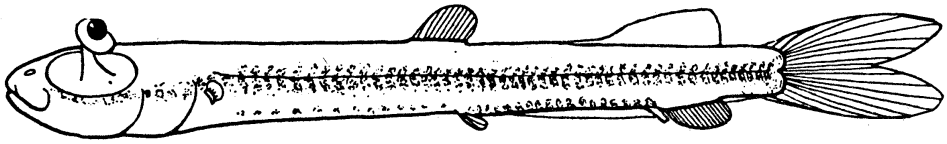
A. 9.1 mm



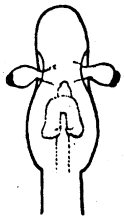
B. 12.4 mm
(Dorsum of Head)



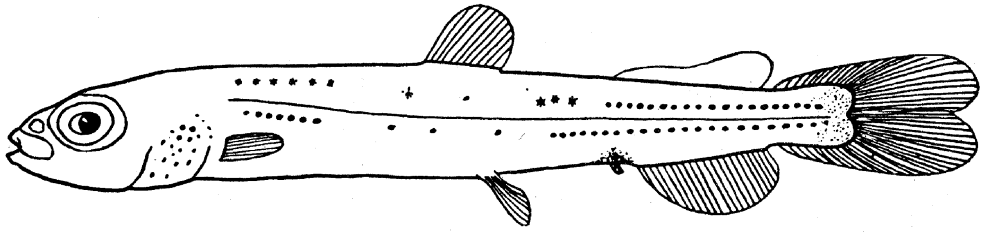
C. 20.1 mm



D. 23.5 mmSL

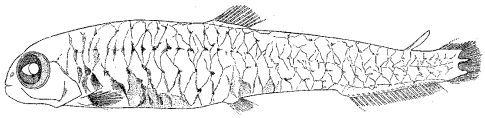


E. 23.5 mmSL
(Dorsum of Head)



F. 30.0 mmSL, (Transforming)

Melanolagus bericoides (Borodin, 1929)
Bathylagidae
No common name



Range: Worldwide in tropical and subtropical waters; in the western North Atlantic from Greenland, through continental slope waters off New England, south to tropical latitudes

Habitat: Meso- and bathypelagic; found in depths of 250–1,700 m

Spawning: Undescribed; summer-fall in eastern Pacific Ocean

Eggs: - Undescribed

Larvae:
- Elongate body with narrow, pointy head and strongly telescopic eyes
- Eye stalks very long before transformation (50–70% HL)
- Eye vertically elliptical
- Preanus length 85–90% SL
- Mouth parts pointy, with protruding lower jaw; ends well short of eye
- Flexion occurs at about 14 mm
- Sequence of fin ray formation: C_1 – A – D, P_1 – P_2 – C_2
- Dorsal and anal fin rays form distally in finfold, then migrate to body's edge
- Base of anal fin much longer than caudal peduncle length
- Pigmentation restricted to series of large melanophores along gut in early larvae; later larvae also have scattered spots on lower opercle and a single melanophore at base of pectoral fin; few spots at base of developing caudal fin
- Transformation occurs at >23 mm

Meristic Characters

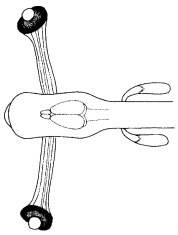
Myomeres:	48–53
Vertebrae:	48–53
Dorsal fin rays:	10–11
Anal fin rays:	18–22
Pectoral fin rays:	10–12
Pelvic fin rays:	9–10
Caudal fin rays:	19 (PrC)

Note:
1. Description based on Pacific specimens; Atlantic larvae have relatively shorter eye stalks and narrower optic lobes of brain
2. Larvae of *Dolicholagus longirostris* are more heavily pigmented and have relatively shorter eye stalks

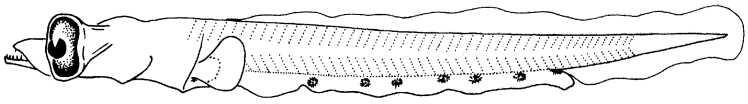
Figures: Adult: Esther Coogle (Cohen, 1964a); **A–D**: Henry Orr (Moser and Ahlstrom, 1996a); **E:** Betsy Washington (Ahlstrom *et al*., 1984b)

References: Ahlstrom *et al*., 1984b; Kobyliansky, 1986; Olivar and Fortuño, 1991

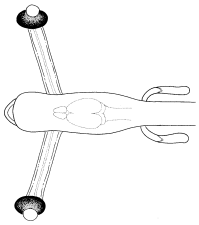
Melanolagus bericoides



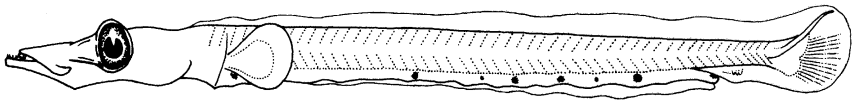
A. 6.4 mm
(Dorsum of Head)



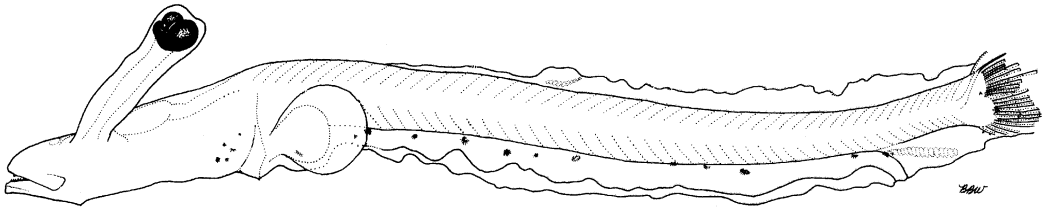
B. 7.3 mm



C. 11.8 mm
(Dorsum of Head)

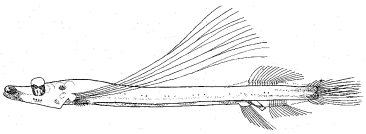


D. 14.5 mm



E. 17.7 mm

Dolichopteryx binocularis Beebe, 1932
Opisthoproctidae
No common name



Range: North and South Atlantic oceans; in study area known from scattered collections between Bermuda and Hudson Canyon

Habitat: Meso- and bathypelagic, to depths of 1,200 m

Spawning: Undescribed

Eggs: – Undescribed

Meristic Characters	
Myomeres:	57–58
Vertebrae:	57–58
Dorsal fin rays:	15
Anal fin rays:	11
Pectoral fin rays:	14
Pelvic fin rays:	7–9
Caudal fin rays:	13 + 19 + 13

Larvae:
- Elongate body, concave dorsum of head, long gut
- Eyes slightly telescopic, dorsally directed
- Dorsal, anal and pelvic fins posteriorly placed
- Pectoral and pelvic fin rays greatly elongate
- Pigment includes series of fine melanophores along gut, and a series of larger spots along lower flank on the posterior 65% of body; also internal pigment on snout
- Members of this genus may be neotenous. Sexually mature specimens have been described with semi-transparent, poorly developed musculature, a membranous body covering, an exposed gut covered only by peritoneum, weakly articulated fin rays, retention of pedunculate pelvic fin base, and bold, "larval" pigment patterns (Cohen, 1960).

Note:

1. The larvae of a congener, *Dolichopteryx longipes* (Vaillant, 1888), have also been described. Although this species occurs worldwide in tropical and temperate waters, generally deeper than 1,000 m, only a single larva has yet been reported from the Atlantic Ocean north of Bermuda (MCZ 66330; 49°53'N, 39°18'W). It is included here because of the strong potential for larvae to occur in the study area in the Gulf Stream or adjacent oceanic waters. Note elongate pelvic fin rays, but lack of elongate rays in the pectoral fin. Pectoral and pelvic fins are the first to form rays, and both have pedunculate bases; bodies are encased in a gelatinous sheath; stomach forms early on the left side (Fig. D); bold pigment is present along gut tube.

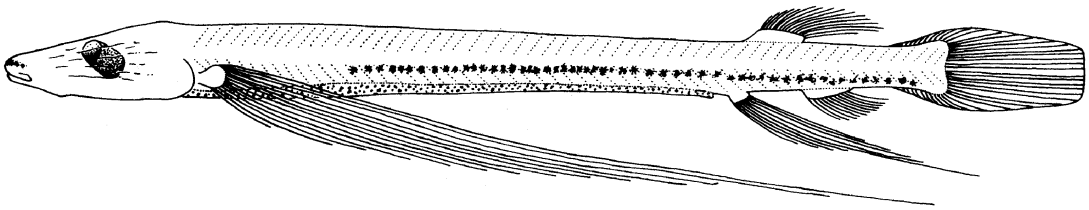
Meristic characters of *Dolichopteryx longipes* (Moser, 1996b):

Vert:	41–44
Dorsal fin rays:	10–11
Anal fin rays:	8–10
Pectoral fin rays:	11–13
Pelvic fin rays:	8–9
Caudal fin rays:	9–14 + 19 + 9–11

Figures: Adult: Beebe, 1933; **A:** Ahlstrom *et al*., 1984b (redrawn from Roule and Angel, 1930); **B–D**: Nancy Arthur (Moser, 1996b)

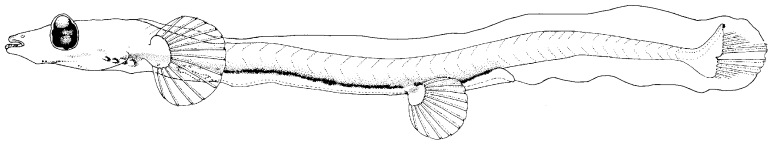
References: Cohen, 1958; 1960; Ahlstrom *et al*., 1984b

Dolichopteryx binocularis

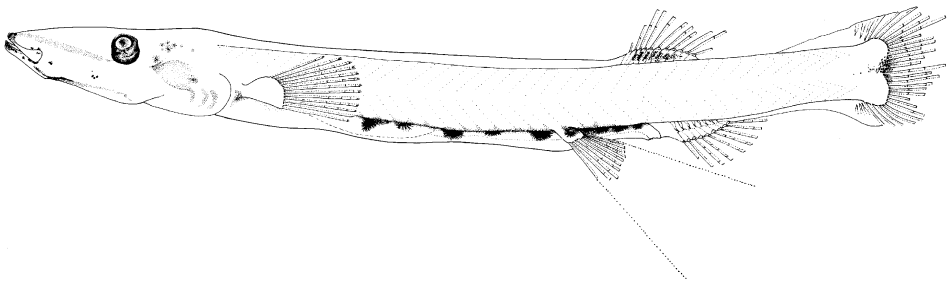


A. 58.0 mm

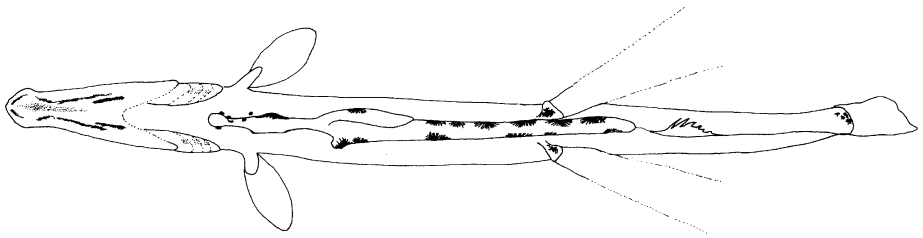
Dolichopteryx longipes



B. 13.4 mm



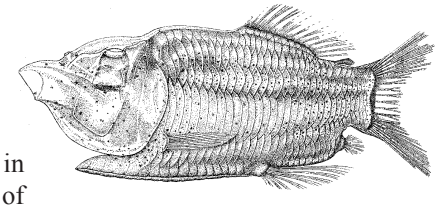
C. 27.8 mm



D. 27.8 mm
(Ventral View)

Note stomach forming on left side of gut

Opisthoproctus grimaldii Zugmayer, 1911
Opisthoproctidae
Barreleye



Range: Atlantic and western Pacific oceans, in tropical and subtropical waters; in the western Atlantic known from the Caribbean Sea, Bahamas and Gulf of Mexico, north to Georgia and rarely to slope water SE of Georges Bank (MCZ 60717)

Habitat: Meso- to bathypelagic, occurring in depths of 300–2,000+ m (mostly 300–400 m)

Spawning: Undescribed; several larvae collected in study area Apr–Oct

Eggs: – Undescribed

Larvae:
- Elongate, tubular snout combined with telescopic eye directed upward
- Body stubby and deep, 'hump' in dorsal outline, ventral surface flat
- Rectal bulb forms, containing a light organ, covered with dense pigment
- Elongate fin rays in pectoral and pelvic fins
- Pelvic and pectoral fins early forming, base of pelvic slightly pedunculate
- Anal fin base oriented horizontally in larvae, more vertically after transformation
- Anal fin shrinks considerably at transformation
- Adipose fin present, very small in adults
- Pigmentation includes a conspicuous saddle shaped patch of melanophores extending across upper flank from base of dorsal fin; also a scattering of smaller melanophores over much of body

Meristic Characters

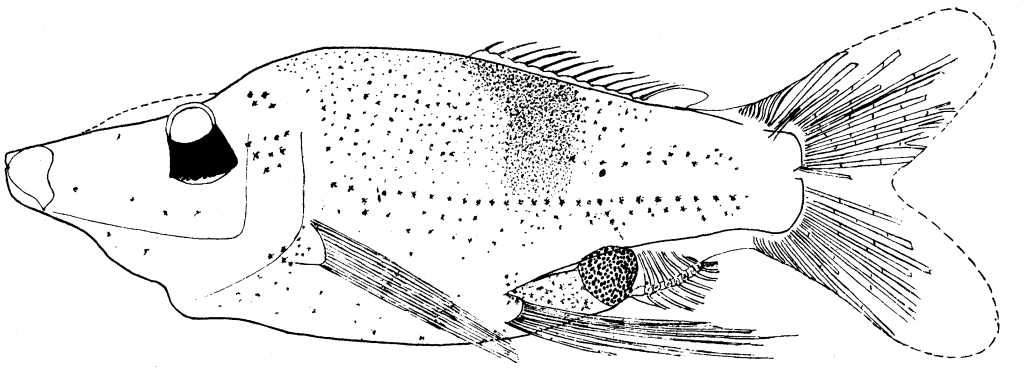
Myomeres:	–
Vertebrae:	–
Dorsal fin rays:	12–14
Anal fin rays:	8
Pectoral fin rays:	11
Pelvic fin rays:	10
Caudal fin rays:	19 (PrC) (about 35 total)

Note:
1. A congener (*Opisthoproctus soleatus*) is distributed worldwide in temperate and tropical waters. Larvae are undescribed, but several have been collected in the study area and are in the collections of the MCZ. See Salmoniformes introductory table for meristic characters.

Figures: Adult: Mildred Carrington (Cohen, 1964a); **A**: Schmidt, 1918

References: Schmidt, 1918; Bertelsen and Munk, 1964; Cohen, 1964a

Opisthoproctus grimaldii



A. 14.0 mm

Examples of larvae from the eastern Pacific and western North Atlantic oceans
Platytroctidae

Range: Several species in 7 genera (including congeners of *Holtbyrnia* and *Sagamichthys*) occur in the present study area (see Salmoniformes, Introductory Table).

Meristic Characters
See Introductory Table (Salmoniformes)

Habitat: Primarily meso- or bathypelagic, rarely occurring shallower than 200 m, usually in depths of 500–1,000 m; members of the 2 genera cited here are mesopelagic, several other genera are mostly bathypelagic. Larvae of these 2 genera have been collected in the same broad range of mesopelagic depths as the adults.

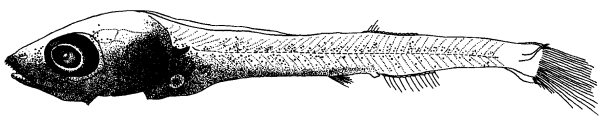
Spawning: Undescribed for species in western North Atlantic Ocean; certain Pacific Ocean species may spawn year-round, based on continued collection of specimens <20 mm during most months

Eggs: – Undescribed

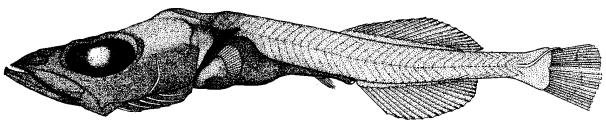
Larvae:
- Larvae and juveniles typified by peculiar "shoulder organ", an elongate, tubular structure arising from side of body above pectoral fin origin, and an early forming gular organ (or photophore) on the ventral surface of the lower jaw
- Yolk retained in larvae as large as 15 mm
- Larvae have small heads, small mouths and horizontally elliptical eyes; eyes and head increase in size, proportionately, with development
- Notochord flexion and (principal) caudal fin ray formation occur early in larval stage
- Persistent predorsal and preanal finfolds retained in juvenile stages; minor finfolds also retained anterior to caudal fin
- Sequence of fin ray formation: C_1 – D, A – P_2 – P_1 – C_2
- Branchiostegal rays (8) form early; adipose fin lacking
- Additional photophores form during larval stage, including an intraventral organ which forms on ventral edge of body anterior to anus
- Pigmentation in the smallest *H. latifrons* larvae includes dense, black coloring on the "shoulder organ" and gular organ, with lighter pigment on the posterior edge of opercle and dorsal surface of yolk-sac; the smallest *S. abei* are similar, but also have a dense concentration of pigment associated with a subopercle photophore; in larger larvae and juveniles of both species, dense black tissue lines mouth, branchial chamber and peritoneum to level of anus; black pigment spreads further in older juveniles and adults, resulting in nearly complete covering of dense, black coloration

Note:
1. Larvae collected from near Bermuda and described as *Bathytroctes rostratus* (Beebe, 1933) were shown to consist of a mixture of species by Parr, (1960) in his review of the family Searsidae (= Platytroctidae).
2. See Matsui and Rosenblatt (1971) and Matsui (1991) for more detail on photophore formation in young platytroctids, and for meristic characters of Pacific genera and species

Late larva and early juvenile (*Sagamichthys* sp.):



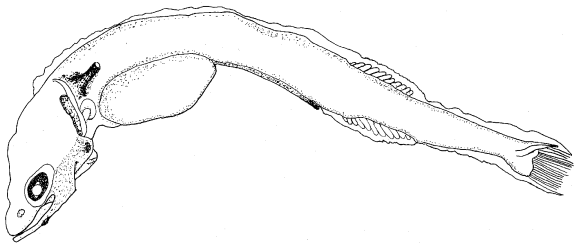
G. 18.5 mmSL



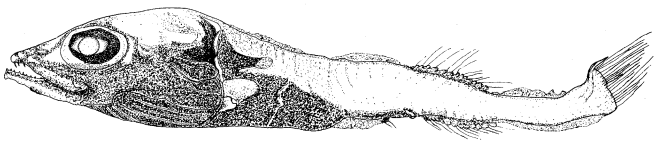
H. 18.0 mmSL, Juvenile

Figures: **A–F**: Matsui, 1991; **G–H**: Richards and Hartel, 2006
References: Beebe, 1933; Parr, 1960; Matsui and Rosenblatt; 1971; 1987

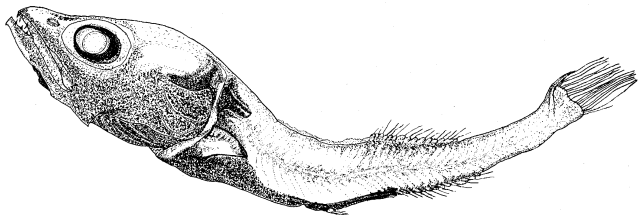
Pacific Ocean Platytroctidae ***Holtbyrnia latifrons***



A. 15 mmSL

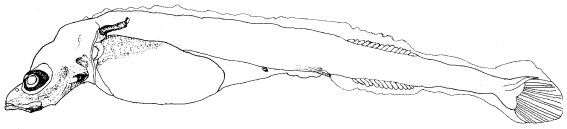


B. 14 mmSL

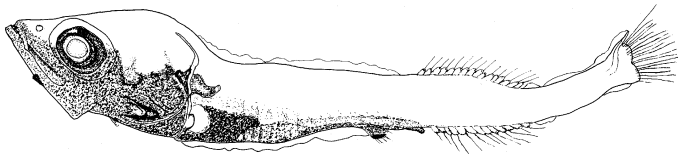


C. 14 mmSL

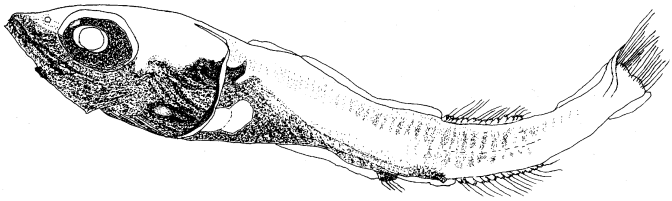
Sagamichthys abei



D. 16 mmSL

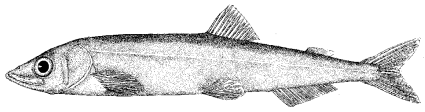


E. 14 mmSL



F. 16 mmSL

Mallotus villosus (Müller, 1776)
Osmeridae
Capelin



Range: Circumpolar in northern parts of Atlantic and Pacific oceans; in the Western North Atlantic from Hudson Bay to Grand Bank, Nova Scotia and Gulf of Maine; most abundant off Labrador and Newfoundland

Habitat: Cold, deep waters of offshore banks, coastal bays and other coastal areas; avoids warmer waters; coastal populations move inshore prior to spawning

Spawning: Mostly occurs Jun–Jul; usually spawn on coarse sand or fine gravel beaches, where eggs are buried in substrate; minor egg deposition also occurs near bottom in depths up to 50 m

Meristic Characters

Myomeres:	62–73
Vertebrae:	64–70
Dorsal fin rays:	12–14
Anal fin rays:	(17)19–21(22)
Pectoral fin rays:	18–20
Pelvic fin rays:	8
Caudal fin rays:	10+9 (PrC)

Eggs:
- Demersal, spherical, adhesive
- Diameter: 0.90–1.16 mm
- Chorion: thick, transparent
- Oil globules: many, tiny
- Perivitelline space: moderately wide
- Embryos develop and hatch while in substrate

Larvae:
- Hatching occurs at 6-7 mm; eyes unpigmented
- Body long and slender; preanus length about 75% TL; preanal myomeres 48–51
- Flexion occurs at 11–16 mmTL
- Sequence of fin ray formation: C – D, A – adipose – P_2 – P_1
- Principal caudal fin rays begin 7 mm; pelvic fin buds form at 21 mm, rays complete at 40 mm; pectoral fin rays form >40 mm
- Pigmentation includes double, ventral row of melanophores between pectoral fin base and yolk-sac, single row from yolk-sac to caudal fin base; other rows of spots form on each side, between dorsal gut and body; note short row of spots above base of anal fin

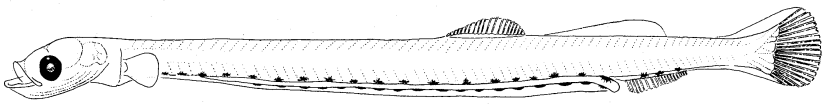
Note:
1. Similar larvae include: *Clupea harengus* – no adipose fin, medial streak of pigment on isthmus, preanus length about 83%TL, yolk-sac larvae larger; *Argentina* sp. – pelvic fins farther posterior, mouth much smaller; *Pholis gunnellus* and *Ammodytes* sp. – preanus length only about 50%TL, longer dorsal and anal fin bases
2. Also see *Osmerus mordax*

Figures: Adult: D.R. Harriott (Scott and Scott, 1988); **A**: Bigelow and Schroeder, 1963; **B–E**: Templeman, 1948 (all redrawn)
References: Bailey *et al*., 1977; Scott and Scott, 1988

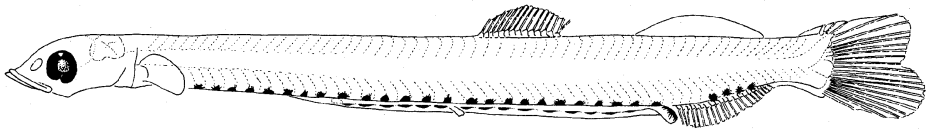
Mallotus villosus

A. 6.0 mm

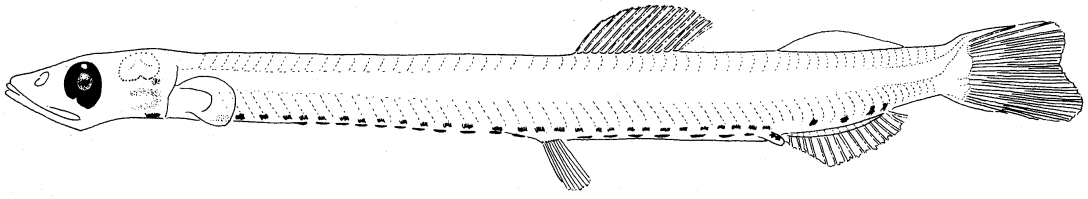
B. 9.0 mm



C. 16.0 mm

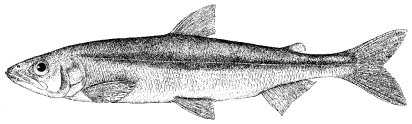


D. 29.0 mm



E. 40.0 mm

Osmerus mordax (Mitchill, 1814)
Osmeridae
Rainbow smelt



Range: Atlantic coast of North America from southern Labrador to New Jersey, including Gulf of St. Lawrence and Gulf of Maine

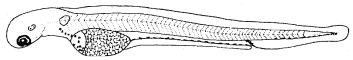
Habitat: Anadromous, inhabiting coastal waters, bays and estuaries, then ascending freshwater streams for spawning; move to cooler depths during summer; can tolerate landlocked freshwater conditions

Meristic Characters

Myomeres:	62–64
Vertebrae:	62–64
Dorsal fin rays:	10–11
Anal fin rays:	15–17
Pectoral fin rays:	11–12
Pelvic fin rays:	8
Caudal fin rays:	10+9 (PrC)

Spawning: Late winter-early spring

Eggs:
- Demersal, adhesive, in clusters
- Outer membrane turns 'inside-out', forms stalk
- Diameter: about 1.0 mm
- Chorion: smooth
- Numerous oil globules coalesce to 1 in anterior yolk

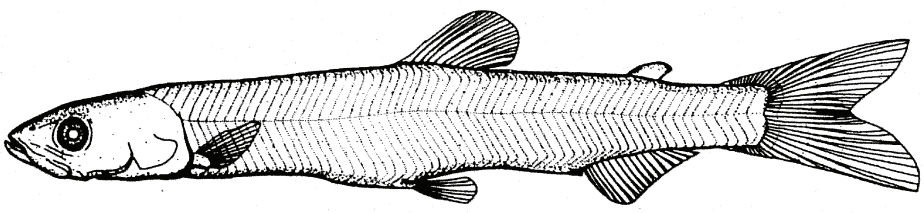


Yolk-sac Larva

Larvae:
- Hatching occurs at 5–6 mm; eyes pigmented, mouth unformed
- Very elongate body with small head, long gut (preanus length 65–75% TL)
- Preanal myomeres 42–48; postanal myomeres 13–17
- Posterior gut thicker than anterior part
- Adipose fin present
- Sequence of fin ray formation: C, D, A, adipose – P_2 – P_1
- All fin rays, except pectoral, completely formed by 30 mm
- Pectoral fin rays complete by 36.0 mm (juvenile stage)
- Pigmentation: series of melanophores along ventral edge of body begins as row along developing gut,including pair of spots anterior to pectoral fins; isolated spots on ventral part of caudal peduncle; spots present on preanal finfold

Note:
1. Ventral melanophores in *Mallotus villosus* are larger and more closely spaced; also note pelvic fin position relative to dorsal fin origin in the 2 osmerid species (farther anterior in *M. villosus*); *O. mordax* transforms to juvenile stage at smaller size

Early Juvenile: – Scale formation begins on tail, proceeds anteriorly; pigmentation light

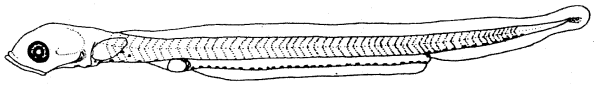


G. 36.0 mm

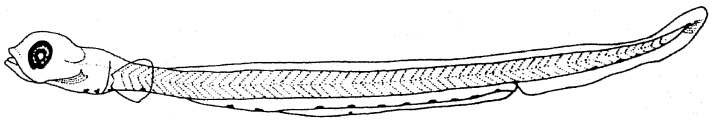
Figures: Adult: D. R. Harriott (Scott and Scott, 1988); egg, yolk-sac larva and **A–D**, **F–G**: Cooper, 1978; **E**: Bigelow and Schroeder, 1963 (redrawn)

References: Cooper, 1978; Scott and Scott, 1988

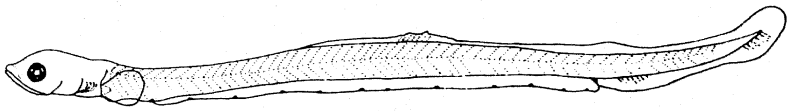
Osmerus mordax



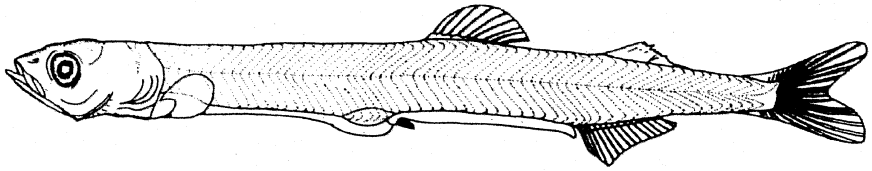
A. 6.3 mm



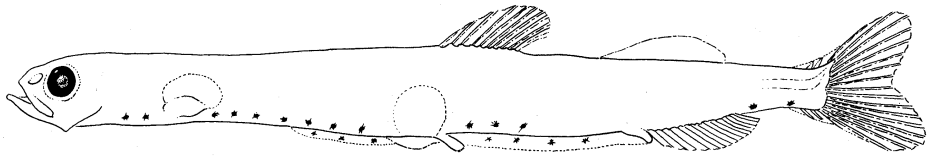
B. 9.3 mm



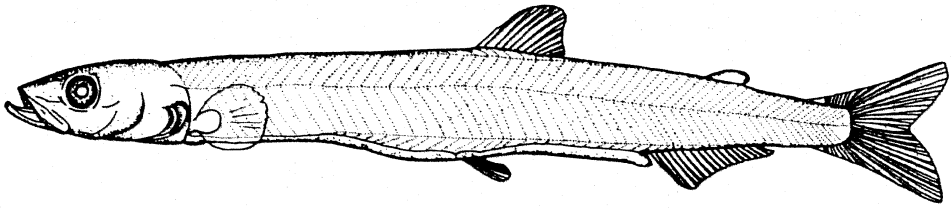
C. 14.0 mm



D. 22.0 mm

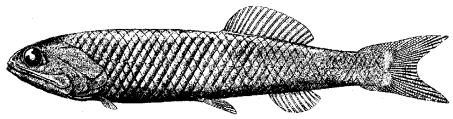


E. 26.0 mm



F. 30.0 mm

Bathylaco nigricans Goode and Bean, 1896
Alepocephalidae
No common name



Range: Worldwide in tropical and temperate waters; in the western North Atlantic from Greenland and southern New England

Habitat: Meso- to bathypelagic in depths of 450–4,376 m (usually 1,750 to 2,200 m)

Spawning: Undescribed

Eggs:
– Undescribed; ovarian eggs described as 2.7 mm diameter (Nielsen and Larsen, 1968)

Meristic Characters

Myomeres:	41–46
Vertebrae:	41–46
Dorsal fin rays:	17–22
Anal fin rays:	11–12
Pectoral fin rays:	5–11
Pelvic fin rays:	6–9
Caudal fin rays:	12–14+10+9 +11–14

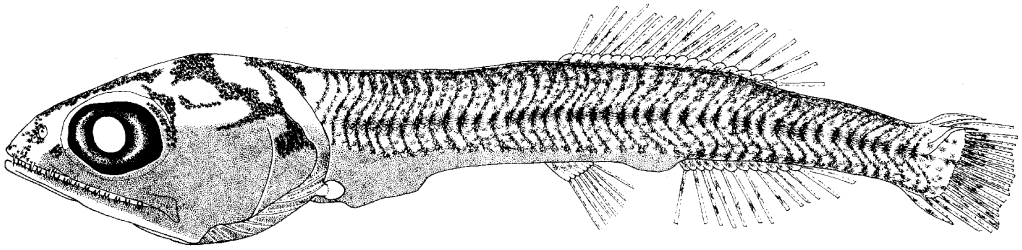
Larvae:
– Thin body with large head
– Large mouth (>60% Head Length)
– Eye oval in larvae, becomes round at transformation
– Peculiar "shoulder organ" (found in Platytroctidae) lacking
– Anal fin origin well posterior to dorsal fin origin
– Pelvic fin origin at level of dorsal fin origin
– Dark, internal pigment lines mouth, branchial chamber, peritoneum
– Heavy body pigment follows outlines of myosepta; heavier concentration along mid-line
– Pectoral fin rays late-forming
– Adipose fin lacking

Note:
1. Young stages of alepocephalids are very poorly known
2. Description and illustration based on eastern Pacific specimens

Figures: Adult: Parr, 1947; **A**: R. C. Walker (Ambrose, 1996a)

References: Nielsen and Larsen, 1968; Markle and Kreft, 1985; Ambrose, 1996a

Bathylaco nigricans



A. 16.3 mmSL

Bajacalifornia megalops (Lütken, 1898)
Alepocephalidae
Bigeye smooth-head

Meristic Characters

Myomeres:	51–53
Vertebrae:	31–32+18–20
Dorsal fin rays:	16–18
Anal fin rays:	14–16
Pectoral fin rays:	13–16
Pelvic fin rays:	7–9
Caudal fin rays:	10+9 (PrC)

Range: Worldwide, within a wide range of latitudes; most records from North Atlantic Ocean; in study area, known from Davis Strait and many sites off North America from Scotian Shelf south into tropical waters

Habitat: Benthopelagic, collected from depths of 820–1,425 m; larvae and juveniles are meso- or bathypelagic, found in depths of 700–2,500 m

Spawning: Undescribed

Eggs: – Undescribed

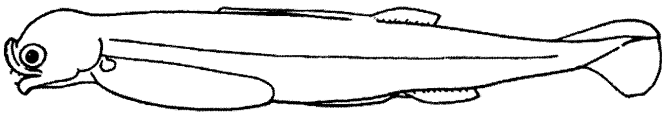
Larvae:
- Body fragile, somewhat elongate, with large head
- Snout pointed, mouth terminal, barely reaching level of anterior eye
- Body depth nearly uniform along entire length and almost cylindrical
- Eye horizontally oval throughout development
- Remnant predorsal and preanal finfolds persist after formation of fin rays
- Dorsal and anal fins situated opposite each other, with dorsal fin origin anterior to anal fin origin
- 7 branchiostegal rays
- Note lack of "shoulder organ" found in platytroctids and lack of adipose fin, found in bathylagids
- Sequence of fin ray formation: C, D, A – P_1, P_2
- Pectoral and pelvic fins form late
- Pelvic fins form anterior to level of dorsal fin origin
- Pigmentation described as dark brownish grey over-all, with dense black on head, opercles and over abdomen; color possibly owing to internal pigment

Note:
1. Scalation and ossification of bones and fin rays delayed until late in ontogeny
2. The early life history stages of very few alepocephalids have been described; see Ambrose (1996a) for descriptions of late larvae or juveniles of several eastern Pacific species
3. The larvae in Figs. A and B were described as *Bathytroctes drakei* by Beebe (1933), and re-identified by Markle and Sazanov (1990)

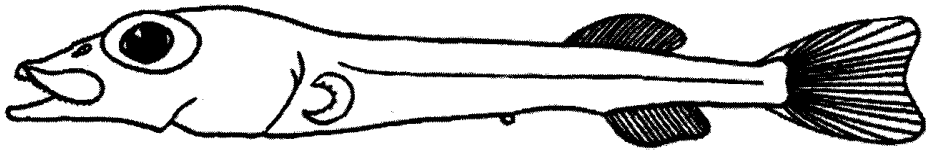
Figures: Adult: Markle and Quéro, 1984a; **A–B**: Beebe, 1933; **C–D**: Markle and Kreft, 1985

References: Beebe, 1933; Markle and Kreft, 1985; Markle, 1986; Markle and Sazanov, 1990

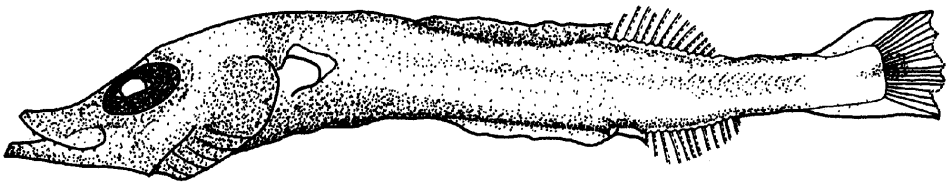
Bajacalifornia megalops



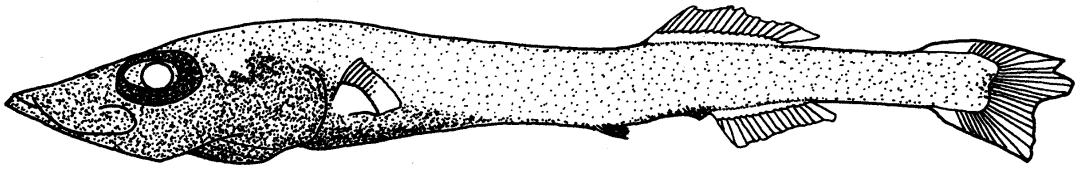
A. 11.5 mm



B. 15.0 mm

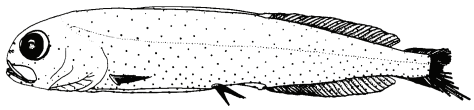


C. 15.4 mmSL



D. 29.8 mmSL

Xenodermichthys copei (Gill, 1884)
Alepocephalidae
Bluntsnout smoothhead



Range: Worldwide in temperate and tropical waters; in the western North Atlantic from Greenland, La Have Bank, east coast of United States, Bermuda, Gulf of Mexico to Brazil; also eastern North Atlantic

Habitat: Meso- to bathypelagic over continental slopes, in depths of 100–2,650 m

Spawning: Near bottom, possibly peaks Sep–Nov

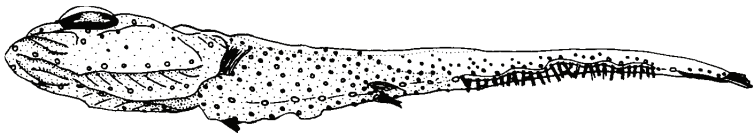
Eggs:
- Undescribed
- Ovarian eggs up to 2.7 mm in diameter

Meristic Characters

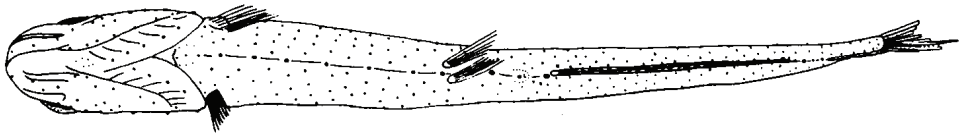
Myomeres:	46–50
Vertebrae:	46–50
Dorsal fin rays:	27–31
Anal fin rays:	26–30
Pectoral fin rays:	7–8
Pelvic fin rays:	6
Caudal fin rays:	10+9 (PrC)

Larvae:
- Body moderately elongate, deepest at level of posterior head, tapering to long and narrow caudal peduncle
- Head deep; snout pointed, becomes blunt in later stages
- Eye large, irregular shape
- Sequence of fin ray formation: C, D, A – P_2, P_1
- Dorsal and anal fins equal in length, opposite each other
- Pectoral fins small, located near venter of body
- Photophores begin formation on midventral line anterior to anal fin, with a few early photophores on venter of caudal peduncle; subsequent photophore development proceeds upward on body over gut; photophores cover much of body in adults (>500)
- Pigment in early stages includes black covering on ventral half of head and over gut

Ventral Views:



E. 22.0 mmSL

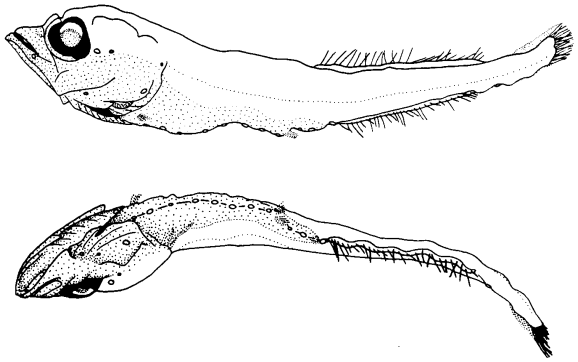


F. 136 mmSL (Adult)

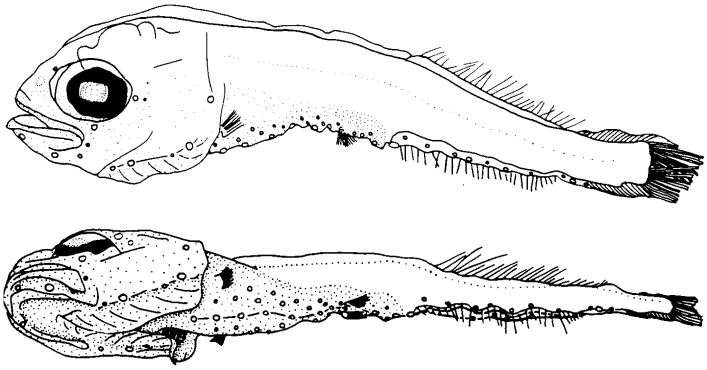
Figures: Adult: Badcock and Larcombe, 1980; **A–F**: Badcock and Larcombe, 1980

References: Markle and Wenner, 1979; Badcock and Larcombe, 1980; Markle and Quero, 1984a; Scott and Scott, 1988; Okamura *et al.*, 1995

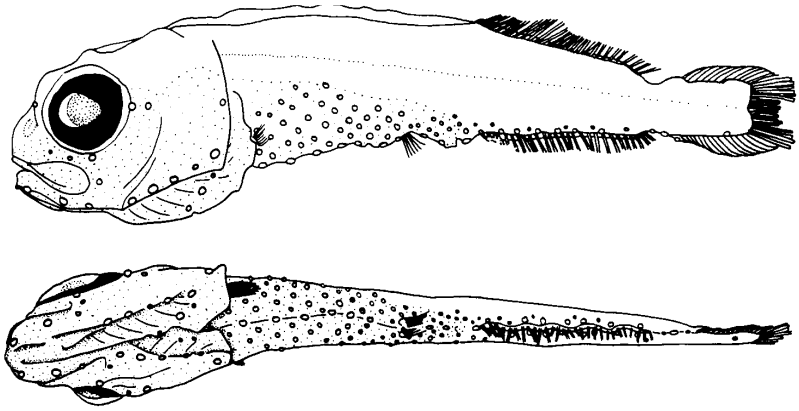
Xenodermichthys copei



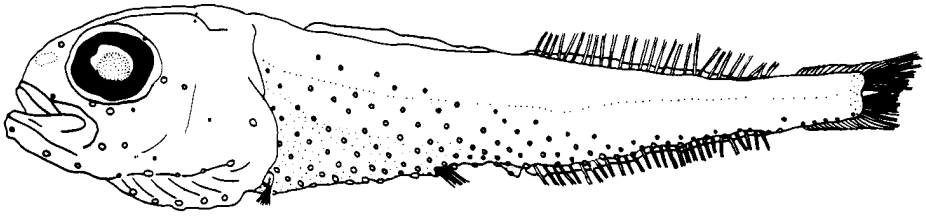
A. 9.0 mmSL
(Lateral & Ventral Views)



B. 11.0 mmSL
(Lateral & Ventral Views)



C. 14.0 mmSL
(Lateral & Ventral Views)



D. 22.0 mmSL