

Gadiformes

Selected meristic characters in species belonging to the order Gadiformes whose adults or larvae have been collected in the study area. Total vertebrae, second dorsal and anal fin rays are numerous in the Bathygadidae and Macrouridae, but are seldom reported. Classification sequence and sources of meristic data: Eschmeyer, 1990; Fahay and Markle, 1984; Fahay, 1989; Cohen *et al.*, 1990; Iwamoto, 2002; Iwamoto and Cohen, 2002a; 2002b; Merrett, 2003. PrC = principal caudal rays; ~ = approximately

Family <i>Species</i>	Precaudal Vertebrae	Total Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Pelvic Fin Rays
Bregmacerotidae						
<i>Bregmaceros atlanticus</i>	14	53–55	47–56	49–58	16–21	5–7
<i>Bregmaceros cantori</i>	14	45–49	45–49	45–49	16–23 (family)	5–7
<i>Bregmaceros</i> sp.	14–15	52–59	52–59	58–69	16–23 (family)	5–7
<i>Bregmaceros houdei</i>	13–14	47–50	47–50	41–46	16–23 (family)	5–7
Family <i>Species</i>	Precaudal Vertebrae	Total Vertebrae	First + Second Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Pelvic Fin Rays
Bathygadidae						
<i>Bathygadus favosus</i>	12–14	~70	9–11+125	110	15–18	9(10)
<i>Gadomus dispar</i>	12–13	80+	12–13	–	18–20	8
<i>Gadomus longifilis</i>	11–13	–	9–11	–	14–16	8–9
Macrouridae						
<i>Caelorinchus caribbeus</i>	11–12	–	11–12+>110	>110	17–20	7
<i>Caelorinchus coelorhynchus</i>	11–12	–	10–11	–	(17)18–20(21)	7
<i>Caelorinchus occa</i>	12–13	–	9–11	–	17–20	7
<i>Coryphaenoides alateralis</i>	–	–	13	–	21–23	8
<i>Coryphaenoides armatus</i>	13–15	–	10–12+~125	~135	19–21	10–11
<i>Coryphaenoides brevibarbis</i>	12–13	–	9	–	19–20	8–9
<i>Coryphaenoides carapinus</i>	12–15	–	10–11+100	117	17–20	9–11
<i>Coryphaenoides guentheri</i>	11–14	–	11–12	–	19–21	7–8(9)
<i>Coryphaenoides leptolepis</i>	12–13	–	8–10	–	19–20	9–10
<i>Coryphaenoides rupestris</i>	11–13	63–79	10–13+103–183	104–193	16–19	7–8
<i>Hymenocephalus italicus</i>	10–11	–	11–14+105	–	14–17	10–11 (12)
<i>Macrourus berglax</i>	16–18	–	11–13+124	148	16–19	7–9
<i>Malacocephalus occidentalis</i>	11–13	–	13–15	–	(21)22–26	(7)8
<i>Nezumia aequalis</i>	13–14	–	11–14	–	(15)19–21(23)	(7)8–9
<i>Nezumia bairdii</i>	13–14	–	11–13+137	120	17–20	(6)7
<i>Nezumia cyrano</i>	13–14	–	11–13	–	18–22	(8)9(10)
<i>Nezumia longebarbata</i>	13–14	–	11–12	–	21–24	10)11–13
<i>Nezumia sclerorhynchus</i>	13–14	–	11–12	–	17–21	7)9(8–10)
<i>Nezumia suilla</i>	13–14	–	11–13	–	19–22	7
<i>Sphagemacrurus grenadae</i>	11–12	–	12–13	–	18–22	11–12
<i>Trachonurus sulcatus</i>	12–13	–	9–11	120	15–17	(6)7
<i>Trachyrincus murrayi</i>	14	–	(10)11	–	21	7

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Family <i>Species</i>	Precaudal Vertebrae	Total Vertebrae	Fin+Second Dorsal Fin Rays	Anal Fin Rays	Caudal Fin Rays	Pectoral Fin Rays	Pelvic Fin Rays
Moridae							
<i>Antimora rostrata</i>	–	57–61	4–7+48–56	36–49	9 PrC	17–25	5–7
<i>Gadella imberbis</i>	17	49–51	10+53–61	63–66	9 PrC	25–26	6–7
<i>Halargyreus johnsonii</i>	22–23	51–58	6–9+47–60	17–26+21–29	38–42	17–20	5
<i>Laemonema barbatulum</i>	13–15	50–56	6–7+57–63	54–63	6 PrC	19–23	2
<i>Laemonema goodebeanorum</i>	15–17	56–59	5–6+66–73	65–71	6 PrC	19–22	2
<i>Laemonema melanurum</i>	15–16	53–57	7+53–61	52–59	6 PrC	25–27	2
<i>Lepidion eques</i>	17–18	58–63	4–5+52–60	47–54	34–36	21–25	8
<i>Physiculus fulvus</i>	12–16	47–50	9–12+57–61	59–68	–	21–26	5–7
Melanonidae							
<i>Melanonus zugmayeri</i>	13	58–62	72–78	50–58	55–60	10–16	5–7
Gadidae							
<i>Arctogadus glacialis</i>	19–23	57–61	9–14+14–22+16–22	17–24+18–24	50–52	–	6–7
<i>Boreogadus saida</i>	18–20	53–58	11–15+12–17+17–24	14–22+18–24	50–54	18–19	6
<i>Gadus morhua</i>	18–20	49–55	13–16+19–24+18–21	20–24+17–22	50–56	–	6–7
<i>Gadus ogac</i>	19–22	53–56	13–17+14–20+15–20	18–22+15–20	47–51	–	6–7
<i>Melanogrammus aeglefinus</i>	19–22	52–57	13–18+19–25+18–23	21–28+19–24	57–60	19–23	6–7
<i>Microgadus tomcod</i>	19–22	53–57	11–15+15–19+16–20	17–21+16–20	46–50	18–19	6
<i>Micromesistius poutassou</i>	24–26	55–58	12–14+12–14+23–28	33–39+24–27	50	18–22	6
<i>Pollachius virens</i>	23–25	53–57	13–14+21–22+24–28	24–28+20–21	66–70	19–22	6–7
Lotidae							
<i>Brosme brosme</i>	20	64–66	85–105	71–76	45–48	22–24	4–5
<i>Molva dipterygia</i>		72–78	11–15+69–83	62–75	–	18–21	6–7
<i>Molva molva</i>	26	62–67	13–16+57–70	55–67	52–53	18–21	6–7
Phycidae							
<i>Enchelyopus cimbrius</i> ¹	15–17	49–55	1,50+45–55	39–49	31–35	15–19	5–7
<i>Gaidropsarus argentatus</i> ¹	16–17	51–52	1,many+53–65	44–50	41–44	22–24	8–9
<i>Gaidropsarus ensis</i> ¹	16–17	52–53	1,many+52–64	40–48	41–46	22–27	8–9
<i>Urophycis chuss</i>	14–17	45–51	9–12+52–64	45–57	28–34	14–17	2
<i>Urophycis chesteri</i>	13–16	45–52	8–12+50–63	43–54	28–36	16–18	2
<i>Urophycis cirrata</i>	15–17	47–53	12+>53	46–58	<35	–	2
<i>Urophycis earlii</i>	14–15	45–48	8–11+57–68	49–60	27–31	–	2
<i>Urophycis floridana</i>	14–17	44–51	11–13+54–63	45–55	28–34	–	2
<i>Urophycis regia</i>	13–14	44–48	8–10+43–52	41–50	30–33	16	2
<i>Urophycis tenuis</i>	15–16	47–51	9–12+50–62	45–53	33–39	16	2
Merluccidae							
<i>Lyconus brachycolus</i>	–	–	90+	65+	Tiny	13–14	7–10
<i>Merluccius albidus</i>	25	51–52	11–13+37–40	I, 37–41	40	13–16	7
<i>Merluccius bilinearis</i>	26–29	54–56	11–14+36–42	I, 37–42	34–37	13–17	7
Steindachneriidae							
<i>Steindachneria argentea</i>	13	Many	I, 7–9+>123	>123	None	14–17	8

¹ These genera are included in the family Gaidropsaridae by several recent authors (e.g. Iwamoto and Cohen, 2002b). See species accounts for discussion.

Gadiformes

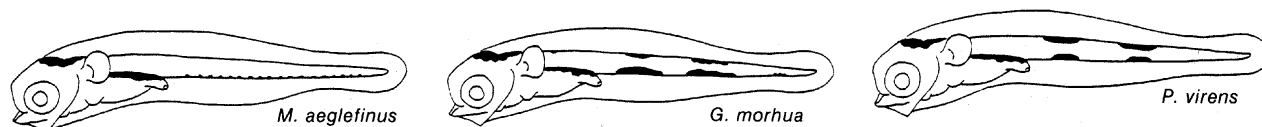
Families Bregmacerotidae, Moridae, Melanonidae, Gadidae, Phycidae, Lotidae, Merlucciidae, Steindachneriidae, Bathygadidae and Macrouridae

General features:

- Eggs**
- Pelagic, buoyant and usually small; (as large as 1.6 mm in certain Gadidae)
 - Chorion smooth, except various kinds of sculpting in Macrouridae and some Lotidae
 - Yolk homogeneous
 - Usually a single oil globule, or multiple coalescing to 1 (in a few genera), or none (in a few genera)
- Larvae**
- Pigment patterns usually well-developed at hatching
 - In early larvae, anus opens at side of finfold rather than margin
 - Gut short and coiled, preanus length 33%–50% SL
 - Pelvic fins thoracic (rarely jugular) in position, often elongate
 - Various genera have 1, 2, or 3 dorsal fins, and 1 or 2 anal fins; high numbers of rays in both fins
 - Barbels often form on symphysis of lower jaw (and on snout in a few)
 - No head spines during larval development (except in *Gaidropsarus*)
 - Gradual transformation, larvae usually followed by a specialized pelagic-juvenile stage
 - Some secondary caudal rays form before some primary rays in forms with a caudal fin

Bregmacerotidae:	Early acquisition of occipital dorsal ray; number of pelvic fin rays increases at transformation
Melanonidae:	Small eye, dark peritoneum, distinctive caudal fin; larvae not well-described
Moridae:	Well developed pelvic fin, often with more rays than in adults; larvae stocky anteriorly
Gadidae:	Caudal fin forms first; 3 dorsal fins, 2 anal fins; pelvic fin forms last
Phycidae:	Pelvic fin forms first, number of rays changes at transformation; stocky body; 2 dorsal fins, 1 anal fin
Lotidae:	Pelvic fin forms early, number of rays increases at transformation; elongate body; 1 or 2 dorsal fins
Merlucciidae:	Pectoral fin moderately stalked; caudal fin forms first; pigment similar to gadids
Steindachneriidae:	Striated luminescent organ on venter; anus separates from urogenital opening; no caudal fin
Bathygadidae and Macrouridae:	Short gut, elongate tail, pectoral fin stalked; no caudal fin; few larvae described

Distinguishing the early larvae of 3 similar species in the family Gadidae:



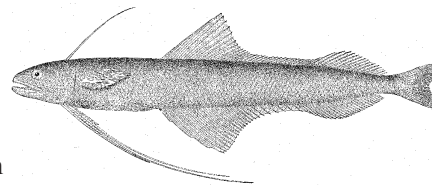
Character	<i>Melanogrammus aeglefinus</i>	<i>Gadus morhua</i>	<i>Pollachius virens</i>
Pigmentation	Single row of ventral spots along tail; no dorsal pigment on tail until late stages	3 ventral groups of pigment on tail, 1 at notochord tip; 2 dorsal groups of pigment on tail; ventral groups longer than dorsal and extend farther posteriorly	2 ventral and 2 dorsal groups of pigment on tail (none at notochord tip); dorsal groups longer and unpigmented space between ventral groups wider than space between dorsal groups
Precaudal vertebrae	19–22	18–20	23–25
First anal fin rays	21–25	20–24	24–28
Second anal fin rays	19–24	18–22	20–21
Anus location	Under anterior end of second dorsal fin	Under anterior end of second dorsal fin	Under posterior end of first dorsal fin
Number of caudal rays on superior hypural	5	4	5

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Ontogenetic characters in gadiform families from the western North Atlantic Ocean.
Revised from Fahay, 1983; Fahay and Markle, 1984; Fahay, 1989.

Character	Bregmaerotidae	Moridae	Gadidae	Phycidae	Lotidae
No. dorsal fins (externally)	1 ray on head + 1 fin divided by low midsection	2 (3)	3	2 (1 st often modified)	1–2
No. anal fins (externally)	1 divided by low midsection	1 (2)	2	1	1
First fin to form rays	Pelvic (or anterior dorsal ray)	Pelvic	Caudal (pelvic last)	Pelvic	Pelvic
No. pelvic rays	3–4 (larvae) 5–7 (adults)	2–8	6–7	3–4 (larvae) 2–9 (adults)	3–4 (larvae) 5–7 (adults)
Pelvic fin elongate?	Yes	Yes (most)	No	Yes	Yes
Pectoral fin forms	Late	Mid- to late	Late	Late	Late
Body shape (larvae)	Elongate	Tapers to narrow peduncle	Moderately elongate	Stocky	Elongate
No. vertebrae	43–59	47–63	49–61	44–55	62–78
Egg diameter (mm)	Unknown	0.52–1.16	1.0–1.9	0.63–0.98	1.3–1.5
Chorion	Unknown	Smooth	Smooth	Smooth	Pitted/smooth
No. oil globules	Unknown	1	None	Multiple to 1	1
Miscellaneous	Occipital ray, early-forming in some	Lower jaw barbel	barbel during or after juvenile stage	Lower jaw (and snout in some) barbel; pterotic spines in few	Lower jaw barbel in juveniles

Character	Melanonidae	Merlucciidae (Merluccius)	Merlucciidae (Lyconus)	Steindachneriidae	Bathygadidae/Macrouridae
No. dorsal fins (externally)	1 (deeply divided)	2 (2 nd divided by low midsection)	1	2	1 (2)
No. anal fins (externally)	1	1 (divided by low midsection)	1 (anterior rays elongate)	1 (anterior rays elongate)	1
First fin to form rays	Unknown	Caudal (pelvic next)	Dorsal and anal	Anal (anterior)	Pelvic, dorsal & anal
No. pelvic rays	5–7	7	7–10	8	(0) 5–13
Pelvic fin elongate?	No	Moderately	No	No	Moderately to very
Pectoral fin forms	Unknown	Late	Late	Late	Late
Body shape (larvae)	Moderately elongate	Elongate	Attenuate	Attenuate (no caudal)	Attenuate (no caudal)
No. vertebrae	58–62	51–56	–	13 + many	80–116+
Egg diameter (mm)	Unknown	0.8–1.2	Unknown	Unknown	1.0–2.5
Chorion	Unknown	Smooth	Unknown	Unknown	Sculpting in some
No. oil globules	Unknown	1	Unknown	Unknown	1
Miscellaneous	Small eye; dense pigment	Fin rays form from 2 centers in 2 nd D fin	Rare and not well described	Luminescent organ; lacks caudal fin	Some luminescent; lower jaw barbel

Bregmaceros atlanticus* Goode and Bean, 1886*Bregmacerotidae****Antenna codlet**

Range: Circumtropical in neritic waters; in the western North Atlantic from New Jersey through Gulf of Mexico to Guianas

Habitat: Epipelagic to mesopelagic

Spawning: Undescribed, possibly protracted; maturity reached at small sizes

Eggs: – Undescribed, although one report gives the following: pelagic, with smooth chorion, diameter 1.1 mm, single oil globule 0.2 mm, and homogeneous yolk (Pertseva-Ostroumova and Rass, 1973)

Larvae:

- Hatch at length of about 1.5 mm
- Body long and slab-sided, with large head and deep caudal peduncle
- Body depth, preanus length and head length all decrease in proportion to increase in total length
- Occipital ray forms at about 5.0–5.5 mmSL
- Pectoral fin situated high on body; fin base pedunculate
- 3–4 pelvic fin rays form early (at 3.5–4.5 mm), before occipital ray appears; an additional 2–3 rays ossify later, yielding an adult complement of 5–7; dorsal, anal and caudal fin rays usually present at 7.5–9.5 mmSL; "notch" forms in middle of dorsal and anal fins
- Pigment in small larvae includes melanophores at angle of jaw and tip of lower jaw; scattered spots on head, over midbrain and base of pectoral fin; scattered, large, internal spots along upper and lower body; some diffuse spots on surface of trunk and tail
- Pigment in larger larvae include many melanophores on surface of head and body, including dorsal, anal and caudal fins; these cover most of the larva
- Transformation occurs at about 18–20 mmSL

Meristic Characters

Myomeres:	50–55
Vertebrae:	53–55
Dorsal fin rays:	47–56
Anal fin rays:	49–58
Pectoral fin rays:	16–21
Pelvic fin rays:	5–7
Caudal fin rays:	12 (branched)

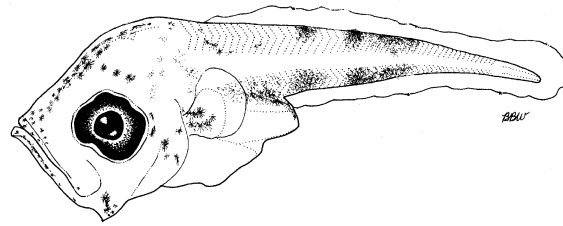
- Note:**
1. Many early contributions on development of *Bregmaceros* are confounded by nomenclatural problems or are based on mixtures of more than one species
 2. Larvae of the 4 species occurring in the study area are best distinguished by meristic characters, relative pigmentation density, and size at formation of occipital ray

	Total Myomeres	Dorsal Fin Rays	Anal Fin Rays
<i>Bregmaceros atlanticus</i>	50–55	47–56	49–58
<i>Bregmaceros cantori</i>	45–48	45–48	45–49
<i>Bregmaceros houdei</i>	44–47	40–44	41–46
<i>Bregmaceros</i> sp.	52–59	57–65	58–69

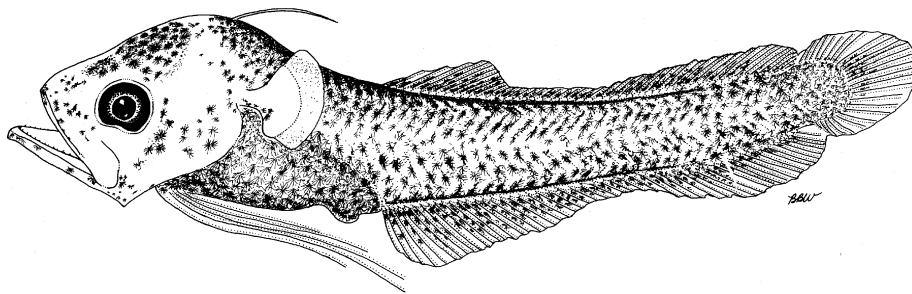
Figures: Adult: Goode and Bean, 1896; **A–B:** Betsy Washington (Houde, 1984a)

References: Houde, 1981, 1984a; Saksena and Richards, 1986

Bregmaceros atlanticus



A. 2.9 mmSL

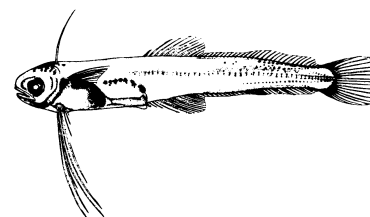


B. 9.0 mmSL

Larvae of this species are heavily pigmented, with relatively late-forming occipital ray

Bregmaceros cantori* Milliken and Houde, 1984*Bregmacerotidae**

No common name



Range: Western North Atlantic Ocean from North Carolina, through the Gulf of Mexico and Caribbean Sea to Brazil; also eastern Atlantic

Habitat: Epipelagic or mesopelagic in neritic, tropical and subtropical waters

Spawning: Undescribed, possibly protracted; maturity reached at small sizes

Eggs: – Undescribed

Larvae:

- Hatch at length of about 1.5 mm
- Body long and slab-sided, with large head and deep caudal peduncle
- Body depth, preanus length and head length all decrease in proportion to increase in total length
- Occipital ray forms at about 6.0–7.0 mmSL
- Pectoral fin situated high on body; fin base pedunculate
- 3–4 pelvic fin rays form early (at 3.5–4.5 mm), before occipital ray appears; an additional 2–3 rays ossify later, yielding an adult complement of 5–7; dorsal, anal and caudal fin rays usually present at 7.5–9.5 mmSL; "notch" forms in middle of dorsal and anal fins
- Pigment in small larvae includes melanophores at angle of jaw and a few spots scattered on ventral gut
- Pigment in larger larvae includes a melanophore over hindbrain and internal pigment near otoliths and near pectoral fin base; internal pigment also often occurs along vertebral column
- Transformation occurs at about 18–20 mmSL

Meristic Characters

Myomeres:	45–48
Vertebrae:	45–49
Dorsal fin rays:	45–48
Anal fin rays:	45–49
Pectoral fin rays:	16–23 (family)
Pelvic fin rays:	5–7
Caudal fin rays:	12 (branched)

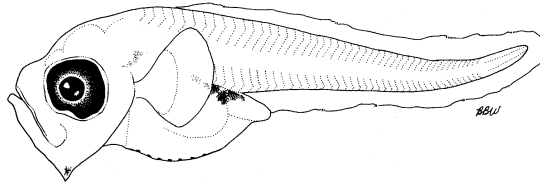
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 2. Larvae of the 4 species occurring in the study area are best distinguished by meristic characters, relative pigmentation density, and size at formation of occipital ray

	Total Myomeres	Dorsal Fin Rays	Anal Fin Rays
<i>Bregmaceros atlanticus</i>	50–55	47–56	49–58
<i>Bregmaceros cantori</i>	45–48	45–48	45–49
<i>Bregmaceros houdei</i>	44–47	40–44	41–46
<i>Bregmaceros</i> sp.	52–59	57–65	58–69

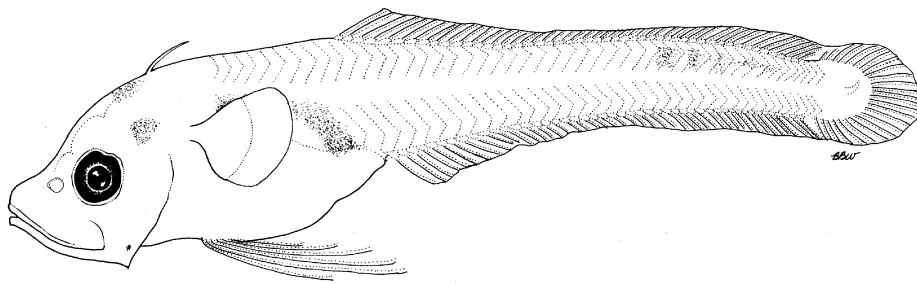
Figures: Adult: 13.5 mmSL, Houde, 1981 (as Type B); **A–B:** Betsy Washington (Houde, 1984a)

References: Belyanina, 1980; Houde 1981, 1984a; Milliken and Houde, 1984

Bregmaceros cantori



A. 2.6 mmSL



B. 8.0 mmSL

Larvae of this species are lightly pigmented, with relatively late-forming occipital ray

Bregmaceros houdei* Saksena and Richards, 1986*Bregmacerotidae****Stellate codlet**

Adult undescribed

Range: Larvae and juveniles are known from the eastern Gulf of Mexico and Caribbean Sea; several larvae have also been collected in study area

Habitat: Epipelagic in waters over deep shelf and slope depths

Spawning: Undescribed, possibly restricted to summer

Eggs: – Undescribed

Larvae:

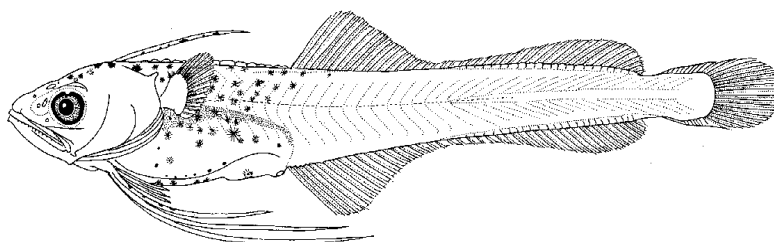
- Hatching length unknown, but probably about 1.5 mm based on smallest larvae available
- Body long and slab-sided, with large head and deep caudal peduncle
- Body depth, preanus length and head length all decrease in proportion to increase in total length
- Occipital ray forms at about 2.0–2.5 mmSL
- Pectoral fin situated high on body; fin base pedunculate
- 3–4 pelvic fin rays form early (at 3.5–4.5 mm), before occipital ray appears; an additional 2–3 rays ossify later, yielding an adult complement of 5–7; dorsal, anal and caudal fin rays usually present at 7.5–9.5 mmSL; "notch" forms in middle of dorsal and anal fins
- Pigment in small larvae includes melanophores at angle of jaw and tip of lower jaw; scattered melanophores over hindbrain; few spots on occipital ray
- Pigment in larger larvae includes melanophores over brain and nape; spots cover the occipital ray and pelvic fin rays; anterior half of gut sometimes pigmented on ventral surface
- Transformation occurs at about 16 mmSL

Meristic Characters

Myomeres:	44–47
Vertebrae:	47–50
Dorsal fin rays:	52–59
Anal fin rays:	41–46
Pectoral fin rays:	16–23 (family)
Pelvic fin rays:	5–7
Caudal fin rays:	12 (branched)

- Note:**
1. Many early contributions on development of *Bregmaceros* are confounded by nomenclatural problems or are based on mixtures of more than one species
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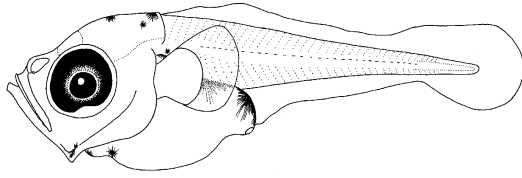
	Total Myomeres	Dorsal Fin Rays	Anal Fin Rays
<i>Bregmaceros atlanticus</i>	50–55	47–56	49–58
<i>Bregmaceros cantori</i>	45–48	45–48	45–49
<i>Bregmaceros houdei</i>	44–47	40–44	41–46
<i>Bregmaceros</i> sp.	52–59	57–65	58–69

Early Juvenile:**F. 16.4 mmSL**

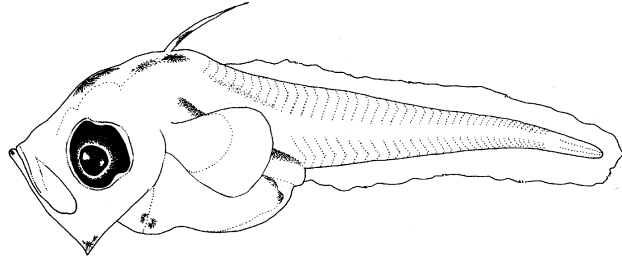
Figures: B, D: Betsy Washington (Houde, 1984a); A, C, E–F: J. C. Javech (Saksena and Richards, 1986)

References: Houde, 1984a; Saksena and Richards, 1986

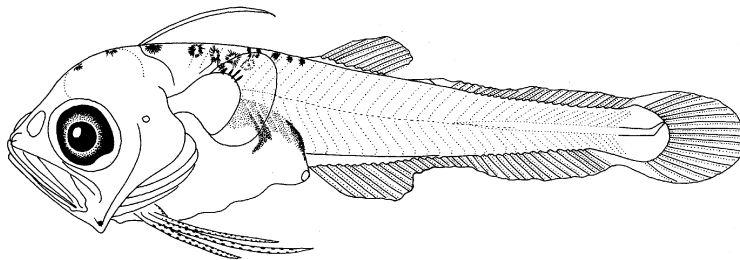
Bregmaceros houdei



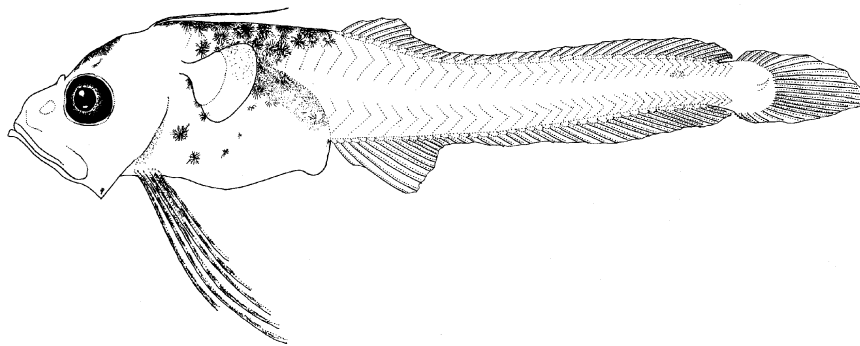
A. 2.0 mmSL



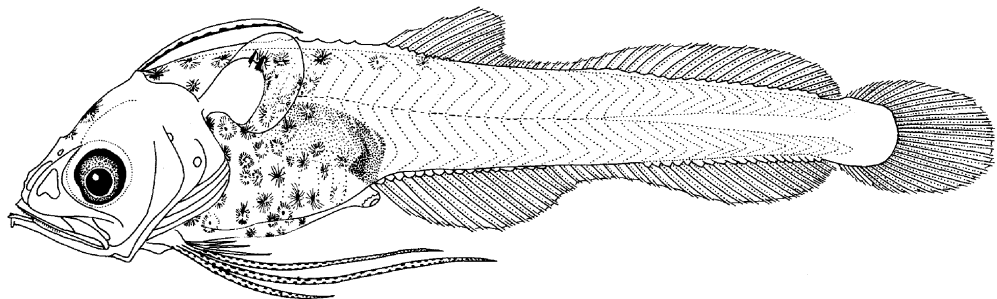
B. 3.1 mmSL



C. 5.8 mmSL



D. 8.5 mmSL

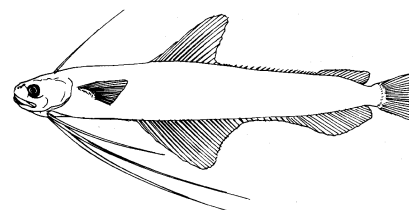


E. 10.5 mmSL

Larvae of this species are lightly pigmented (except for nape and gut regions), with relatively early-forming occipital ray

Bregmaceros* sp. (see Note 2, below)*Bregmacerotidae**

No common name



Range: Western North Atlantic Ocean from Cape Cod and slope of Georges Bank through Gulf of Mexico and Caribbean Sea to Brazil

Habitat: Epipelagic or mesopelagic in neritic waters

Spawning: Undescribed, possibly protracted; maturity reached at small sizes

Eggs: – Undescribed

Larvae:

- Hatch at length of about 1.5 mm
- Body long and slab-sided, with large head and deep caudal peduncle
- Body depth, preanus length and head length all decrease in proportion to increase in total length
- Occipital ray forms at about 2.0–2.5 mmSL
- Pectoral fin situated high on body; fin base pedunculate
- 3–4 pelvic fin rays form early, just after occipital ray appears; an additional 2–3 rays ossify later, yielding an adult complement of 5–7; dorsal, anal and caudal fin rays usually present at 7.5–9.5 mmSL; "notch" forms in middle of dorsal and anal fins
- Pigment in small larvae includes melanophores at angle of jaw and tip of lower jaw and scattered spots on head and base of pectoral fin; a few, large internal spots in two pairs along side of body; melanophores on ventral gut anteriorly
- Pigment in larger larvae includes small, scattered melanophores over head and most of body, but not on posterior part of tail; several, large, internal spots in double row along side of body and tail
- Transformation occurs at about 18–20 mmSL

Meristic Characters

Myomeres:	52–59
Vertebrae:	52–59
Dorsal fin rays:	52–59
Anal fin rays:	58–69
Pectoral fin rays:	16–23 (family)
Pelvic fin rays:	5–7
Caudal fin rays:	12 (branched)

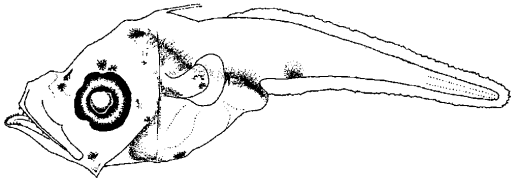
- Note:**
1. Many early contributions on development of *Bregmaceros* are confounded by nomenclatural problems or are based on mixtures of more than one species
 2. This species is often referred to as *B. mcclellandi*, a valid species (Torii, *et al.*, 2003), however, one that does not occur in the western Atlantic Ocean
 3. Larvae of the 4 species occurring in the study area are best distinguished by meristic characters, relative pigmentation density, and size at formation of occipital ray

	Total Myomeres	Dorsal Fin Rays	Anal Fin Rays
<i>Bregmaceros atlanticus</i>	50–55	47–56	49–58
<i>Bregmaceros cantori</i>	45–48	45–48	45–49
<i>Bregmaceros houdei</i>	44–47	40–44	41–46
<i>Bregmaceros</i> sp.	52–59	57–65	58–69

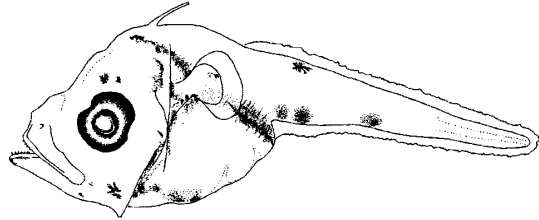
Figures: Adult: Cohen, 1986 (based on *Bregmaceros* sp. Maul, 1952 from Eastern Atlantic); **A–B, E:** Michael Greene (Hare *et al.*, 2006); **C–D:** Betsy Washington (Houde, 1984a)

References: Belyanina, 1980; Houde, 1984a; Saksena and Richards, 1986; Torii, *et al.*, 2003; Hare *et al.*, 2006

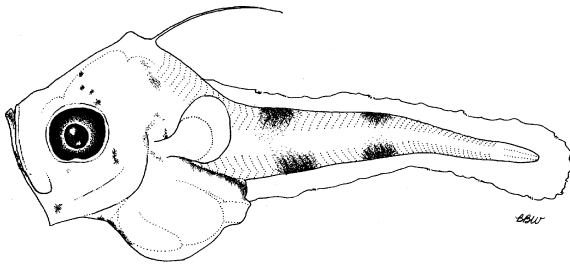
Bregmaceros sp.



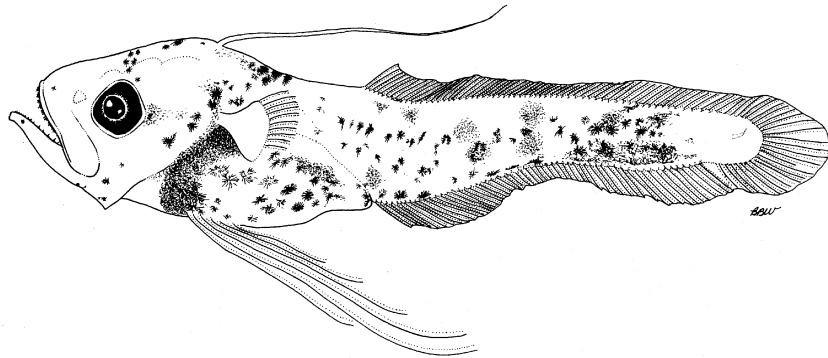
A. 2.96 mmNL



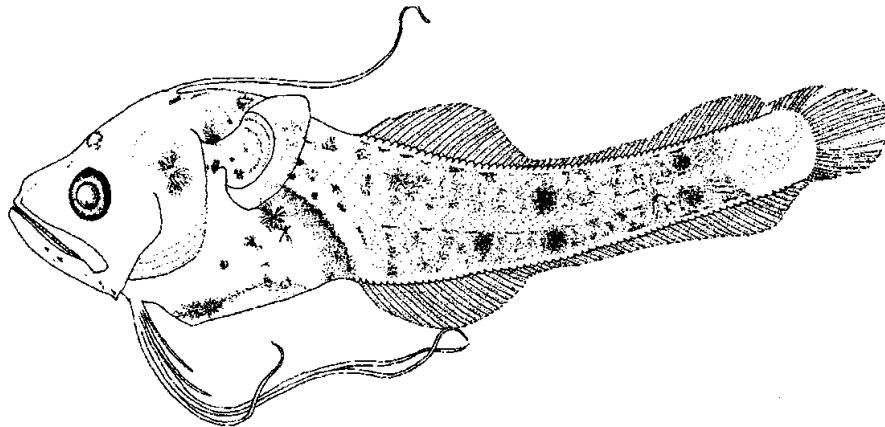
B. 3.32 mmNL



C. 3.0 mmNL



D. 7.0 mmSL

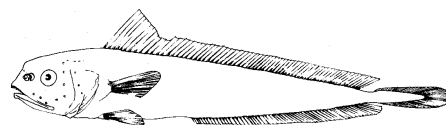


E. 8.8 mmSL

Larvae of this species are heavily pigmented, with relatively early-forming occipital ray

Melanonus zugmayeri* Norman, 1930*Melanonidae**

No common name



Range: Worldwide in tropical to temperate seas; in the western North Atlantic from La Have Basin (National Museum of Canada: NMC 82-0177) and south of Sable Island Bank to Caribbean Sea

Habitat: Meso- to bathypelagic at depths of 200–1,000 m; uncommon

Spawning: Undescribed; larvae rarely collected

Eggs: – Undescribed

Larvae:

- Dorsal fin with slightly elevated anterior portion
- Dorsal fin rays longer than anal fin rays
- No other elongate fin rays
- Smallest size studied has small eye, dark peritoneum and a distinctive caudal fin
- Chin barbel lacking
- 13 vertebrae associated with caudal fin; many secondary caudal rays (23–25 dorsal, 22–25 ventral)
- Very narrow caudal peduncle in all stages
- Body shape of adult assumed by about 15 mmSL
- All fin rays formed by 15 mmSL
- X and Y bones lost in caudal skeleton

Meristic Characters

Myomeres:	about 58–62
Vertebrae:	13+47=58–62
Dorsal fin rays:	72–78
Anal fin rays:	50–58
Pectoral fin rays:	10–16
Pelvic fin rays:	5–7
Caudal fin rays:	55–60

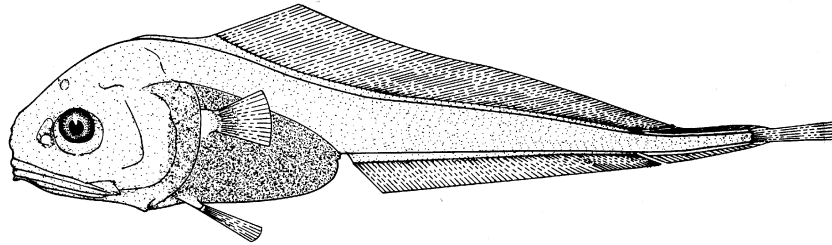
Note: 1. This enigmatic species is similar to gadids and lotids in loss of X and Y bones and total caudal fin ray count >50

Early Juvenile: The 30.6-mm individual (Fig. B) was collected in the Southern Ocean (35°19'S, 07°30'E) and can not be distinguished from *Melanonus gracilis*

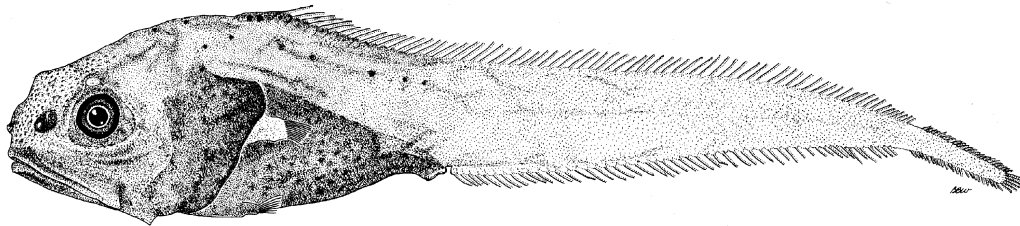
Figures: Adult: Cohen, 1986; **A:** Bev Vinter (Matarese *et al.*, 1989; **B:** Betsy Washington (Fahay and Markle, 1984)

References: Fahay and Markle, 1984; Scott and Scott, 1988; Cohen *et al.*, 1990

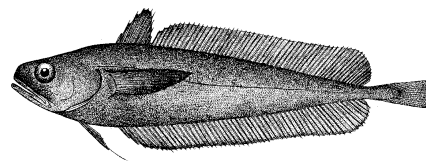
Melanonus zugmayeri



A. 17.0 mmSL



B. 30.6 mmSL (*Melanonus* sp.)

Gadella imberbis* (Vaillant, 1888)*Moridae****Beardless codling**

Range: Western Atlantic Ocean from about 40°N along coast of United States through Gulf of Mexico and Caribbean Sea to Brazil; also eastern Atlantic off coast of Africa

Habitat: Benthopelagic on upper continental slope, generally in depths of 100–800 m

Spawning: Undescribed

Eggs: – Undescribed

Larvae:

- Large-headed with body tapering to narrow caudal peduncle
- Pelvic fin origin well anterior to pectoral fin origin
- Flexion occurs at sizes between 5.6 and 10.6 mm
- Sequence of fin ray formation: P₁, P₂ – D, A–C
- Chin barbel absent
- Pigmentation includes a dark patch on ventral surface of gut associated with developing light organ; scattered spots on top of head and on dorsal and posterior regions of gut; prominent patch of pigment forms on flank, midway between anus and caudal fin; later larvae develop intense swath of pigment between nape and gut

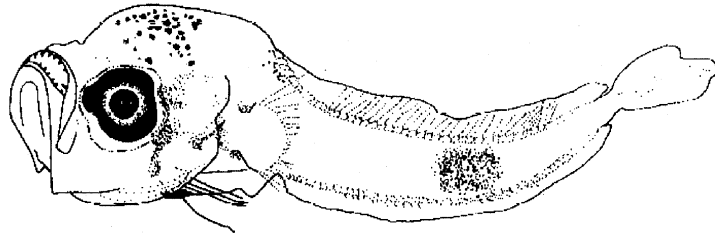
Meristic Characters

Myomeres:	about 50
Vertebrae:	17 (pc) 49–51 (tot)
Dorsal fin rays:	10+53–61
Anal fin rays:	63–66
Pectoral fin rays:	25–26
Pelvic fin rays:	6–7
Caudal fin rays:	9 (PrC)

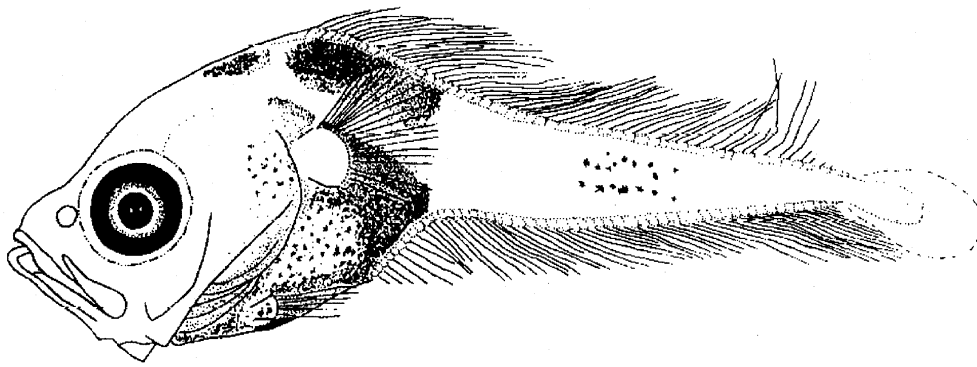
Figures: Adult: Cohen *et al.*, 1990 (after Poll, 1953); **A–B:** Comyns and Bond, 2006

References: Fahay and Markle, 1984; Iwamoto and Cohen, 2002a; Comyns and Bond, 2006

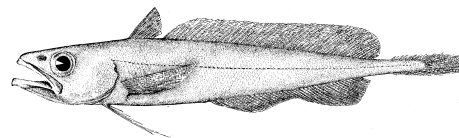
Gadella imberbis



A. 5.7 mm



B. 11.8 mm

Halargyreus johnsonii* Günther, 1862*Moridae****Dainty mora**

Range: Worldwide (except Mediterranean Sea) in subarctic and temperate waters; in the western North Atlantic from Greenland, Grand Bank, Hudson Canyon and Bear Seamount

Habitat: Benthopelagic or epibenthic over continental slopes, in depths of 585–1,967 m

Spawning: Not well understood

Eggs: – Undescribed

Larvae:

- Undescribed; notes below pertain to pelagic juvenile (Fig. A)
- Body moderately shallow, tapering to very narrow caudal peduncle
- Eyes oriented dorsally
- Chin barbel lacking
- Sequence of fin ray formation: undescribed
- Pelvic fin rays elongate; pelvic fin origin well anterior to pectoral fin base
- Terminal dorsal fin rays farther posterior than terminal anal fin rays; posterior parts of both fins voluminous, well-rounded
- Depression (or "notch") in mid-anal fin
- Caudal fin pointed; becomes rounded in adults
- Pigment uniformly scattered over body, except terminus of caudal peduncle unpigmented; large spots cover the gut; band-like pattern of pigment on second dorsal and anal fins; few large spots on branchiostegal membrane and gular membrane

Note: 1. Unlike certain other morids (e.g. *Laemonema*), no ontogenetic reduction in number of pelvic fin rays occurs between larval and adult stages

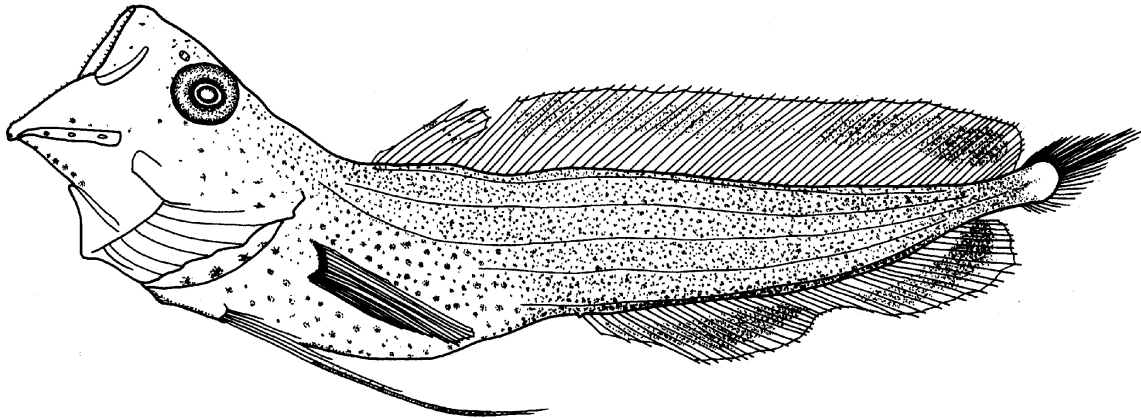
Meristic Characters

Myomeres:	51–58
Vertebrae:	22–23+30–35=51–58
Dorsal fin rays:	6–9 + 47–60
Anal fin rays:	39–53
Pectoral fin rays:	15–20
Pelvic fin rays:	5–6
Caudal fin rays:	38–43

Figures: Adult: D. R. Harriott (Scott and Scott, 1988); A: Fukui, *et al.*, 2003

References: Scott and Scott, 1988; Fahay and Markle, 1984; Ambrose, 1996; Meléndez and Markle, 1997; Moore *et al.*, 2003; Fukui *et al.*, 2003

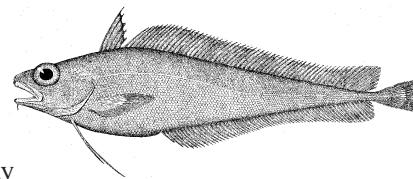
Halargyreus johnsonii



A. 43.0 mmSL

Laemonema barbatulum* Goode and Bean, 1883*Moridae**

No common name



Range: Western North Atlantic Ocean between latitudes 40°N and 02°N; in study area as far north as Nova Scotia

Habitat: Meso- or benthopelagic in continental slope waters with depths of 50–1,620 m

Spawning: Undescribed; larvae rarely collected in study area; mostly spring-summer

Eggs: – Undescribed

Larvae:

- Large head and eyes on slender body, tapering to very thin caudal peduncle
- Body deepest at level of pectoral fin base
- Pectoral and pelvic fin bases pedunculate
- Pelvic fin rays = 10–11 in larvae; decrease to 2 after transformation (at sizes of about 60 mmSL)
- Caudal fin last to form
- Gill rakers formed >11 mmSL
- Terminal ends of dorsal, anal and caudal fins asymmetrical; dorsal fin pterygiophores extend posteriorly farther than anal fin pterygiophores; more ventral secondary caudal rays than dorsal (see figures)
- Note anterior origin of pelvic fins
- Pigment includes scattered head and body melanophores extending to the level of mid-anal fin; a separate band of pigment crosses body at level of posterior anal fin; latter band spreads onto adjacent areas of dorsal and anal fins in larger larvae; caudal peduncle remains unpigmented

Meristic Characters

Myomeres:	about 50–56
Vertebrae:	50–56
Dorsal fin rays:	see table
Anal fin rays:	see table
Pectoral fin rays:	see table
Pelvic fin rays:	2
Caudal fin rays:	see table

Meristic characters of 3 *Laemonema* species occurring in study area (after Meléndez and Markle, 1997):

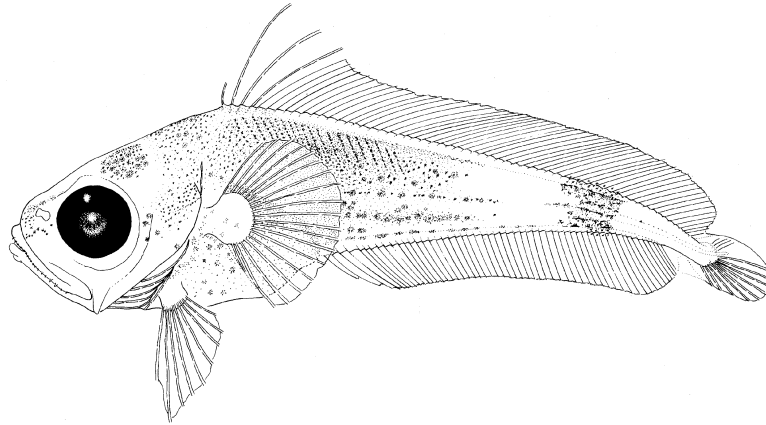
<i>Species</i>	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Caudal Fin Rays	Gill Rakers
<i>Laemonema barbatulum</i>	13–15+37–42	6(7)+57–63	54–63	19–23	7–9+6+14–20	3–6+10–13
<i>Laemonema melanurum</i>	15–16+38–42	7+53–61	52–59	25–27	7–10+6+11–15	4–6+12–15
<i>Laemonema. goodebeanorum</i>	15–17+39–43	(5)6+66–73	65–71	19–22	8–11+6+12–16	7–9+17–20

- Note:**
1. This species is best distinguished from congeners in study area by a combination of pectoral fin ray, gill raker and vertebral counts.
 2. The juvenile stage of this species was described as "*Svetovidovia*" by Koefoed (1953); Cohen (1973); Cohen (1986). These juveniles were then ascribed to *Lepidion* based on the presence in some specimens of seven or more pelvic fin rays (Haedrich, 1964). They were tentatively referred to *Laemonema* (Fahay and Markle, 1984) after a series of specimens revealed an ontogenetic loss of pelvic fin rays (see above). Their final recognition as *Laemonema* is presented in Meléndez and Markle (1997).

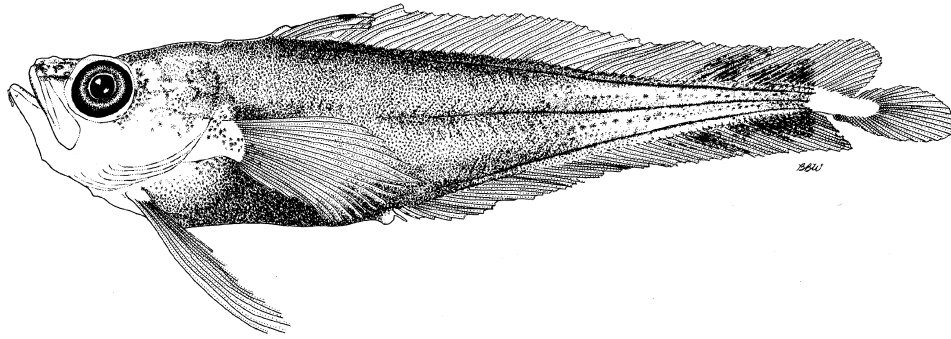
Figures: Adult: Goode and Bean, 1896; **A:** Fahay, 1983; **B:** Betsy Washington (Fahay and Markle, 1984)

References: Fahay and Markle, 1984; Markle, 1989; Meléndez and Markle, 1997

Laemonema barbatulum



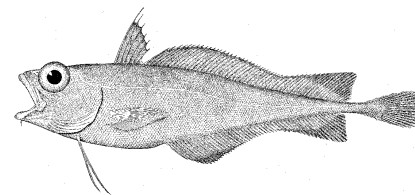
A. 13.0 mmSL



B. 44.0 mmSL

Laemonema melanurum* Goode and Bean, 1896*Moridae**

No common name



Range: Western North Atlantic Ocean off coast of United States

Habitat: Meso- or benthopelagic in continental slope waters with depths of 452–644 m

Spawning: Undescribed; larvae rarely collected in study area

Eggs: – Undescribed

Larvae:

- Large head and eyes on deep body, tapering to thin caudal peduncle
- Body deepest at level of pectoral fin base
- Pectoral and pelvic fin bases moderately pedunculate
- Pelvic fin rays = 7–10 in larvae; decrease to 2 after transformation
- Caudal fin last to form
- Gill rakers formed at unknown size
- Terminal ends of dorsal and anal fins and caudal fin less asymmetrical than in *Laemonema barbatulum*; dorsal fin pterygiophores extend posteriorly slightly farther than anal fin pterygiophores; more ventral secondary caudal rays than dorsal (see figures)
- Note anterior origin of pelvic fins
- Pigment includes dense melanophores covering entire body from level of pectoral fins to bases of secondary caudal fin rays; later larvae add heavy pigment over head; end of caudal peduncle remains unpigmented

Meristic Characters

Myomeres:	about 53–57
Vertebrae:	53–57
Dorsal fin rays:	see table
Anal fin rays:	see table
Pectoral fin rays:	see table
Pelvic fin rays:	2
Caudal fin rays:	see table

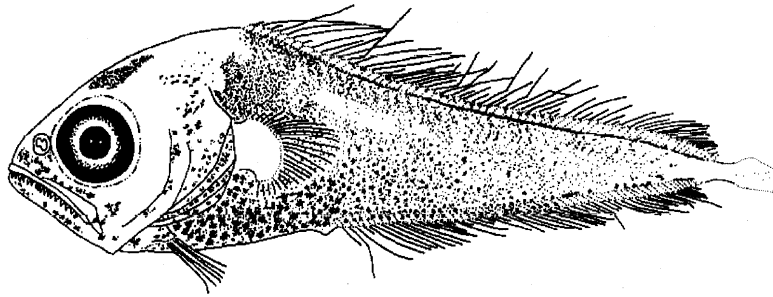
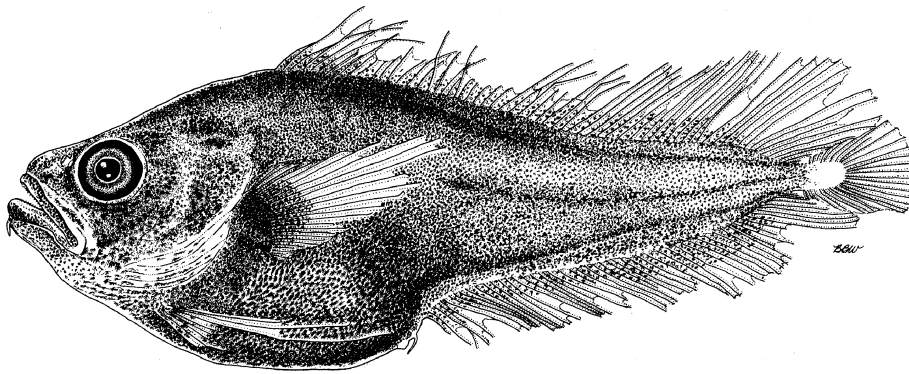
Meristic characters of 3 *Laemonema* species occurring in study area (after Meléndez and Markle, 1997):

<i>Species</i>	Vertebrae	Dorsal Fin Rays	Anal Fin Rays	Pectoral Fin Rays	Caudal Fin Rays	Gill Rakers
<i>Laemonema barbatulum</i>	13–15+37–42	6(7)+57–63	54–63	19–23	7–9+6+14–20	3–6+10–13
<i>Laemonema melanurum</i>	15–16+38–42	7+53–61	52–59	25–27	7–10+6+11–15	4–6+12–15
<i>Laemonema goodebeanorum</i>	15–17+39–43	(5)6+66–73	65–71	19–22	8–11+6+12–16	7–9+17–20

- Note:**
1. This species is best distinguished from congeners in study area by a combination of pectoral fin ray, gill raker and vertebral counts
 2. See Note 2 on *Laemonema barbatulum* page

Figures: Adult: Goode and Bean, 1896; **A:** Comyns and Bond, 2006; **B:** Betsy Washington (Fahay and Markle, 1984)

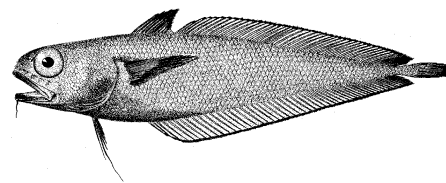
References: Fahay and Markle, 1984; Markle, 1989; Meléndez and Markle, 1997

Laemonema melanurum**A. 17.9 mm****B. 44.0 mmSL**

The early stages of morids, worldwide, are not well-known. Common characters in the pelagic-juveniles of several taxa, including some that occur outside the study area, include:

1. Body tapering to narrow caudal peduncle
2. Pelvic fins elongate and early forming; some rays lost at transformation in many genera
3. Posterior rays of dorsal and anal fins typically longer than others in these fins
4. Pectoral fin base only slightly pedunculate
5. Caudal fin last to form rays
6. Pelvic fin origin typically placed anterior to pectoral fin base
7. Head and eyes proportionately large; some have barbel at tip of lower jaw
8. Luminous organ, surrounded by dense black pigment, develops

See Fahay and Markle (1984), for examples of several extra-limital taxa, some of which have been described with invalid names pertaining to special pelagic-juvenile stages, e.g. *Svetovidovia* (= *Laemonema*), *Rhynchogadus*, *Eretmophorus*

Physiculus fulvus* (Bean, 1884)*Moridae****Hakeling**

Range: Western North Atlantic Ocean along east coast of United States and Gulf of Mexico; collected as far north as Nantucket Island and to 43°16'N off Canada (Markle *et al.*, 1980)

Habitat: On or near-bottom in depths of 142–1,719 m

Spawning: Undescribed; larvae collected in study area mostly summer-fall

Eggs: – Undescribed; (eggs of 3 other *Physiculus* species described as 0.93–1.08 mm diameter, with single oil globule 0.19–0.30 mm)

Larvae:

- Large-headed with body tapering to narrow caudal peduncle
- Pelvic fin origin well anterior to pectoral fin origin
- Flexion occurs at length of 6–7 mm
- Sequence of fin ray formation: P₁, P₂ – D, A – C
- Pelvic fin rays become elongate in juveniles
- Chin barbel forms at tip of lower jaw during juvenile stage
- Pigmentation in small larvae includes a dark patch on ventral gut, associated with developing light organ, pigment over much of gut; dense accumulations on top of head, nape, and 2 prominent bands on flank between anus and caudal fin; also 3 ventral, linear stripes of pigment on tail along edge of body; anterior 2 associated with bands, posterior 1 consisting of a few spots visible in larvae as small as 3–4 mm; larger larvae become more heavily pigmented, with an unpigmented area on caudal peduncle; 2 linear pigment patches occur near base of caudal fin

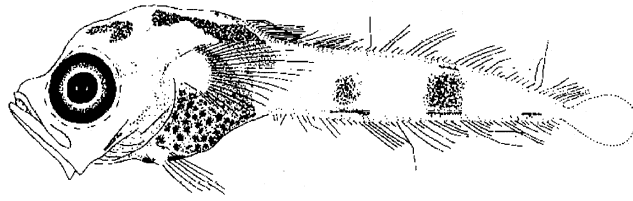
Meristic Characters

Myomeres:	about 47–50
Vertebrae:	12–16 (pc) 47–50 (tot)
Dorsal fin rays:	9–12+57–61
Anal fin rays:	59–68
Pectoral fin rays:	21–26
Pelvic fin rays:	5–7
Caudal fin rays:	–

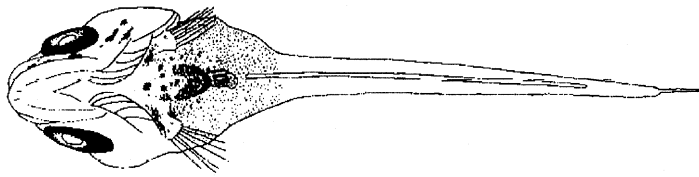
Figures: Adult: H. L. Todd; A–D: Comyns and Bond, 2006

References: Fahay and Markle, 1984; Comyns and Bond, 2006

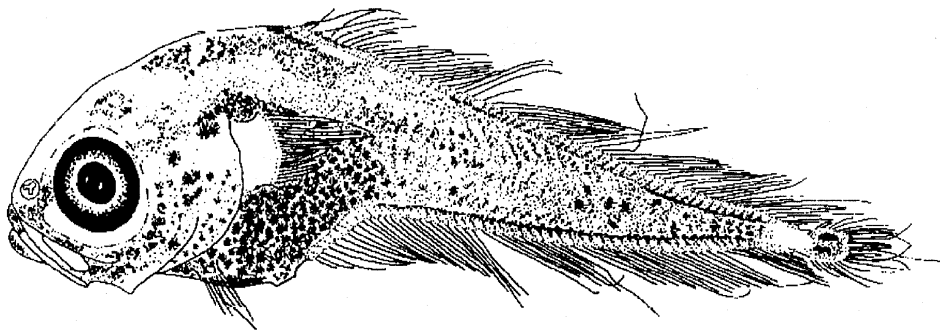
Physiculus fulvus



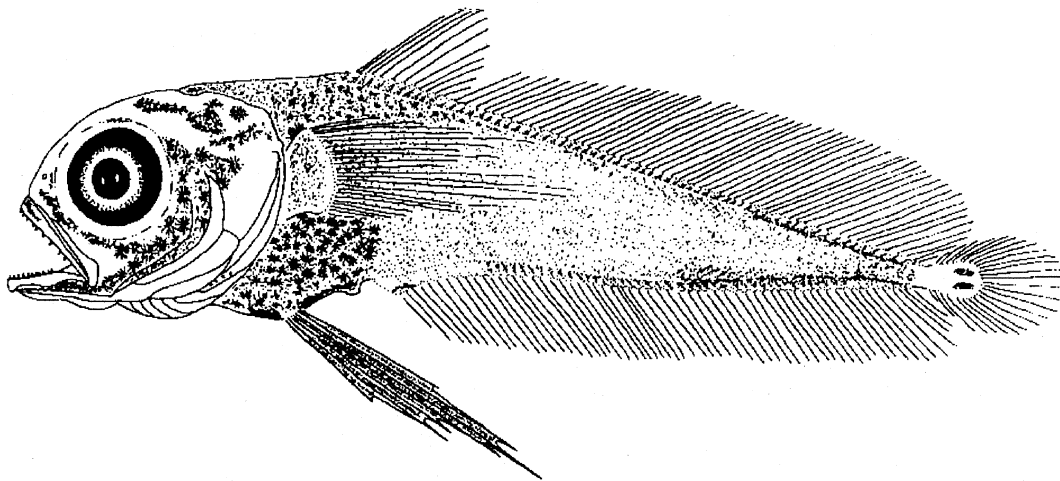
A. 6.9 mm



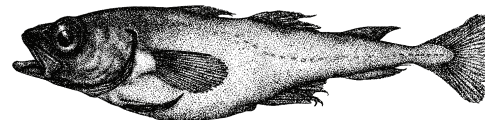
**B. 7.4 mm
(Ventral View)**



C. 13.7 mm



D. 17.0 mm

Arctogadus glacialis* (Peters, 1874)*Gadidae****East Siberian cod**

Range: Northern and southern coasts of Greenland; also western Canadian Arctic and coast of Siberia

Habitat: Near bottom from littoral zone to far offshore, in depths to 930 m; associated with pack-ice; may also enter low-salinity river mouths

Spawning: Winter; Dec–Mar in arctic conditions possibly timed for larvae to take advantage of freshwater run-off and plankton blooms in spring

Eggs: – Undescribed (demersal); ovarian eggs have thick chorion

Larvae:

- Hatching length unknown; body and tail long and tapering
- Anus opens laterally on finfold (not at margin) in gadid early larvae (not verified in this species); in later larvae, anus is located under anterior end of second dorsal fin
- Preanus length = 42.4–46.2% TL through development (shorter than in *G. morhua*)
- Sequence of fin ray formation: C–D₂, D₃, A₁, A₂ – D₁ – P₁ – P₂
- Rays begin to form in 2nd and 3rd dorsal fins at about 14 mm
- Chin barbel forms late in development
- Transformation occurs at sizes greater than 20 mm, when all fin rays are formed
- Pigmentation: early larvae have scattering of melanophores on head, both jaws and on peritoneum; 3 rows form on body (see figures); early juvenile pigmentation includes intense pigment on snout, a ring of spots around eye, increased pigment along dorsum, darker melanophores overlying the gut, and intensified lateral pigment, interrupted by 4–6 pale areas on the midline; a line of spots occurs along venter, from pelvic fins to anus (not present in *G. morhua*)

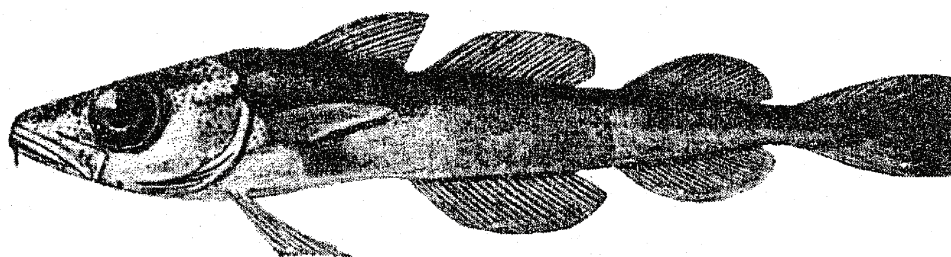
Meristic Characters

Myomeres:	57–61
Vertebrae:	19–23+36–41=57–61
Dorsal fin rays:	9–14+14–22+16–22
Anal fin rays:	17–24+18–24
Pectoral fin rays:	–
Pelvic fin rays:	6–7
Caudal fin rays:	50–52

Note: 1. See distribution of caudal fin rays in the family Gadidae on *Gadus ogac* figure page

2. *Arctogadus borisovi* Drjagin, 1932 is a junior synonym of *Arctogadus glacialis* (Jordan *et al.*, 2003)

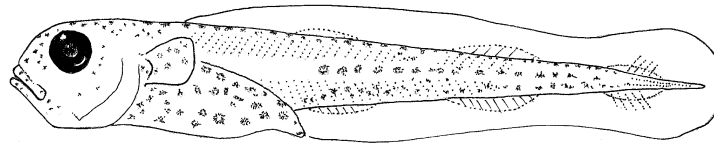
Early Juvenile: Note shallow body, long chin barbel, wide space between dorsal and anal fins, and pale areas along flank

**E. Length unknown**

Figures: Adult: Jordan *et al.*, 2003; A–D: Zvyagina, 1961 (A–C redrawn); E: Andriyashev, 1954

References: Dunn and Matarese, 1984; Fahay and Markle, 1984; Cohen *et al.*, 1990; Jordan *et al.*, 2003

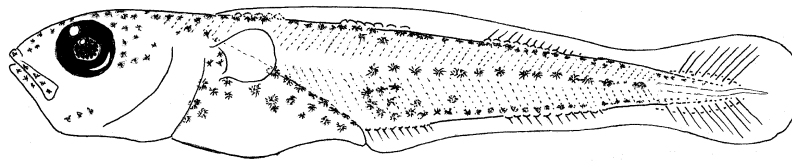
Arctogadus glacialis



A. 11.9 mm

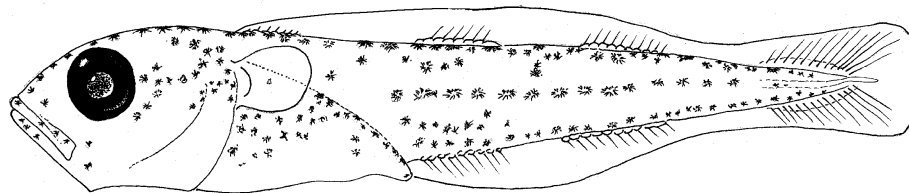
Larvae very similar to those of *Gadus morhua*

3 rows of pigment form along body; along dorsal and ventral edges and on midline beginning a few myomeres posterior to level of anus



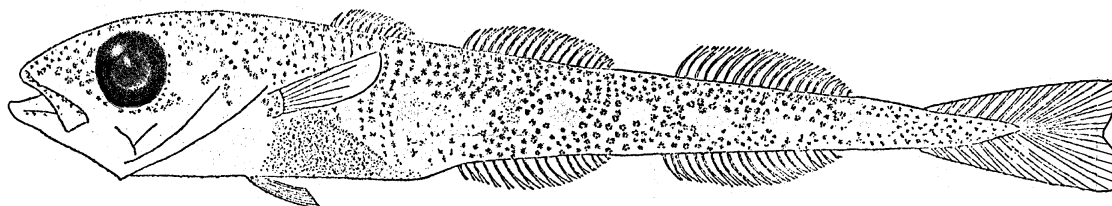
B. 14.9 mm

No ventral pigment anterior to anus

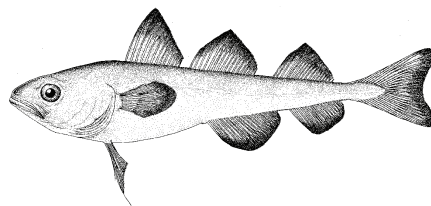


C. 16.7 mm

All 3 pigment rows reach base of caudal fin



D. 51.0 mm, Juvenile

Boreogadus saida* (Lepechin, 1774)*Gadidae****Polar cod**

Range: Circumpolar in arctic waters; in study area found on both coasts of Greenland, Labrador and Hudson Bay

Habitat: Mesopelagic in coastal waters both summer and winter; also in brackish conditions such as river mouths; found at depths of 40–400 m; tolerates wide range of temperatures, salinities, turbidity

Spawning: Winter in Barents, White and Beaufort seas; sometimes under ice

Eggs:

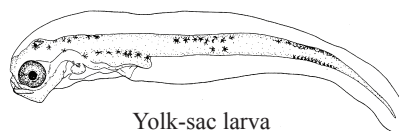
- Pelagic, spherical
- Diameter: 1.53–1.90 mm
- Chorion: thin, fragile, unsculpted
- Yolk: homogeneous
- Oil globules: none

Larvae:

- Hatching occurs at about 5.5–6.0 mm
- Body elongate and slender
- Sequence of fin ray formation: C – D₂, D₃, A₁, A₂ – D₁ – P₁ – P₂
- Caudal fin forms first (at about 8 mm) followed by dorsal and anal fins (at about 13 mm), pectorals and pelvic fin rays form last
- 4 rays on superior hypural
- Anus forms under 2nd dorsal fin
- Flexion occurs at 11–17 mm
- Pigmentation includes dorsal and ventral bars of pigment as in *Gadus morhua*, but pigment at notochord tip is on dorsal edge, rarely with a spot on the ventral edge; the dorsal bars are more strongly developed than the ventral; dorsal bars fuse at about 7 mm, ventral bars fuse at about 10 mm; the posterior dorsal bar is longer than the anterior and extends farther posteriorly than the posterior ventral bar; a midlateral streak of pigment begins as a single spot between the bars in early larvae; lateral surface of head unpigmented; preanal pigment absent <10 mm

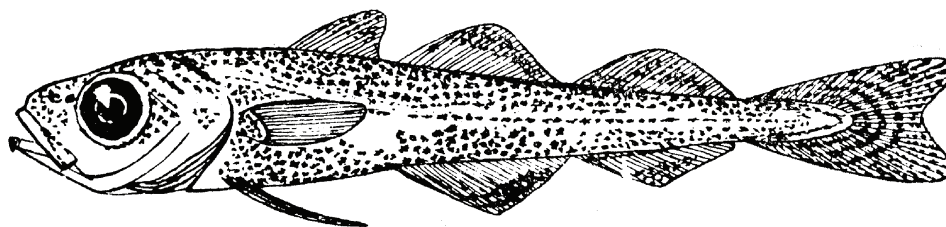
Meristic Characters

Myomeres:	53–58
Vertebrae:	18–20+35–39=53–58
Dorsal fin rays:	11–15+12–17+17–23
Anal fin rays:	14–20+18–24
Pectoral fin rays:	18–21
Pelvic fin rays:	6
Caudal fin rays:	50–54



Yolk-sac larva

Note: 1. See distribution of caudal fin rays in the family Gadidae on *Gadus ogac* figure page

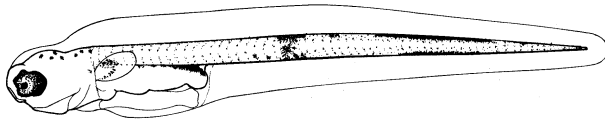
Early Juvenile:**F. 46.0 mm**

Fins well pigmented

Figures: Adult: P. McWhirter (Scott and Scott, 1988); Yolk-sac larva: O. G. N. Andersen (Andersen *et al.*, 1994) **A–D:** Bev Vinter (Dunn and Vinter, 1984); **E:** Bev Vinter (Matarese *et al.*, 1989); **F:** Schmidt, 1905a

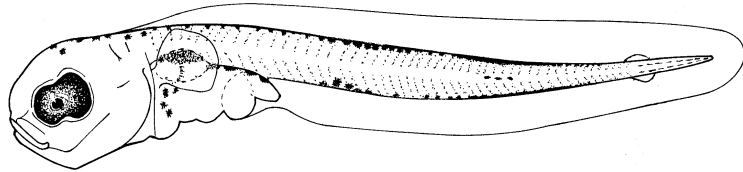
References: Schmidt, 1905a; Russell, 1976; Dunn and Vinter, 1984; Matarese *et al.*, 1989

Boreogadus saida

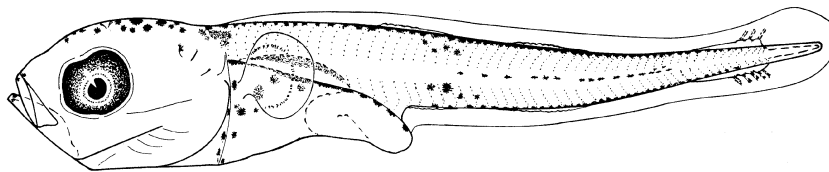


A. 6.3 mmSL

Note ventral pigment bars shorter than dorsal bars

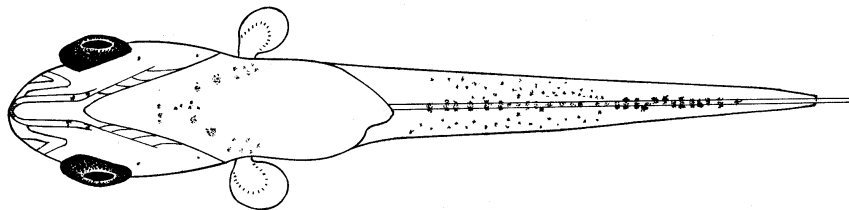


B. 7.3 mmSL



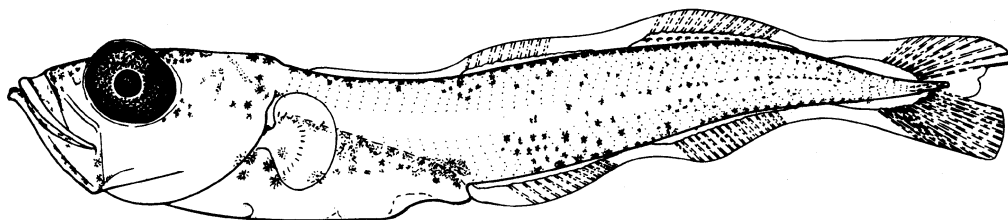
C. 10.1 mmSL

Midline streak of pigment begins under 2nd dorsal fin

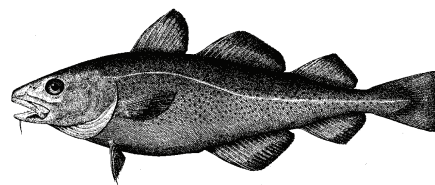


**D. 10.1 mmSL
(Ventral View)**

Note ventral pigment consisting of a row along midline plus scattered spots on each side of midline



E. 16.3 mmSL

Gadus morhua* Linnaeus, 1758*Gadidae****Atlantic cod**

Range: Coast of North America from Ungava Bay to Cape Hatteras; also both coasts of Greenland, around Iceland, and European coastal waters from Barents Sea to Bay of Biscay

Habitat: Widely variable from nearshore to depths of 600 m; mostly on continental shelf between 150 and 200 m; typically on or near pebbly or rocky bottoms, avoiding finer substrates; larger individuals remain in deeper waters, and many move to offshore banks during summer. Juveniles in northern part of range occur in very shallow water (2–3 m).

Spawning: On Georges Bank, 90% of spawning occurs between mid-Nov and mid-May, (median date mid-Mar); peaks in Apr on Browns Bank; Apr–Jun in NE Newfoundland; intense activity occurs on the Northeast Peak of Georges Bank, perimeter of Gulf of Maine, inner half of continental shelf off Southern New England

Eggs:

- Pelagic, buoyant, spherical and transparent; diameter 1.2–1.7 mm
- Chorion smooth (unsculpted); yolk homogeneous
- Oil globules lacking; Perivitelline space narrow
- Hatching occurs after 8–60 days incubation, depending on temperature; 2–3 weeks in average spring conditions; early egg similar to egg of *Melanogrammus aeglefinus* and *Glyptocephalus cynoglossus*

Larvae:

- Hatching length 3.3–5.7 mm; mouthparts unformed, eyes well pigmented; characteristic larval pigment present in late stage embryo
- Body and tail long and tapering; preanus length 39% TL at hatching, increases to <50% TL
- Anus opens laterally on finfold (not at margin) in early larvae; in later larvae, anus is located under anterior part of second dorsal fin
- Sequence of fin ray formation: C – D₂, D₃, A₁, A₂ – P₂ – D₁ – P₁
- Pigmentation: spots on crown, lower jaw and peritoneum; two dorsal and two ventral groups of spots on tail (ventral groups wider and extend farther posteriorly than dorsal); few ventral spots at notochord tip, may be faint; distinct preanal streak of ventral pigment present (compare to *Pollachius virens*); continuous lateral streak of pigment forms on tail at about 6.5 mm TL; all tail pigment fuses together at 8–10 mm; dorsal, anal and caudal fins unpigmented until transformation
- Transformation occurs at sizes greater than 20 mm, when all fin rays are formed

Early Juvenile: Descent to benthic habitats occurs at sizes <24–60 mm; most settlement occurs on cobble substrates or in eelgrass beds; coloration during this settlement mimics the substrate, reducing predation.

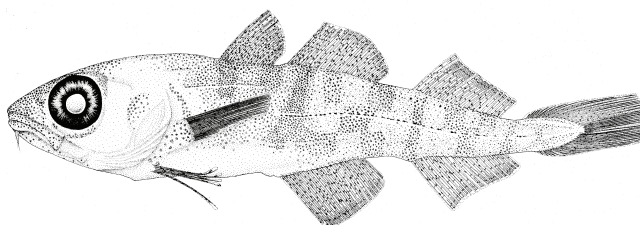
Meristic Characters

Myomeres:	49–53
Vertebrae:	18–20+32–35=49–55
Dorsal fin rays:	13–16+19–24 +18–21
Anal fin rays:	20–24+17–22
Pectoral fin rays:	19–20
Pelvic fin rays:	6–7
Caudal fin rays:	51–58



See distribution of caudal fin rays in the family Gadidae on *Gadus ogac* figure page

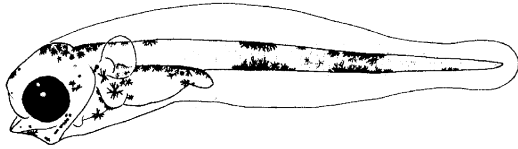
H. 67.7 mmSL



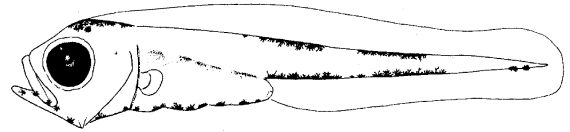
Figures: Adult: H. L. Todd; Egg: Ehrenbaum, 1909; **A:** Dannevig 1919; **B–E:** Schmidt 1905a (all redrawn); **F–H:** Betsy Broughton (Auditore *et al.*, 1994)

References: Schmidt 1906a; Ehrenbaum 1909; Leim and Scott 1966; Colton and Marak, 1969; Markle 1982; Markle and Frost 1985; Fahay and Markle 1984; Lough *et al.* 1989; Auditore *et al.* 1994; Methven and Schneider, 1998; Page *et al.*, 1998; Fahay *et al.* 1999a; Methven *et al.*, 2003

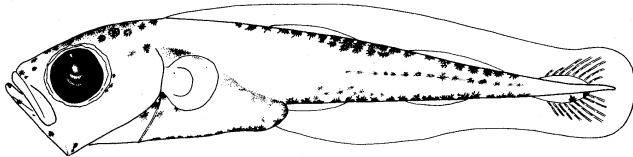
Gadus morhua



A. 3.8 mmTL



B. 4.5 mmTL

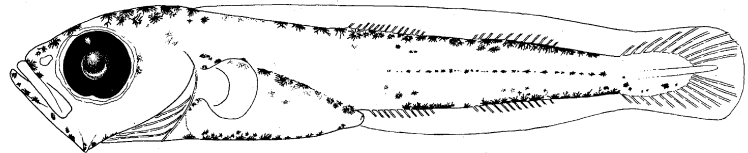


C. 9.0 mmTL

Ventral pigment bars wider than dorsal

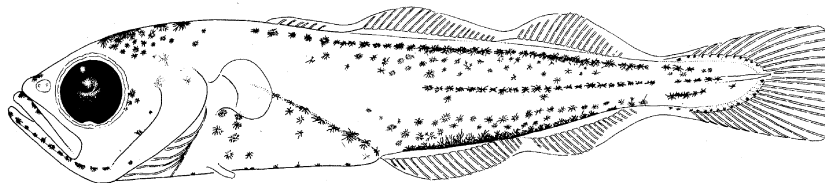
Note few ventral spots at notochord tip

Ventral pigment extends farther posteriorly than dorsal



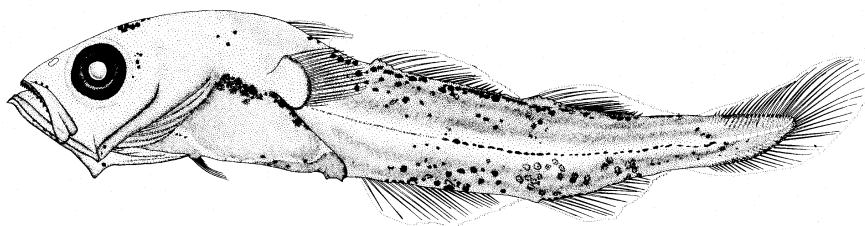
D. 11.0 mmTL

Distinct streak of ventral pigment anterior to anus

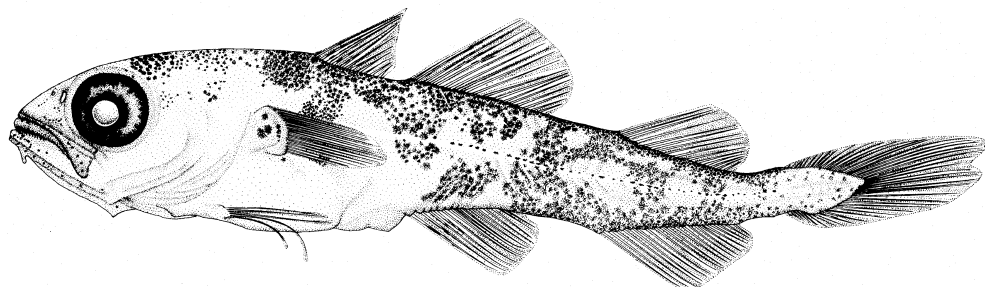


E. 16.0 mmTL

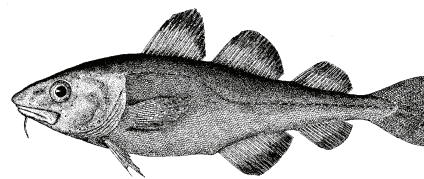
Pigment bars fuse together at 8-10 mm



F. 25.3 mmSL



G. 35.2 mmSL

Gadus ogac* Richardson, 1836*Gadidae****Greenland cod**

Range: Western North Atlantic Ocean from Baffin Island to Gulf of St. Lawrence, west coast of Greenland, Labrador, NE Newfoundland and Hudson Bay; also Canadian and Alaskan shores of Arctic Ocean

Habitat: Usually close to coast, in depths <200 m; common in harbors and fjords; tolerates low salinities, but not freshwater; juveniles (30–120 mm) very abundant in very shallow water, often in eelgrass beds

Spawning: Late winter to early spring, possibly in brackish waters; earlier than spawning in *Gadus morhua* in Labrador and Newfoundland

Eggs:

- Demersal, spherical
- Diameter: 1.13–1.17 mm
- Yolk: homogeneous
- Oil globule: none

Larvae:

- Hatching length about 4.0 mmNL
- Body and tail long and tapering
- Anus opens laterally on finfold (not at margin) in early larvae
- Preanus length 43% NL at hatching
- Pigmentation: no external pigment anterior to anus, ventrally or dorsally; however, internal, peritoneal pigment covers developing gut; anterior dorsal pigment bar on tail shorter than ventral bar; second dorsal pigment bar on tail longer than ventral bar; at notochord tip, there are 0–1 spots dorsally and 2–6 spots ventrally
- Transformation occurs at unknown size

Note:

1. Small larvae may be distinguished from those of *Gadus morhua* by lack of pigment anterior to level of anus.
2. Juveniles (87–135 mm) have smaller eyes and a deeper body than juveniles of *G. morhua*. Freshly collected *Gadus ogac* are generally green in color, whereas *G. morhua* are mostly brownish. The lateral line is usually more arched and dark in color in *G. ogac*, straighter and pale in *G. morhua*. See table below:

Character	<i>Gadus ogac</i>	<i>Gadus morhua</i>
Eye diameter (% Head Length)	Mean: 26.1 (23.7–29.1)	Mean: 30.6 (25.3–34.7)
Body depth at 2 nd dorsal fin origin (% SL)	Mean: 18.2 (16.2–19.8)	Mean: 17.5 (14.9–20.1)

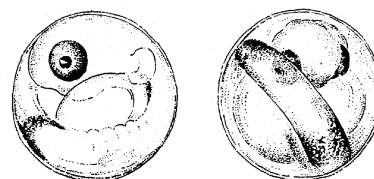
3. A recent publication, received too late to include in this monograph, adds pigment data for distinguishing the early stages of this species and *G. morhua* (Evseenko *et al.*, 2006). This report demonstrates differences in head pigment and location of dorsal and ventral pigment bars on the body.
4. See Table on opposite page for caudal fin formulae in Gadidae.

Figures: Adult: D. R. Harriott (Scott and Scott, 1988); Eggs and A–B: P. H. Winther (Andersen *et al.*, 1994); C: J. Kreutzmann (Andersen *et al.*, 1994)

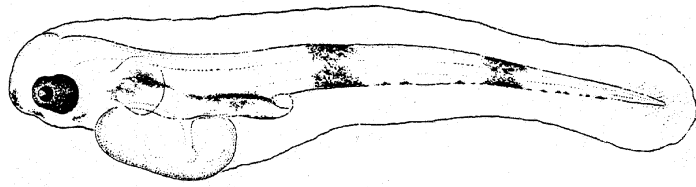
References: Markle, 1982; Fahay and Markle, 1984; Scott and Scott, 1988; Cohen *et al.*, 1990; Andersen *et al.*, 1994; Methven and McGowan, 1998

Meristic Characters

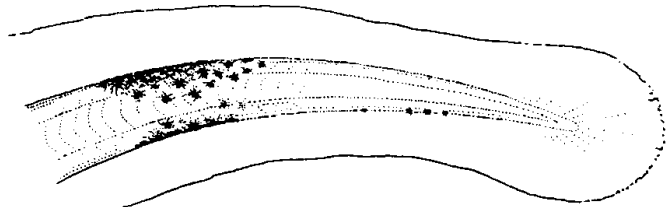
Myomeres: 53–57
 Vertebrae: 19–22+32–36=53–56
 Dorsal fin rays: 13–17+14–20+15–20
 Anal fin rays: 18–23+15–20
 Pectoral fin rays: –
 Pelvic fin rays: 6–7
 Caudal fin rays: 47–51



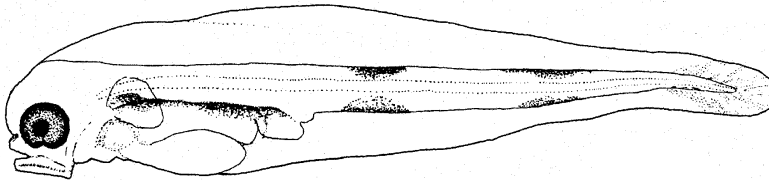
Gadus ogac



**A. 3.8 mmNL
(Yolk Sac Larva)**



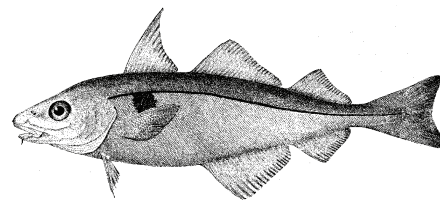
**B. 3.8 mmNL
(End of Tail Pigment)**



C. 5.3 mmNL

Distribution of caudal fin rays in Gadidae:

<i>Species</i>	Dorsal Secondary Rays	Superior Hypural Rays	Inferior Hypural Rays	Ventral Secondary Rays	Vertebrae Supporting Caudal Fin
<i>Arctogadus glacialis</i>	21-26	4	1	22-25	15
<i>Boreogadus saida</i>	21-25	4	2	21-25	13-14
<i>Gadus morhua</i>	22-26	4	2	23-27	13-14
<i>Gadus ogac</i>	21-23	4	2	21-24	14
<i>Melanogrammus aeglefinus</i>	25-27	5	2	26-27	14
<i>Microgadus tomcod</i>	21-22	4	1	21-24	13-14
<i>Micromesistius poutassou</i>	21-22	5	2	23-24	15
<i>Pollachius virens</i>	30-32	5	2	31-33	15-16

Melanogrammus aeglefinus* (Linnaeus, 1758)*Gadidae****Haddock**

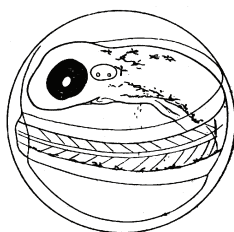
Range: Coast of North America from Strait of Belle Isle to latitude of Delaware Bay; also both coasts of southern Greenland and eastern Atlantic from Barents Sea and Iceland to Bay of Biscay

Habitat: Mostly 40–150 m depth on gravel or pebble substrates, or hard sand areas between rocky patches; avoid ledges, rocks, kelp and soft mud

Spawning: Jan–Jul with peaks Mar–Apr depending on location; Georges Bank and Browns Bank are important areas

Eggs:

- Pelagic, buoyant, spherical and transparent
- Diameter: 1.2–1.6 mm
- Chorion: smooth
- Yolk: homogeneous
- Oil globules: none
- Perivitelline space: narrow



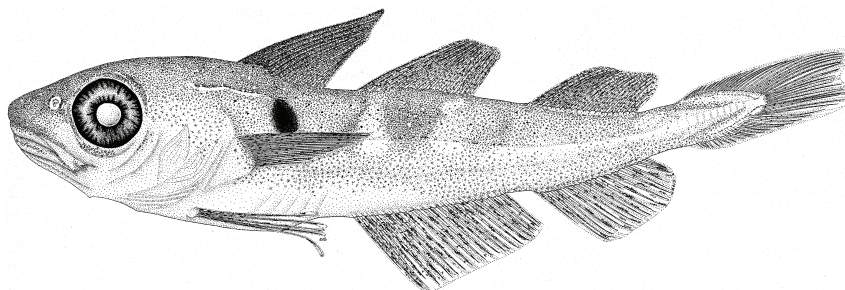
Larvae:

- Hatching length 3.3 mm (mean)
- Body and tail long and tapering, but slightly deeper than larvae of *Gadus* and *Pollachius*
- Anus opens laterally on finfold (not at margin) in early larvae; in later larvae, anus is located under anterior half of second dorsal fin
- Preanus length = 37% TL in early larvae, increases slightly with growth (to about 45% TL)
- Sequence of fin ray formation: C – D₂, D₃, A₁, A₂ – D₁ – P₁ – P₂
- Pigmentation: early larvae have melanophores on top of head, dorsum of body over gut, and peritoneum; also row of spots along ventral edge from anus to notochord tip; this pattern persists until about 10 mm; little or no ventral pigment anterior to anus; pigment on sides spreads posteriorly, but no lateral midline streak; pectoral and pelvic fins develop pigment at 10–15 mm; larger juveniles paler (and first dorsal fin higher) than in juveniles of *Gadus* or *Pollachius*
- Transformation occurs at sizes about 20 mm, when all fin rays are formed

Note:

1. Early egg similar to egg of *Gadus morhua* and *Glyptocephalus cynoglossus* (Pleuronectidae)
2. Early larvae similar to larvae of *Myoxocephalus aeneus* and *M. octodecemspinus* (Cottidae) but latter larvae lack head pigment in early stages and have fewer myomeres

Early Juvenile: Pelagic until a length of 50–100 mm, when they descend to pebbly or gravel bottoms



See distribution of caudal fin rays in the family Gadidae on *Gadus ogac* figure page

I. 68 mmSL

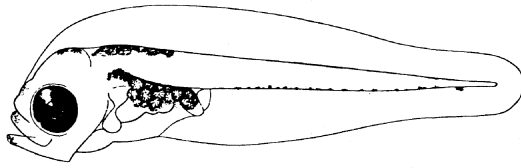
Figures: Adult: H. L. Todd; Egg: Ehrenbaum, 1905; **A:** Schmidt, 1905a; **B:** Betsy Washington (Dunn and Matarese, 1984); **C:** Dann- evig, 1919; **D–E:** Rass, 1949 (**C–E** redrawn); **F–I:** Betsy Broughton (Auditore *et al.*, 1994)

References: Schmidt, 1906a; Fahay and Markle, 1984; Markle and Frost, 1985; Scott and Scott, 1988; Page *et al.*, 1998; Cargnelli, *et al.*, 1999a; Klein-MacPhee, 2002d

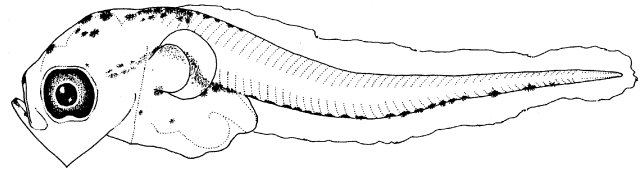
Meristic Characters

Myomeres:	50–57
Vertebrae:	19–22+32–35
Dorsal fin rays:	13–18+19–25 +18–23
Anal fin rays:	21–28+19–24
Pectoral fin rays:	19–23
Pelvic fin rays:	6–7
Caudal fin rays:	57–60

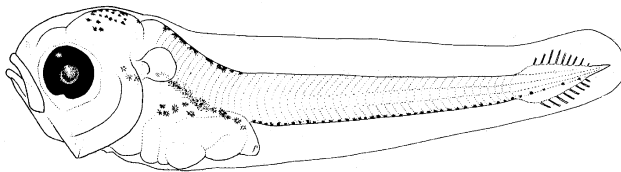
Melanogrammus aeglefinus



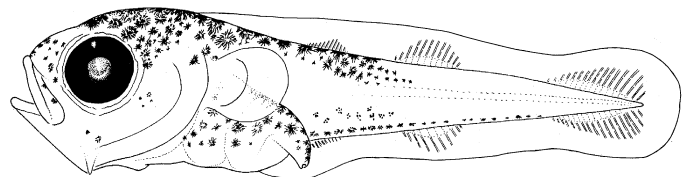
A. 4.5 mmTL



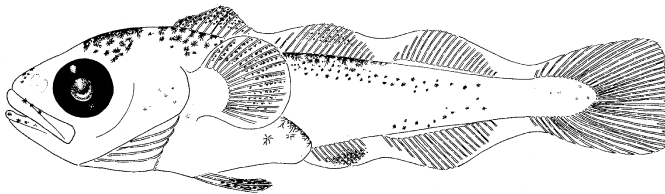
B. 6.1 mmSL No lateral pigment streak



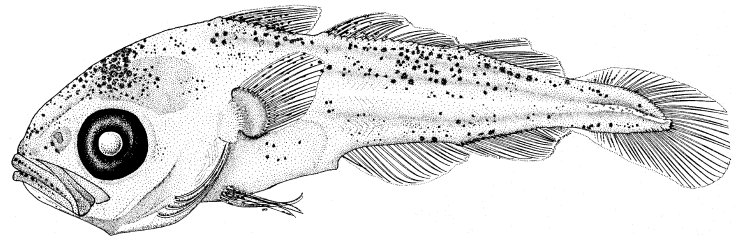
C. 7.0 mmTL



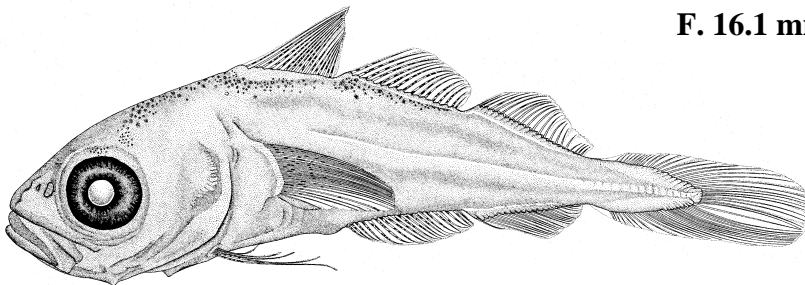
D. 10.0 mmTL
Little or no ventral pigment anterior
to anus



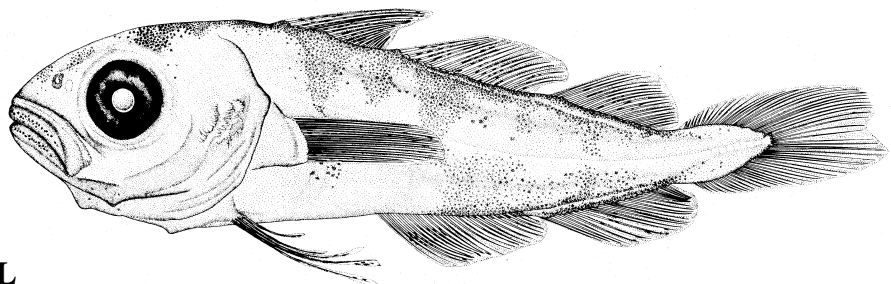
E. 15.8 mmTL
Pectoral and pelvic fins
develop pigment at 10-15 mm



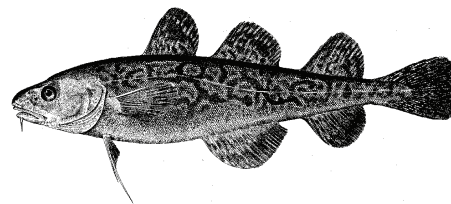
F. 16.1 mm SL



G. 22.5 mmSL



H. 35.1 mm SL

Microgadus tomcod* (Walbaum, 1792)*Gadidae****Atlantic tomcod**

Range: Western North Atlantic Ocean along coast of North America from Labrador to Virginia (rare south of Hudson River)

Habitat: Demersal in coastal, estuarine and fresh waters; few landlocked in lakes; some populations coastal, ascending low-salinity streams, some are strictly riverine (e.g. Hudson River)

Spawning: Winter, mostly in freshwater, near upstream extent of saltwater intrusion

Eggs:

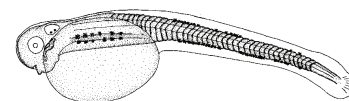
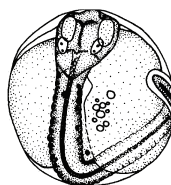
- Demersal, spherical to slightly oval, 1.39–1.70 mm
- Weakly adhesive
- 3–12 tiny oil globules in some; absent in most

Larvae:

- Hatching length 5–7 mm; eyes unpigmented
- Body and tail long and tapering
- Anus opens laterally on finfold (not at margin) in early larvae; in later larvae, anus is located under junction between 1st and 2nd dorsal fins
- Preanus length about 35% TL at hatching, increases to 40–45% TL
- Flexion occurs at 8–10 mmTL
- Sequence of fin ray formation: C – D₂, D₃, A₁, A₂ – D₁, P₁ – P₂
- Pigmentation: early larvae have pigment ventrally anterior to anus, over swim bladder, along dorsum of gut tube and a ventral row along ventral edge of body; later larvae add rows of spots along dorsal edge of body and a cluster on top of head; a midlateral streak of pigment forms in larger larvae, beginning over middle of 1st anal fin
- Transformation occurs at sizes greater than 23 mm, when all fin rays are formed

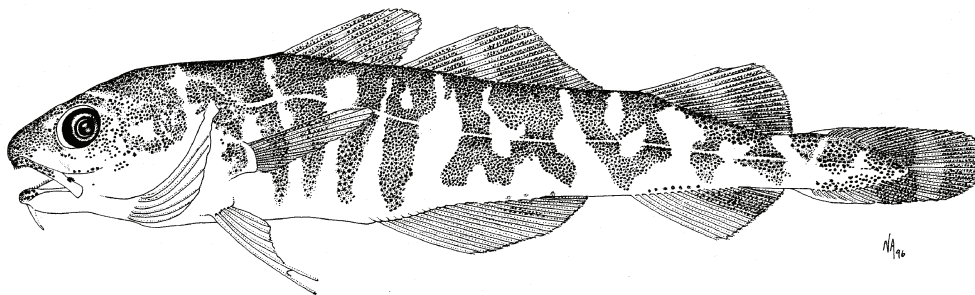
Meristic Characters

Myomeres:	53–57
Vertebrae:	53–57
Dorsal fin rays:	11–15+15–19 +16–21
Anal fin rays:	17–21+16–20
Pectoral fin rays:	18–19
Pelvic fin rays:	6
Caudal fin rays:	46–50



Yolk-sac larva

Early Juvenile: Larvae develop as they drift downstream. Transformation occurs in lower portions of rivers, and juveniles gradually migrate back upstream during summer, when freshwater outflow is at its lowest rate. Note development of mottled pigment pattern.

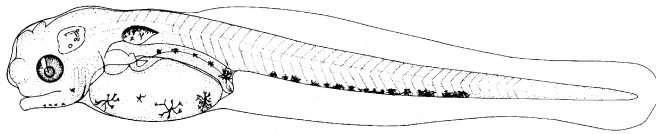
**H. 53.3 mmTL**

See distribution of caudal fin rays in the family Gadidae on *Gadus ogac* figure page

Figures: Adult: H.L. Todd; egg, yolk-sac larva and **A**: Jerry Hardy (Hardy, 1978a); **B–F**: Booth, 1967 (**D–F** modified); **G**: L.L. Hudson (Hardy, 1978a); **H**: Nancy Arthur (Able and Fahay, 1998)

References: Booth, 1967; Dunn and Matarese, 1984; Fahay and Markle, 1984; Able and Fahay, 1998

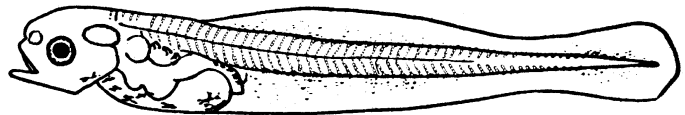
Microgadus tomcod



Note single row of spots along ventral edge of body

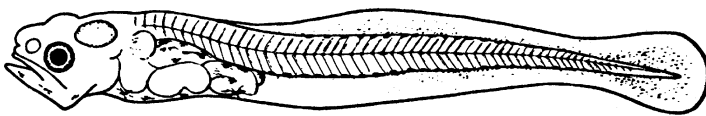
A. 4.7 mmTL

Ventral pigment anterior to anus present at smallest sizes

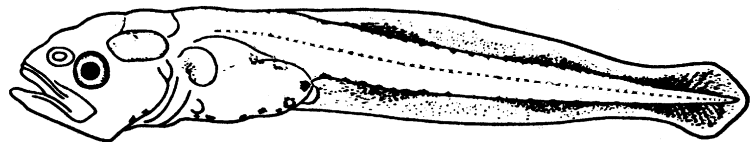


B. 6.0 mmTL

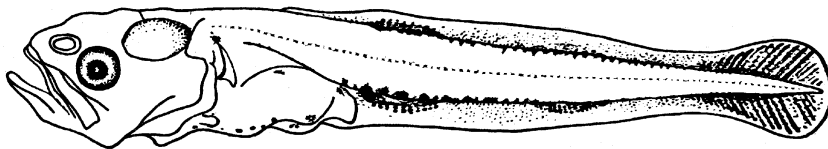
Single rows of spots form along dorsal and ventral edges of body



C. 7.0 mmTL

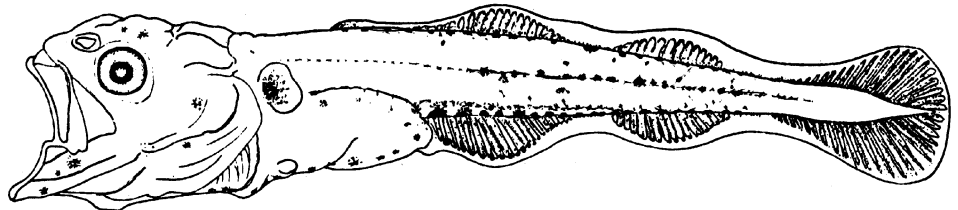


D. 7.9 mmTL



Midline streak of pigment forms in larger larvae

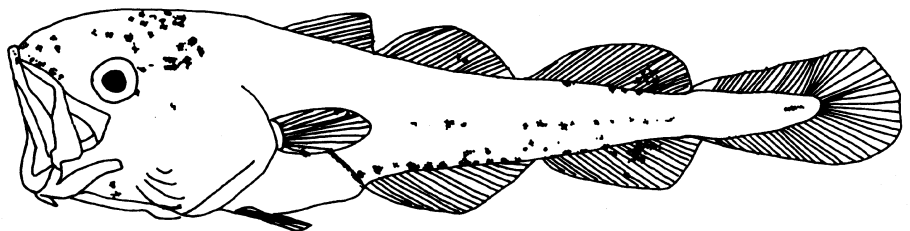
E. 9.2 mmTL

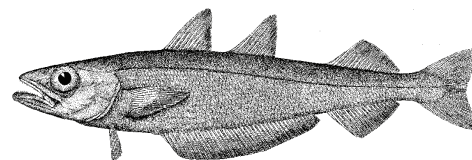


F. 11.6 mmTL

Top of head unpigmented until later stages

G. 23.0 mmTL



Micromesistius poutassou* (Risso, 1826)*Gadidae****Blue whiting**

Range: Western Atlantic Ocean off southern Greenland and coast of North America from Nova Scotia to about 35°N; also eastern Atlantic from Greenland and Barents Sea to western Mediterranean Sea

Habitat: Meso- and benthopelagic over continental slope and shelf waters in depths of 150 to >1,000 m (most commonly 300–400 m)

Spawning: Late winter-early spring in eastern Atlantic where it spawns close to bottom near edge of continental shelf; not well-described in western Atlantic

Eggs:

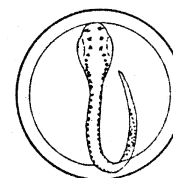
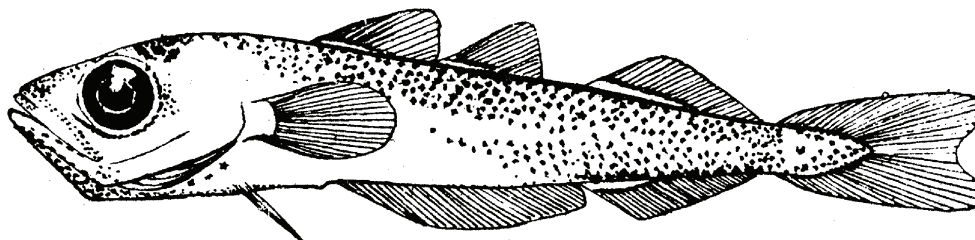
- Pelagic, spherical
- Diameter: 1.04–1.28 mm
- Yolk: homogeneous
- Oil globules: none
- Embryo has 2 rows of melanophores from snout to about 80% of body length

Larvae:

- Hatching length 2.0–3.0 mm (at 10–11°C incubation); eyes unpigmented
- Body and tail long and tapering, large head
- Anus opens laterally on finfold (not at margin) in early larvae; in later larvae, anus is located under anterior end of 2nd dorsal fin
- Preanus length = about 50%SL at hatching, decreases to about 40%SL after flexion
- Flexion occurs at 8–13 mm
- Sequence of fin ray formation: C – D₂, D₃, A₁, A₂ – D₁, P₁ – P₂
- 5 caudal fin rays on superior hypural
- Pigmentation: early larvae have melanophores over head and a line of spots over yolk and developing gut; a single pair of pigment bars forms on dorsal and ventral edges of body, about midway along length of tail; in later larvae, pigment spreads over nape area and between the bars; near transformation, the mid-flank is dense with scattered pigment with a clear, unpigmented streak along midline
- Transformation occurs at sizes greater than 20 mm, when all fin rays are formed

Meristic Characters

Myomeres:	about 55–58
Vertebrae:	24–26+30–33=55–58
Dorsal fin rays:	12–14+12–14 +23–28
Anal fin rays:	33–39+24–27
Pectoral fin rays:	18–22
Pelvic fin rays:	6
Caudal fin rays:	50

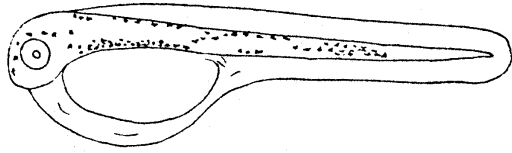
**Early Juvenile:****G. 32.0 mm**

See distribution of caudal fin rays in the family Gadidae on *Gadus ogac* figure page

Figures: Adult: D. R. Harriott (Scott and Scott, 1988); Egg and A–D: Seaton and Bailey, 1971; E: Betsy Washington (Dunn and Matarese, 1984); F–G: Schmidt, 1906a

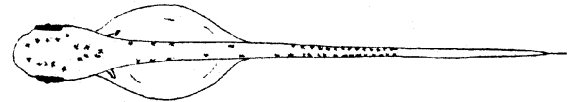
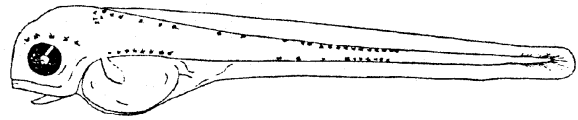
References: Seaton and Bailey, 1971; Coombs and Hiby, 1979; Dunn and Matarese, 1984; Scott and Scott, 1988; Cohen *et al.*, 1990; Munk and Nielsen, 2005

Micromesistius poutassou

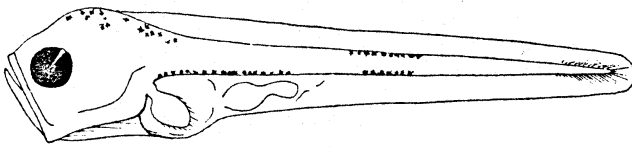


A. 2.5 mmTL

Note line of pigment spots along ventral edge of body over gut

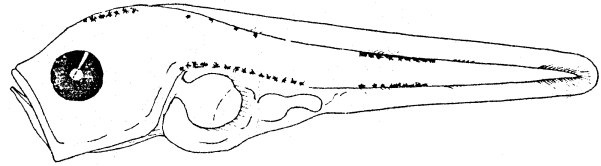


**B. 3.3 mmTL
(Lateral and ventral views)**

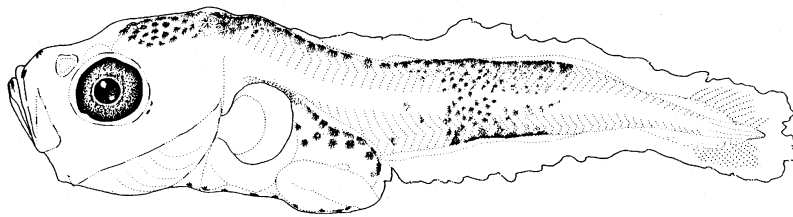


C. 3.7 mmTL

Note single pair of pigment bars on body

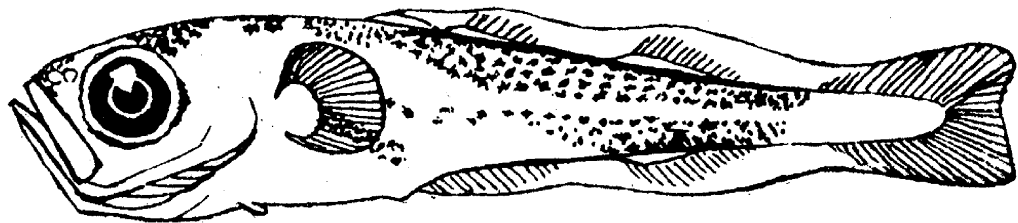


D. 4.1 mmTL



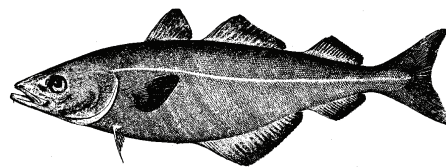
E. 8.0 mmSL

Pigment bars fuse and spread over body



F. 14.0 mm

Note clear, unpigmented stripe along midline

Pollachius virens* (Linnaeus, 1758)*Gadidae****Pollock**

Range: Coast of North America from Hudson Strait to Cape Hatteras; also southwest Greenland and eastern Atlantic from Barents Sea and Iceland to Bay of Biscay

Habitat: Pelagic, schooling, in nearshore and offshore waters to about 200 m depth; occur both on nearshore shoals and over offshore banks; little selectivity for substrate type

Spawning: Sep–Apr with peaks early Nov to mid-Jan; important locations include western Gulf of Maine-Massachusetts Bay, Georges Bank and Browns Bank

Eggs:

- Pelagic, buoyant, spherical and transparent
- Diameter: 1.0–1.2 mm
- Chorion: smooth
- Yolk: homogeneous
- Oil globules: none
- Perivitelline space: narrow

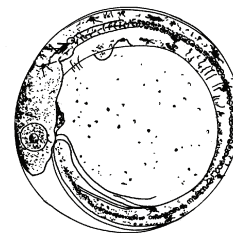
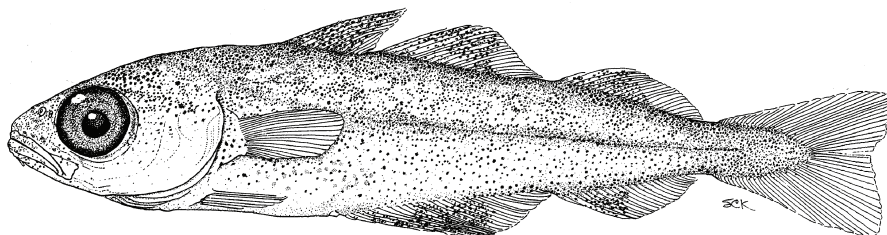
(Late-stage eggs similar to eggs of *Gadus morhua* but smaller)

Meristic Characters

Myomeres:	53–57
Vertebrae:	23–25+29–32
Dorsal fin rays:	13–14+21–22+24–28
Anal fin rays:	24–28+20–21
Pectoral fin rays:	19–22
Pelvic fin rays:	6–7
Caudal fin rays:	66–70

Larvae:

- Hatching occurs at 3.0–4.0 mm; eyes unpigmented; anterior pigment scattered and light
- Body and tail long and tapering
- Anus opens laterally on finfold (not at margin) in early larvae; in later larvae, anus is located under posterior part of first dorsal fin
- Preanus length = about 42% NL at hatching, increases to about 50% SL
- Sequence of fin ray formation: C – D₂, D₃, A₁, A₂ – D₁, P₁ – P₂
- Caudal fin rays begin at about 9.0 mm; pelvic buds form at about 12.5 mm
- Pigmentation: early larvae have melanophores on top of head, tip of lower jaw and peritoneum; 2 dorsal and 2 ventral groups of spots form on tail, dorsal groups longer than ventral and more space between ventral groups than between dorsal groups; dorsal groups fuse together at about 9.0 mm; notochord tip remains unpigmented throughout development; preanal ventral streak weak, shorter than streak in *Gadus*; lateral, interrupted streak on midline distinct at 6.75 mm, most intense posteriorly
- Transformation occurs at sizes greater than 25 mm, when all fin rays are formed

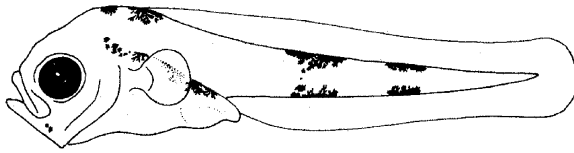
**Early Juvenile:****G. 39.5 mmSL**

See distribution of caudal fin rays in the family Gadidae on *Gadus ogac* figure page
Note high number of caudal fin rays and vertebrae supporting caudal fin in *P. virens*

Figures: Adult: H. L. Todd; Egg: M^cIntosh, 1893; **A:** Rass, 1949 (redrawn); **B:** Betsy Washington (Dunn and Matarese, 1984); **C–F:** Schmidt, 1905a (redrawn); **G:** Susan Kaiser (Able and Fahay, 1998)

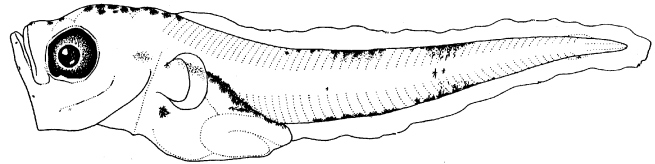
References: Schmidt, 1906a; Scott and Scott, 1988; Markle, 1982; Fahay and Markle, 1984; Markle and Frost, 1985; Able and Fahay, 1998; Cargnelli *et al.*, 1999b; Klein-MacPhee, 2002d

Pollachius virens



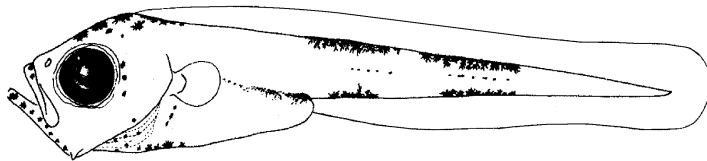
A. 4.0 mmTL

2 dorsal and 2 ventral bars of pigment form on body, dorsal wider than ventral



B. 5.9 mmSL

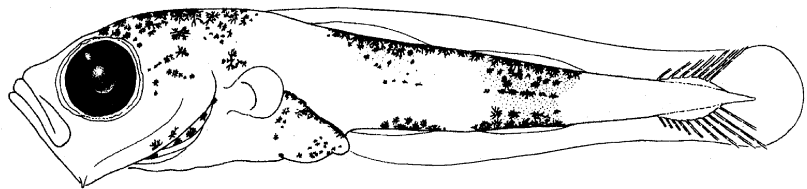
Space between ventral pigment bars wider than space between dorsal bars



C. 6.8 mmTL

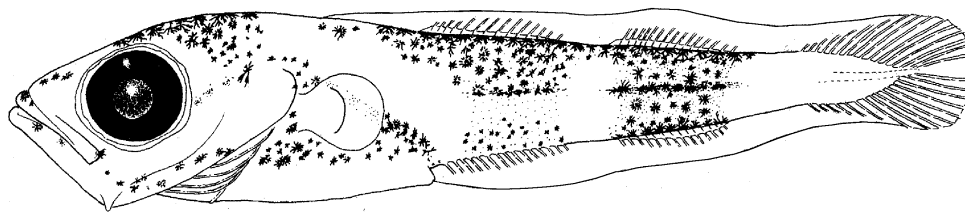
Short preanal streak of pigment ventrally (shorter than in *G. morhua*)

No pigment at notochord tip



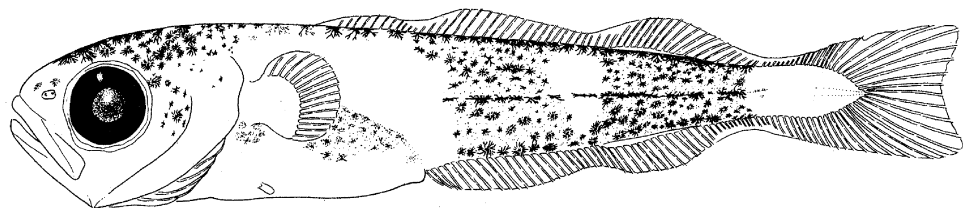
D. 9.0 mmTL

Midline pigment interrupted



E. 11.0 mmTL

As pigment fuses and spreads over body, 3 unpigmented areas remain



F. 15.0 mmTL