NOAA Professional Paper 15

October 2013

Guide to the identification of larval and early juvenile pricklebacks (Perciformes: Zoarcoidei: Stichaeidae) in the northeastern Pacific Ocean and Bering Sea

Ann C. Matarese
Deborah M. Blood
Morgan S. Busby

U.S. Department of Commerce
Penny S. Pritzker
Secretary of Commerce

National Oceanic and Atmospheric Administration
Kathryn D. Sullivan
Acting Administrator

National Marine Fisheries Service
Samuel D. Rauch III
Acting Assistant Administrator
for Fisheries

NOAA Professional Papers NMFS

The NOAA Professional Paper NMFS (ISSN 1931-4590) series is published by the Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.
The Secretary of Commerce has determined that the publication of this series is necessary in the transaction of the public business required by law of this Department. Use of funds for printing of this series has been approved by the Director of the Office of Management and Budget.

The NOAA Professional Paper NMFS series carries peer-reviewed, lengthy original research reports, taxonomic keys, species synopses, flora and fauna studies, and data-intensive reports on investigations in fishery science, engineering, and economics. Copies of the NOAA Professional Paper NMFS series are available free in limited numbers to government agencies, both federal and state. They are also available in exchange for other scientific and technical publications in the marine sciences. Professional Papers are published online in PDF format at http://spo.nmfs.noaa.gov

NOTICE: This series was established in 2003 to replace the NOAA Technical Report NMFS series.

NOAA Professional Paper 15

Guide to the identification of larval and early juvenile pricklebacks (Perciformes: Zoarcoidei: Stichaeidae) in the northeastern Pacific Ocean and Bering Sea

Ann C. Matarese
Deborah M. Blood
Morgan S. Busby

October 2013

U.S. Department of Commerce
Seattle, Washington

Suggested reference

Matarese, Ann C., Deborah M. Blood, and Morgan S. Busby. Guide to the identification of larval and early juvenile pricklebacks (Perciformes: Zoarcoidei: Stichaeidae) in the northeastern Pacific Ocean and Bering Sea. NOAA Professional Paper NMFS 15, 96 p. doi:10.7755/PP.15

Online dissemination

This report is posted online in PDF format at http://spo.nmfs.noaa.gov (click on *Professional Papers* link).

Copyright law

Proprietary products

CONTENTS

Guide to the identification of larval and early juvenile pricklebacks (Perciformes: Zoarcoidei: Stichaeidae) in the northeastern Pacific Ocean and Bering Sea

Ann C. Matarese (contact author)

Deborah M. Blood

Morgan S. Busby

Recruitment Processes Program
Resource Assessment and Conservation Engineering Division
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE
Seattle, Washington 98115

Email address for contact author: ann.matarese@noaa.gov

Abstract—Stichaeidae, commonly referred to as pricklebacks, are intertidal and subtidal fishes primarily of the North Pacific Ocean. Broad distribution in relatively inaccessible and undersampled habitats has contributed to a general lack of information about this family. In this study, descriptions of early life history stages are presented for 25 species representing 18 genera of stichaeid fishes from the northeastern Pacific Ocean, Bering Sea, and Arctic Ocean Basin. Six of these species also occur in the North Atlantic Ocean. Larval stages of 16 species are described for the first time. Additional information or illustrations intended to augment previous descriptions are provided for nine species. For most taxa, we present adult and larval distributions, descriptions of morphometric, meristic, and pigmentation characters, and species comparisons, and we provide illustrations for preflexion through postflexion or transformation stages. New counts of meristic features are reported for several species.

Introduction

Stichaeidae, commonly referred to as pricklebacks, are intertidal and subtidal fishes primarily of the North Pacific Ocean and Bering Sea; a few species also are found in the Arctic and North Atlantic oceans (Table 1). They are commonly found under rocks and among algae in the intertidal zone or in shallow bays and reported to occur at depths ≥250 m on the outer continental shelf and upper slope (Mecklenburg and Sheiko, 2004). High diversity (76 species in 37 genera) and broad distribution in relatively inaccessible and undersampled habitats have contributed to a general lack of information about this family. Although not commercially important, stichaeids are important in ecological interactions as forage for commercial and noncommercial fishes, marine birds, and marine mammals of the ecosystems of the North Pacific Ocean and Bering Sea (Golet et al., 2000). Information about stichaeid early life history is essential to our understanding of recruitment and survival of intertidal and nearshore fishes.

Stichaeids have elongate, slightly compressed bodies with numerous sharp spines in the dorsal fin. They are related most closely to the Pholidae, Zoarcidae, and other zoarcoid fishes but can be distinguished by a combination of the following characters: spinous dorsal fin continuous along the entire body or with some soft rays posteriorly; anal fin with 0–5 anterior spines; pelvic fin, when present, that has one spine and up to four rays; teeth simple; and ribs, intercalar bone, and bony actinosts (proximal pectoral radials) present (Anderson, 1984, 1994). Historically, Makushok (1958) divided Stichaeidae into eight subfamilies. Although Makushok's (1958) comprehensive study has been accepted for many years, providing insight into character evolution, identification, and classification of known stichaeid species, not all taxa were examined in that study. The current classification of Stichaeidae with six subfamilies results from cladistic

Table 1

Distribution of Stichaeidae in the Bering Sea and northeastern Pacific Ocean with the current status of early life history descriptions based on this study.

Taxon	Distribution[1]	Number of species	Early life history Published	Updated	New
STICHAEINAE		2			
Eumesogrammus praecisus	Sea of Okhotsk; Beaufort–Bering Seas; Arctic–W North Atlantic				X[2]
Stichaeus punctatus	Okhotsk and Japan Seas; Beaufort Sea–North Pacific; Arctic–W North Atlantic		Faber (1976); Farwell et al. (1976); Haryu et al. (1985); Fahay (1983, 2007)	X	
CHIROLOPHINAE		7			
Bryozoichthys lysimus	Sea of Okhotsk–N Sea of Japan; Bering Sea–N Gulf of Alaska		Shiogaki and Haryu (1988)		X[3]
Bryozoichthys marjorius	Aleutian Is.–S British Columbia				X
Chirolophis decoratus	E Bering Sea, Aleutian Is.–N Calif.				X
Chirolophis nugator	Aleutian Is.–S Calif.				X
Chirolophis snyderi	W Bering Sea–Sea of Okhotsk; Chukchi Sea–W Gulf of Alaska		Grigor'ev (1992a)	X	
Chirolophis tarsodes	North Pacific and Kodiak Is.–N British Columbia				
Gymnoclinus cristulatus	Hokkaido; Commander Is.–Amchitka Island		Tokuya and Amaoka (1980); Shiogaki (1988)	X	
LUMPENINAE		7			
Acantholumpenus mackayi	Okhotsk and Japan Seas–Hokkaido; Beaufort Sea–NE Gulf of Alaska				X
Lumpenella longirostris	Sea of Okhotsk–N Japan; Bering Sea–S British Columbia; Greenland		Matarese et al. (1989)		X[3]
Lumpenus fabricii	Okhotsk and Japan Seas; Beaufort Sea–North Pacific; Arctic–North Atlantic		Grigor'ev (1992b)		X[3]
Lumpenus maculatus	Okhotsk and Japan Seas; Beaufort–North Pacific (Washington); North Atlantic		Faber (1976); Grigor'ev (1992b)		X[3]
Lumpenus medius	Okhotsk and Japan Seas; Beaufort Sea–North Pacific; Arctic–North Atlantic		Grigor'ev (1992b)		X[3]
Lumpenus sagitta	Okhotsk and Japan Seas; Bering Sea, Aleutian Is.–N Calif.		Shiogaki and Sasaki (1988); Matarese et al. (1989)	X	
Poroclinus rothrocki	SE Bering Sea, Aleutian Is.–S Calif.		Matarese et al. (1989)		X[3]
OPISTHOCENTRINAE		3			
Lumpenopsis hypochroma	S British Columbia–S Calif.				X[2]
Opisthocentrus ocellatus	Okhotsk and Japan Seas–North Korea; Kuril Is.–Commander Is.		Tokuya and Amaoka (1980); Shiogaki (1982)	X	
Plectobranchus evides	British Columbia–S Calif.		Matarese et al. (1989)	X	
XIPHISTERINAE		8			
Alectridium aurantiacum	Commander Is.; Bering Sea, Aleutian Is., and N Gulf of Alaska				X[2]
Alectrias alectrolophus	Sea of Okhotsk–N Sea of Japan; Norton Sound (Bering Sea)				X
Anoplarchus insignis	SE Bering Sea, Aleutian Is.–N Calif.				X
Anoplarchus purpurescens	SE Bering Sea, Aleutian Is.–S Calif.		Wang (1986); Matarese et al. (1989)	X	
Cebidichthys violaceus	Oregon–Baja Calif.		Wang (1986)		X[3]
Phytichthys chirus	Aleutian Is., Gulf of Alaska–S Calif.		Matarese et al. (1989)	X[2]	
Xiphister atropurpureus	W Gulf of Alaska–Baja Calif.		Matarese et al. (1989)	X[2]	
Xiphister mucosus	W Gulf of Alaska–S Calif.		Wang (1986); Matarese et al. (1989)		
TOTALS		27	17	9	16

[1] Mecklenberg et al. (2002).

[2] Identification is tentative.

[3] Previously published illustration or description incomplete or limited to one early life history stage (preflexion, flexion, postflexion).

studies that focus on the Xiphisterinae (Stoddard, 1985; Yatsu, 1986). However, more work is required to demonstrate the monophyly of this family and its subfamilies and to better define genera and species (Mecklenburg and Sheiko, 2004). Recent molecular work has linked the stichaeids and other zoarcoids with cottoids (e.g., anoplopomatids, hexagrammids, and cottids) (Smith and Wheeler, 2004). Identification of a suite of early life history characters may provide additional insight into the classification of stichaeids and enable higher-level studies of stichaeid and zoarcoid phylogeny.

Early life history stages are known for only 55% of stichaeid species that occur in the northeastern Pacific (NEP). In taxa for which information is available, eggs are demersal, spherical, 1.3–2.5 mm in diameter, contain one or more oil globules, and form an adhesive egg mass that is guarded by the male or female parent (Fujita and Uchida, 1959; Shiogaki and Dotsu, 1972; Wourms and Evans, 1974a, 1974b; Marliave and DeMartini, 1977; Shiogaki, 1981, 1982, 1983; Watson, 1996). Eggs are not well known and were not considered in the study presented here. Incomplete developmental series have been published for some species (Table 1), but larvae of the majority of taxa remain unknown. In this study, we describe the early life history stages of 16 species for the first time and provide updated information for nine additional species (Table 1).

Materials and methods

The study area extends from the Beaufort Sea to the west coast of the United States, including the Chukchi Sea, Bering Sea, and Gulf of Alaska, as well as the southern coast of British Columbia (Fig. 1). Historical ichthyoplankton data were obtained from surveys conducted by the Recruitment Processes Program of the Alaska Fisheries Science Center (AFSC), National Marine Fisheries Service. Data for cruises prior to 1988 were found in Dunn and Rugen,[1] and those data from 1989 to 2009 were found in the AFSC Ichthyoplankton Cruise Database (http://access.afsc.noaa.gov/icc/index.cfm). Ichthyoplankton data were accessed in ICHBASE, the larval fish database maintained by and available from the AFSC.

Most ichthyoplankton were collected with a bongo sampler (Posgay and Marak, 1980), with nets that had an inside diameter of 0.6 m and mesh of 0.505 mm or 0.333 mm, similar to that of the Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP). Bongo nets were lowered at a rate of 40 m/min and retrieved at a rate of 20 m/min, sampling obliquely from the surface to within 10 m of the seafloor or to targeted depths in deeper waters, following standard MARMAP procedures (Smith and Richardson, 1977). Other gear used included 1-m^2 Tucker trawls, sled trawls (modified Tucker trawl towed on the seafloor), Methot nets, Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS), surface-towed trawls (modified Cantrawls), modified beam trawls, rock dredges, Sameoto neuston nets, and dip nets (Tucker, 1951; Sameoto and Jaroszyinski, 1969; Wiebe et al., 1976; Methot, 1986; Eisner et al., 2012). Ichthyoplankton samples were preserved in a 5% buffered formalin-seawater solution and later sorted for eggs and larvae, which were removed and identified to the lowest possible taxon at the Plankton Sorting and Identification Center in Szczecin, Poland. Egg and larval identifications were verified at AFSC. Detailed accounts of sampling and identification protocols are available in Matarese et al. (2003). Other sources of material include the University of Washington Fish Collection, the Vancouver Public Aquarium, Hokkaido University Museum of Zoology, Oregon State University, Canada Department of Fisheries and Oceans, and Chris Ehrler of Tenera Environmental, Inc., in San Luis Obispo, California.

Larvae were identified with the serial method. This method uses adult characters to identify juveniles and progressively links them to smaller specimens through a continuous sequence of shared or similar features (Powles and Markle, 1984). Characters described by Mecklenburg et al. (2002), especially meristic counts, were used to progressively link adults and juveniles to larvae through the use of shared characters (Busby, 1998). Developmental series were illustrated with a camera lucida attached to a dissecting microscope. Only melanistic pigment was described because formalin fails to preserve other color pigments. The best representative specimen of each taxon at each stage of development (preflexion, flexion, and postflexion) was illustrated. Transformation or juvenile stages were illustrated if available. Because pigmentation among specimens was variable, some pigment described in the taxon accounts may not be visible on the illustrations. Some larvae (e.g., High Cockscomb [*Anoplarchus purpurescens*]) used for illustrations were reared in captivity (e.g., at Vancouver Public Aquarium and NOAA wet labs). Comparisons between reared and wild-caught larvae must be done with caution because rearing (culture) may affect the morphology, behavior, and biochemistry of individuals (Blaxter, 1976; Hunter, 1984). Reared larvae also may be more heavily pigmented than are wild-caught specimens (Watson, 1982). Reared larvae are noted on figures.

Overall larval pigmentation for most stichaeids is categorized as follows: 1) lightly pigmented, with pigment on the body limited to postanal ventral melanophores (PVM); 2) moderately pigmented, with pigment on the body consisting of PVM and dorsal or lateral pigment; or 3) heavily pigmented, with pigment distributed over

---

[1] Dunn, J. R., and W. C. Rugen. 1989. A catalog of Northwest and Alaska Fisheries Center ichthyoplankton cruises 1965–1988. Northwest and Alaska Fish.Cent. Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle WA 98115. NWAFC Proc. Rep. 89-04, 201 p.

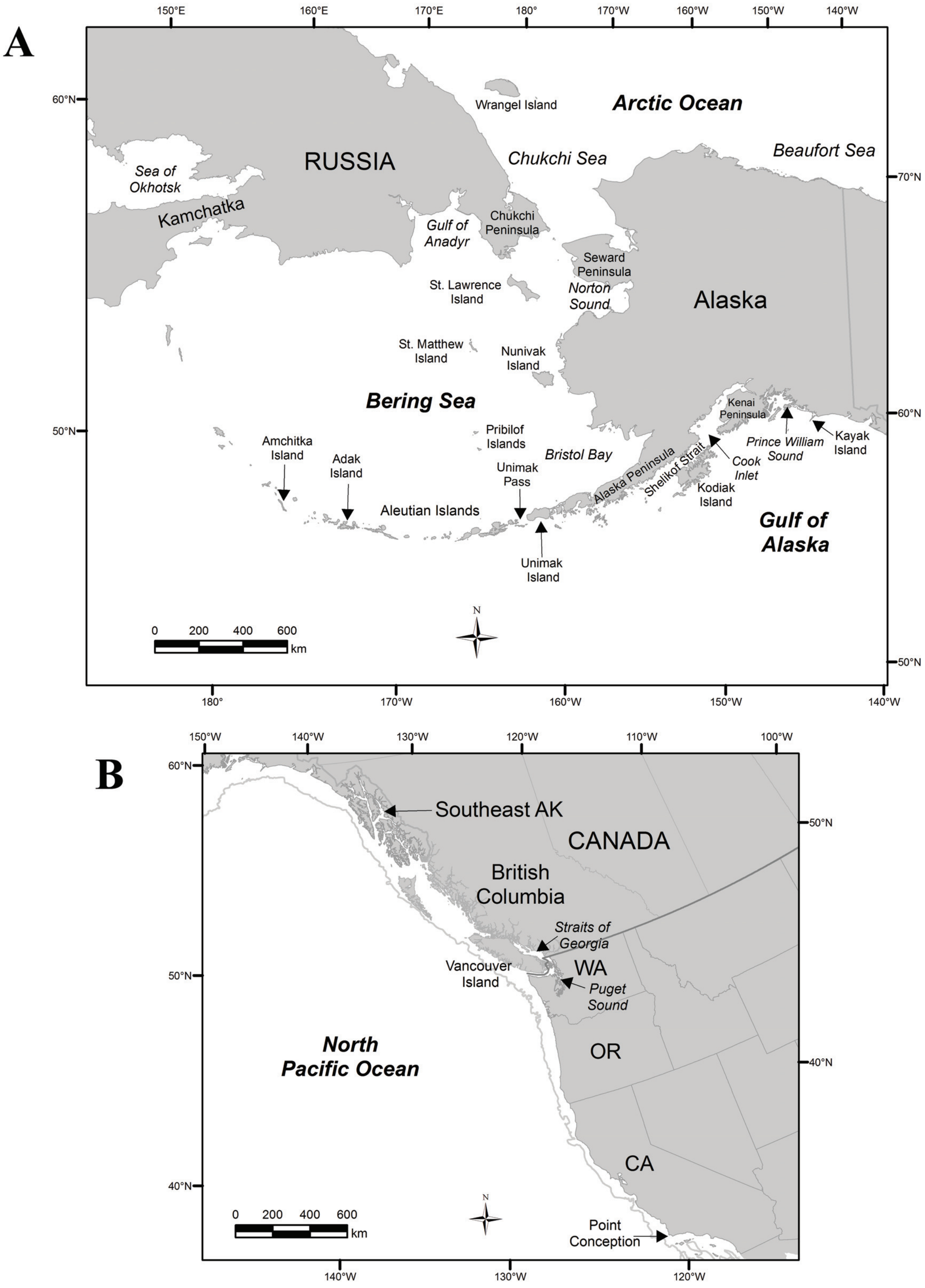

Figure 1

Maps of study area showing geographic features described in species accounts for (**A**) North Pacific Ocean off Alaska, and (**B**) North Pacific Ocean off Canada and the west coast of the United States.

the entire body. Descriptions and illustrations of anatomical and morphometric features and other terms used herein to describe placement of pigment can be found in Matarese et al. (1989) and Moser (1996) with one exception: the area of the body between the anus and posterior edge of the hypural plates is defined as the *postanal body* instead of the *tail*.

Measurements were taken on the left side of a fish, when possible, with a calibrated digital image-analysis system. The system consists of a video camera attached to a dissecting stereomicroscope or camera lens, a computer with a digital imaging board, software, and a video monitor (Blood and Matarese, 2010). Only larvae that were not badly damaged during collection or preservation were measured. In some cases, early transformation-stage individuals were included in morphometric measurements of postflexion larvae. The transformation stage begins at the first appearance of adult pigmentation and ends at the juvenile stage with the beginning of squamation (Kendall et al., 1984); early transformation-stage larvae are most similar morphologically to postflexion larvae. The following measurements were made on larvae and early juveniles:

Standard length (SL): Snout tip to notochord tip prior to development of caudal fin (=notochord length), then to posterior margin of hypural element. All larval body lengths in this study are standard lengths unless otherwise noted.
Body depth: Vertical distance from dorsal to ventral body margin at the pectoral-fin origin. Larvae are referred to as slender-bodied (body depth <10% SL), having a moderate body depth (10–12% SL), or deep-bodied (body depth >12% SL).
Snout to anus length: Distance along body midline from snout tip to a vertical line through center of anal opening.
Head length (HL): Snout tip to posterior edge of opercle.
Snout length: Snout tip to anterior margin of orbit.
Eye diameter: Greatest distance of orbit.

Selected specimens were cleared and differentially stained to count meristic structures and follow sequence of fin development (Potthoff, 1984). Meristic counts reported for each species were compiled from this study, the AFSC meristic database, and other sources (Tokuya and Amaoka, 1980; Watson, 1996; MacDonald, 2001; Hatooka, 2002; Mecklenburg et al., 2002; Hastings and Walker, 2003). Illustrated specimens were not cleared and stained, and, although their meristic counts fall within the overall ranges listed for each species (Table 2), individual counts from illustrations may differ from those found in the species-specific meristic tables generated from clearing and staining in this study. In descriptions of development of meristic features, unossified precursors of fin and vertebral elements are classified as *present*. The term *developed* is used to indicate that the adult complement of fin elements, vertebral centra, or neural and haemal spines are completely formed but have not begun to ossify. Fins and vertebral elements are referred to as ossified upon initial uptake of alizarin red-s stain. The order of presentation of osteological descriptions is median fins, paired fins, and vertebrae, by sequence of ossification within each. For some taxa, not all stages of development could be cleared and stained since the number of specimens was limited. Radiographs of adults were used to count meristic features of taxa that lack complete published data.

A brief summary of the life history of each species is provided primarily on the basis of previously published literature. Some unpublished AFSC data were used to describe adult distributions (RACEBASE, an Oracle database developed by and available through the AFSC Resource Assessment and Conservation Engineering Division, comprises data from adult groundfish assessment, hydroacoustic, and foreign surveys conducted by federal fishery scientists from 1948 to the present). Adult lengths are reported as SL (standard length) or TL (total length), depending on the source of information.

Larval distribution is described on the basis of data obtained from this study and from ICHBASE (if available), unless otherwise noted. Larval lengths and months when collected pertain to planktonic larvae (i.e., larvae collected with dip nets and bongo, Cantrawl, neuston, Methot, MOCNESS, and Tucker gear). Previously published information on occurrence of larvae is reported if available.

Maps of larval distribution were produced from data collected for this study and display locations of planktonic larvae. Data collected by AFSC include information on abundance. For those taxa accompanied by abundance data, a geographic information system (GIS) based on ArcInfo software, vers. 8.1.2 (Esri, Inc., Redlands, CA) was used to produce a black-and-white choropleth map to show the general spatial extent of the data and the general trend of average larval abundance over space. Choropleth maps shade statistical units with intensity proportional to the data values. A fourth-root transformation was applied to the Slender Cockscomb (*Anoplarchus insignis*) data to normalize the abundance. The data for all other species were normally distributed. For species lacking abundance data, such as specimens obtained from the Hokkaido University Museum of Zoology, Vancouver Public Aquarium, Oregon State University, and Canada Department of Fisheries and Oceans, black-and-white maps were produced with point data. On these maps, symbols indicate presence only.

Nomenclature generally follows Makushok (1958) and common names follow Nelson et al. (2004). Nomenclature of the genus *Lumpenus* follows MacDonald (2001), who cited Makushok (1958) as stating that "*Lumpenus*, *Leptoclinus*, and *Anisarchus* form a natural

Table 2

Meristics of northeastern Pacific Ocean and Bering Sea Stichaeidae. Additional meristic information for *Eumesogrammus, Chirolophis, Acantholumpenus, Alectridium, Anoplarchus*, and *Cebidichthys* obtained from radiographs. Br=branchiostegal rays.

	Vertebrae			Fins					
Taxon	Precaudal	Caudal	Total	Dorsal	Anal	Pectoral	Pelvic	Caudal	Br
STICHAEINAE									
Eumesogrammus praecisus[1]	15–17	35–37	50–53	XLVII–L	I–II,29–32,II–III	16–19	I,3	3–5,6–7+6–7,4–5	6
Stichaeus punctatus	14–16	36–40	51–55	XLVI–XLIX	I–II,32–37	15–16	I,4	5–6,6–7+6–7,3–5	6
CHIROLOPHINAE									
Bryozoichthys lysimus	16–17	53–58	69–75	LXI–LXVI	I,47–53	14–15	I,3	6,6+7–8,3–5	6
Bryozoichthys marjorius	15–17	55–59	71–76	LXVII–LXXI	I,51–59	15–16	I,3	5-6,6+7–8,3–4	6
Chirolophis decoratus[2]	16–17	50–53	65–69	LX–LXIV	I–II,44–49	13–16	I,3–4	2–6,6+8–9,1–4	6
Chirolophis nugator[3]	14–16	42–46	55–61	LIII–LVI	I–II,37–42	13–14	I,3–4	3–6,6+7–8,1–4	6
Chirolophis snyderi[4]	16–17	44–48	61–65	LVII–LXI	I–II,43–47	13–16	I,4–5	5,6+7–8,2–4	6
C. tarsodes [holotype radiograph]	15 [15]	47–49 [50]	63–65 [65]	LVIII–LX [LIX]	I,43–46 [I,46]	14–15 [14?]	I,3–4 [I,4?]	[4,6+7,2]	6
Gymnoclinus cristulatus	18–19	46–47	65	LVIII–LXIII	40–43	14–16	I,2	5,6+7,2–3	6
LUMPENINAE									
Acantholumpenus mackayi[4]	27–30	47–50	76–80	LXVIII–LXXVI	II,41–48	13–16	I,3	4,6+7,5	6
Lumpenella longirostris	22–25	47–49	70–75	LXI–LXXI	II–V,36–42	12–14	I,2–3	4–5,6+6,4–6	6
Lumpenus fabricii	23–28	43–49	70–75	LX–LXVI	I,38–44	13–16	I,3	5–6,6+7,4–6	6
Lumpenus maculatus	25–30	39–43	66–72	LVII–LXIV	I–II,34–40	14–16	I,3–4	6-7,7+6–7,5-6	6
Lumpenus medius	21–25	42–50	65–70	LVIII–LXIV	I,37–42	13–15	I,3	4–5,6–7+6–7,2–4	6
Lumpenus sagitta	26–29	46–55	75–82	LXIV–LXXII	I–II,44–50	13–17	I,3	5–7,6+7–8,4–6	6
Poroclinus rothrocki	18–20	45–48	64–68	LVII–LXVII	III,40–44	13–15	I,3	5–6,7+6,4	6
OPISTHOCENTRINAE									
Lumpenopsis hypochroma	17–18	36–38	54–55	XLIV–XLIX	I,30–32	12–13	I,3	6,6+7,6	
Opisthocentrus ocellatus	21–23	39–44	61–67	L–LXII	I–II,32–39	18–21	absent		5
Plectobranchus evides	20–21	39–40	59–61	LIV–LVII	II–III,34–36	14–15	I,3	4,7+6–7,2–4	5–6
XIPHISTERINAE									
Alectrias alectrolophus	17–20	47–50	64–70	LIX–LXVI	I,41–45	9–11	absent		5
Alectridium aurantiacum[5]	20–21	47	60–68	LII–LXIV	I,41–44	11	absent	3–4,6+7,2	5
Anoplarchus insignis[6]	17–19	42–49	60–69	LVII–LXIV	I,38–46	9–10	absent	1–5,6–7+6–7,1–4	5
Anoplarchus purpurescens[7]	16–19	40–46	58–64	LIV–LX	I–II,35–42	9–10	absent	1–4,6–7+6–7,1–4	5
Cebidichthys violaceus[8]	23–25	40–47	65–71	XXII–XXV, 40–43	I–II,39–42	10–11	absent	4–5,7+7,2–3	5
Phytichthys chirus	24–25	50–52	75–76	LXIX–LXXVIII	II–III,40–50	14–15	absent	6+7	6
Xiphister atropurpureus	22–24	51–56	73–80	LXV–LXXII	0–I,49–55	11–12	absent	5–6,6+6–7,3–4	6
Xiphister mucosus	29–31	44–53	73–83	LXXI–LXXVIII	0–I,46–50	12	absent	5,6+6–7,3–4	6

[1] Radiographs examined for 11 specimens.
[2] Radiographs examined for 5 specimens.
[3] Radiographs examined for 25 specimens.
[4] Radiographs examined for 6 specimens.
[5] Radiographs examined for 2 specimens.
[6] Radiographs examined for 32 specimens.
[7] Radiographs examined for 42 specimens.
[8] Radiographs examined for 10 specimens.

group with *Leptoclinus* and *Anisarchus* representing a more derived condition." With this taxonomic consideration, *Leptoclinus* and *Anisarchus* are considered synonyms (subgenera) of *Lumpenus*, leading to the validity of the species names *Lumpenus maculatus* and *L. medius* for the Daubed Shanny and Stout Eelblenny. The composition of the suborder Zoarcoidei follows Nelson (2006), including the families Bathymasteridae, Zoarcidae, Stichaeidae, Cryptacanthodidae, Pholidae, Anarhichadidae, Ptilichthyidae, Zaproridae, and Scytalinidae.

Overall comparisons

Family

Stichaeidae is the most diverse zoarcoid family in terms of early life history stages in the NEP. Stichaeidae larvae can be distinguished from other zoarcoid larvae by a combination of characters, including myomere count, snout to anus length <50% SL, and light pigment patterns. Before fin rays develop, small larvae are elongate and resemble other elongate zoarcoid forms, especially bathymasterids and pholids. Larvae in these three families share a relatively similar overall pigment pattern that includes PVM and melanophores positioned dorsally over the gut and hindgut. Meristic features, not always visible in early stage larvae, may serve to distinguish stichaeid larvae from other similar zoarcoid larvae. The typical I,5 pelvic-fin count is present in bathymasterids, but it is reduced or absent in pholids and stichaeids and absent in all other zoarcoid families. Although zoarcoids typically hatch at relatively large sizes (e.g., up to 33 mm), newly hatched stichaeid larvae are small, usually hatching at lengths of 6–11 mm (Matarese et al., 1989). Larvae do not undergo a dramatic transformation stage, but some species have an extended pelagic prejuvenile stage (e.g., *Lumpenus* spp.).

In general, bathymasterids have fewer myomeres (46–55) than do the other two families, and pholids have a comparatively longer gut (snout to anus length >50%) and more myomeres (81–101) than do stichaeids (Matarese et al., 1989). Zoarcids lack a pelagic larval stage; after yolk absorption, their larvae resemble small juveniles (Kendall et al., 1983). Cryptacanthodids have considerably more pigment than stichaeids. Anarhichadids have highly distinctive larvae; *Anarhichas* larvae have a large eye and heavy pigmentation pattern, and *Anarrhichthys* larvae are highly elongate with 221–251 myomeres. Among the remaining monotypic zoarcoid families (Ptilichthyidae, Scytalinidae, and Zaproridae), larval *Ptilichthys* are distinctive with an elongate body and 227–240 myomeres, larval *Zaprora* have a distinctive heavy pigmentation pattern and large eye, and larval *Scytalina* are unknown (Matarese et al., 1989).

Subfamilies (Table 1)

According to Nelson (1984, 2006), Stoddard (1985), Yatsu (1986), Mecklenburg and Sheiko (2004), and others, the family Stichaeidae includes six subfamilies, of which five are present in the NEP. Larval Stichaeinae, with two species in the NEP, usually have a short gut, PVM, hypaxial pigment, and a low myomere count. Larval Chirolophinae, with seven species in the NEP, possess more pigment than do other subfamilies except Stichaeinae, with pigment dorsally on the gut, PVM, caudal melanophores, and internal pigment along the notochord. Larval Lumpeninae, with seven species in the NEP, generally possess a more elongate body and gut, and they usually have pigment dorsally over the gut and PVM but lack internal pigment along the notochord. Larval Opisthocentrinae, with three species in the NEP, are individually distinctive and do not form a cohesive group on the basis of known larval characters. Larval Xiphisterinae, with eight species in the NEP, all lack pelvic fins and have pigment dorsally on the gut, a row of melanophores on the ventral surface of the gut, PVM, and internal pigment along the notochord.

Subfamily Stichaeinae

Eumesogrammus praecisus, Fourline Snakeblenny

See "Other material" section of this guide.

Stichaeus punctatus, Arctic Shanny (Figs. 2, 3; Tables 3, 4)

Literature. Faber (1976), Farwell et al. (1976), Eschmeyer et al. (1983), Haryu et al. (1985), Keats et al. (1993), Mecklenburg et al. (2002).

Material examined. 80 specimens (6.4–35.0 mm) from the Chukchi and Bering seas and Gulf of Alaska (see Appendix for details).

Distribution and life history. *Stichaeus punctatus* is circumarctic on subtidal (0–100 m) rocky to sandy bottom (Mecklenburg et al., 2002), occurring in the seas of Okhotsk and Japan, in the Beaufort Sea southward to British Columbia in the North Pacific Ocean, and in the Arctic Ocean south to the Gulf of Maine in the western North Atlantic Ocean. Maximum length is 22 cm TL (Eschmeyer et al., 1983) and longevity is 16 years (Keats et al., 1993). Information on spawning is restricted to the North Atlantic Ocean, where the spawning season is February and March, egg diameter is 1.7 mm, and absolute fecundity is about 1600–2500 eggs (Farwell et al., 1976). Larvae are pelagic. Transformation to the juvenile stage occurs at about 25 mm (Farwell et al., 1976).

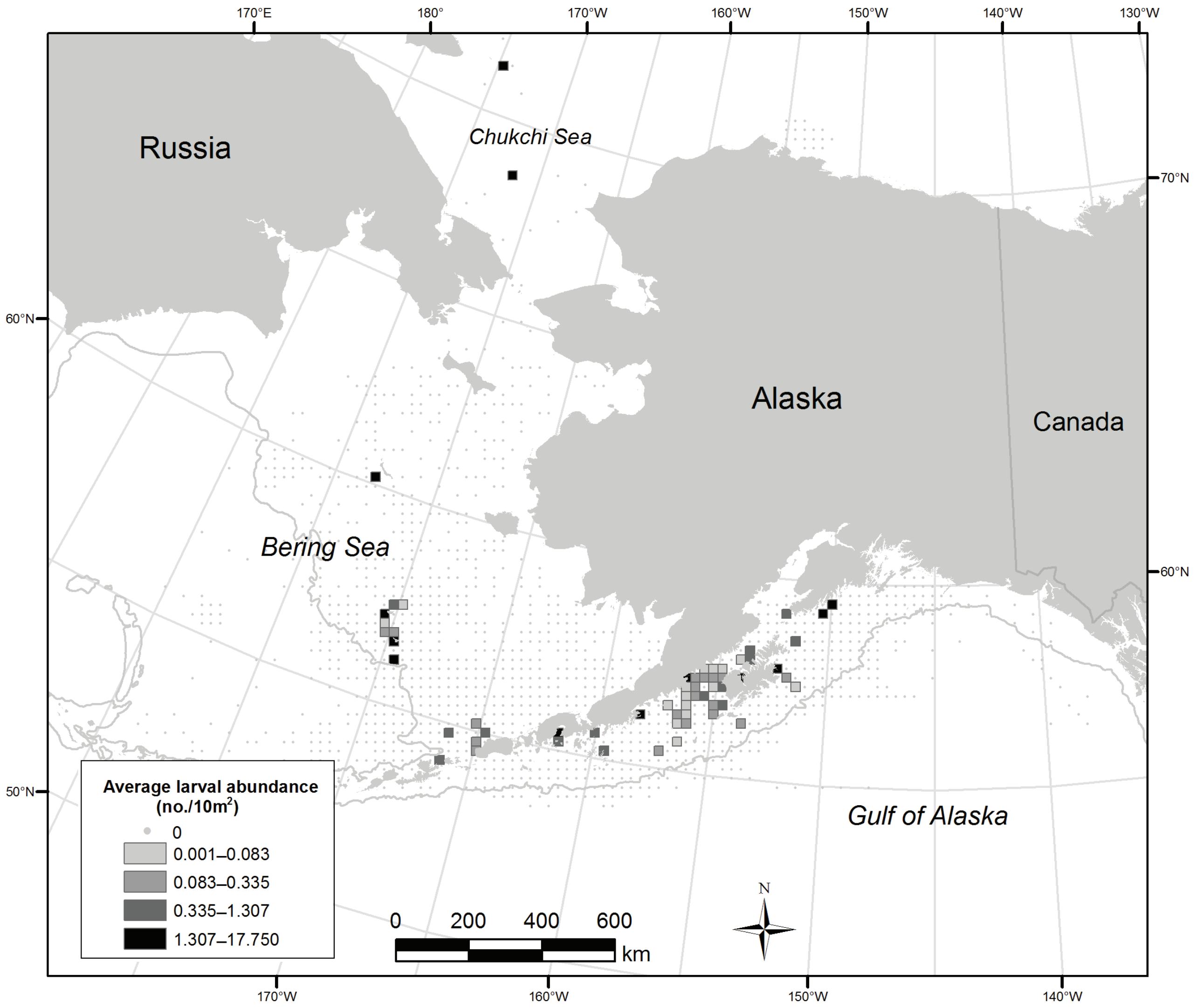

Figure 2

Distribution and abundance of larvae of Arctic Shanny (*Stichaeus punctatus*) collected by bongo net in the Chukchi and Bering seas and Gulf of Alaska. Isobath=1000 m.

Larval distribution (Fig. 2). Larvae of *S. punctatus* are found from the western Chukchi Sea, the Bering Sea near St. Matthew and the Pribilof Islands, Unimak Pass, nearshore areas along the Alaska Peninsula and Shumagin Islands, in Shelikof Strait and around Kodiak Island, to nearshore areas along the Kenai Peninsula. Larvae at lengths of 6.4–27.0 mm are collected in April–August, with highest abundances in May.

Morphology (Table 3). Notochord flexion in *S. punctatus* begins at 9.0 mm and is complete by 16.4 mm. Postflexion larvae are 16.4–28.2 mm. Farwell et al. (1976) presented an illustration of a 25.0 mm specimen that appears to be in early transformation stage. In our material, transformation was not evident until after 28.2 mm; the juvenile stage began before 35.0 mm. Larvae are initially slender with a mean body depth of 9.0% SL in the preflexion stage, becoming moderately deep (10.7% SL) in the flexion stage and deep-bodied (12.3% SL) in the postflexion stage. Relative head and snout lengths increase through development, while eye diameter decreases. Snout to anus length increases slightly with

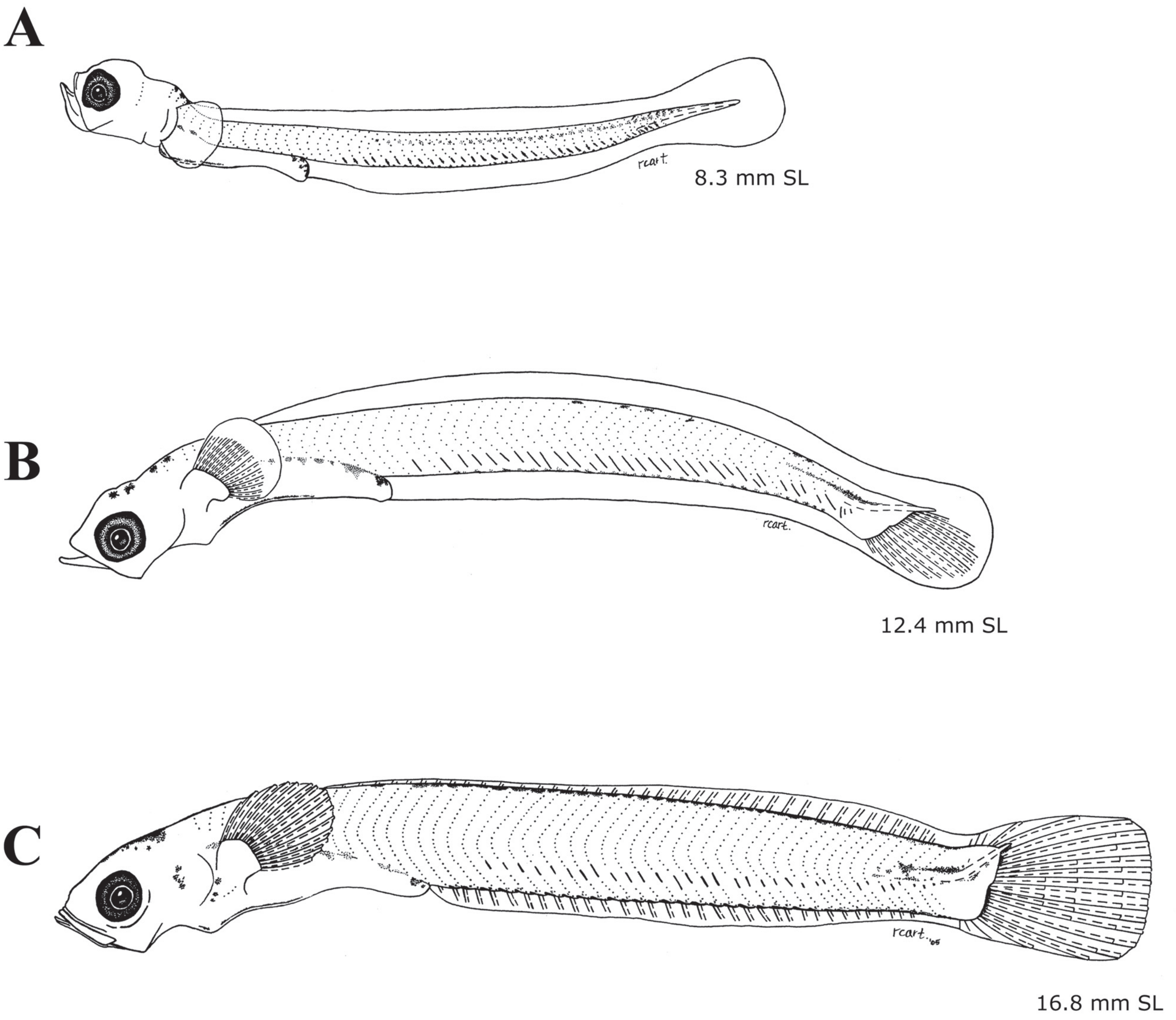

Figure 3

Larvae of Arctic Shanny (*Stichaeus punctatus*): (**A**) preflexion stage, 8.3 mm standard length (SL), University of Washington (UW) 144830; (**B**) flexion stage, 12.4 mm SL, UW 144858; and (**C**) postflexion stage, 16.8 mm SL, UW 144862. Illustrations by R. Cartwright.

development from 37.4% SL in the preflexion stage to 40.2% SL in the postflexion stage.

Pigmentation (Fig. 3). Larvae of *S. punctatus* are moderately pigmented (dorsal and lateral pigment in addition to PVM). Although the earliest preflexion-stage larvae lack head pigment, it is present on the head throughout most of larval development. Nape pigment is present in preflexion and later stages. Preflexion larvae have several melanophores anteriorly along the dorsal surface of the gut, and a continuous line of pigment along the anterior ventral midline of the gut persists throughout development. Melanophores are present along the hindgut nearly to the anus. A row of PVM, spaced at about one melanophore per myomere, begins about five myomeres posterior to the anus. Several melanophores are on the dorsal midline of the caudal peduncle, and internal pigment is present along the dorsal surface of the notochord. Postanal pigment along the hypaxial myomeres, characteristic for larvae of *S. punctatus*, is present in the earliest preflexion larvae.

Table 3

Body proportions of Arctic Shanny (*Stichaeus punctatus*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	16		28		30	
Standard length (mm)	7.8±0.8	(6.4–9.0)	11.1±1.7	(9.0–15.5)	21.5±3.3	(16.4–28.2)
Head length/SL	12.8±1.3	(10.8–15.2)	13.7±1.5	(9.6–16.5)	18.6±2.1	(14.2–23.2)[1]
Snout length/HL	16.6±6.2	(7.9–27.0)[2]	23.6±5.2	(14.7–32.1)	26.3±6.1	(15.8–33.6)[3]
Eye diameter/HL	48.1±4.7	(41.3–57.4)	43.1±6.2	(30.7–59.2)	29.0±3.9	(20.9–34.9)[3]
Snout to anus length/SL	37.4±2.3	(34.4–43.6)[2]	38.8±2.0	(32.9–43.1)	40.2±3.1	(31.4–44.9)
Body depth/SL	9.0±1.0	(7.9–11.2)	10.7±0.9	(9.1–12.0)	12.3±1.6	(8.9–15.5)[2]

[1] *n*=29
[2] *n*=15
[3] *n*=28

Table 4

Meristic counts of cleared and stained Arctic Shanny (*Stichaeus punctatus*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchi-ostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
6.2													
7.5													
9.1													
11.2													
13.1										15	32	47	
14.8					4	15	30	45	31	15	38	53	7+7,1
16.2					6	14	37	51	37	14	38	52	3,7+7,1
18.5	XLVI	34	15	I,2	6	14	38	52	38	14	39	53	5,7+7,4
20.5	XLVII	II,34	15	I,4	6	14	39	53	38	14	40	54	6,6+6,5
24.5	XLVIII	II,35	15	I,4	6	14	39[1]	53	39[1]	14	39	53	5,7+6,5
28.0	XLIX	II,35	15	I,4	6	15	38	53	38	15	39	54	6,7+6,5
35.0	XLVII	II,33	15	I,4	6	15	37	52	37	15	38	53	5,7+7,3

[1] Two neural and haemal spines on second preural centra.

Flexion-stage larvae have pigment dorsally on the head and nape. Melanophores extend along the entire dorsal surface of the gut, and pigment on the postanal body increases significantly. Several melanophores appear along each side of the dorsal midline, continue to increase anteriorly and posteriorly, and appear as a double row when viewed dorsally. The series of PVM begins about 4–6 myomeres posterior to the anus and hypaxial pigment increases to appear as oblique pigment lines. The internal pigment along the dorsal surface of the notochord is visible only in the area of the caudal peduncle. A small patch of pigment develops at the base of the caudal-fin rays along the margin of the lower hypural plate in late flexion.

Head pigment increases in postflexion larvae; melanophores are added dorsally on the head and posterior to the eye in the opercular region. Nape pigment was visible during early postflexion in some specimens but was less visible in later larvae as the melanophores became embedded. The dorsal pigment on the gut becomes internal. Several melanophores are visible on the hindgut. The double row of dorsal pigment extends anteriorly onto the preanal myomeres. PVM (>30) begin just posterior to the anus. In the caudal peduncle area, internal pigment is present above and below the notochord. Pigment at the base of the caudal-fin rays is present along the margins of the upper and lower hypural plates.

Meristic features (Table 4). Principal caudal-fin rays are present by 9.1 mm, developed by 13.1 mm, and ossified by 14.8 mm. Procurrent caudal-fin rays are present by 14.8 mm, and ossification begins before all elements are developed. All procurrent caudal-fin rays are ossified by 18.5 mm. Anal-fin elements are present by 14.8 mm and dorsal-fin spines by 16.2 mm. Ossification begins before all elements in both fins are developed, with the dorsal spines ossified by 18.5 mm and the anal-fin elements ossified by 20.5 mm. Pectoral-fin rays are present by 11.2 mm, developed by 16.2 mm, and ossified by 18.5 mm. A pelvic-fin bud is present at 16.2 mm. Pelvic-fin elements are present and begin to ossify by 18.5 mm; development and ossification are complete by 20.5 mm. Vertebral centra are present by 6.2 mm; development and ossification are complete by 14.8 mm. Neural and haemal spines are present and partially ossified by 14.8 mm and are developed and ossified by 16.2 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larvae of *S. punctatus* are unique among stichaeids because they have slash-like postanal pigment along the hypaxial myomeres and the lowest total vertebral counts (51–55) in the family, except for *Eumesogrammus praecisus* (50–53). In addition, *S. punctatus* is deeper bodied (mean 9.0–12.3% SL) compared to most other larval stichaeids, particularly during the flexion and postflexion stages.

Larval *S. punctatus* are most likely to be confused with the bathymasterid Northern Ronquil (*Ronquilus jordani*). However, *S. punctatus* can be distinguished in the preflexion stage by the postanal hypaxial pigment, which is absent in *R. jordani*. *Ronquilus jordani* also has a row of melanophores along the dorsal midline and some pigment spots on the ventral caudal finfold that are absent in preflexion-stage *S. punctatus*. In later-stage larvae, slash-like postanal pigment along the hypaxial myomeres forms in *R. jordani* but is restricted to the posterior one-fourth of the body. *Ronquilus jordani* is deeper bodied throughout development, has a shorter snout to anus length, has fewer vertebrae (49–50 versus 51–55), and completes its flexion and postflexion stages at smaller sizes than does *S. punctatus*.

Subfamily Chirolophinae

Bryozoichthys lysimus, Nutcracker Prickleback (Figs. 4–6; Tables 5, 6)

Literature. Haryu et al. (1985), Shiogaki and Haryu (1988), Mecklenburg et al. (2002), Tokranov and Orlov (2004).

Material examined. 82 specimens (6.9–49.0 mm) from the Bering Sea and Gulf of Alaska (see Appendix for details).

Distribution and life history. *Bryozoichthys lysimus* has been collected in the eastern Bering Sea northwest of St. Matthew Island, along the entire Aleutian Island Archipelago (RACEBASE), and northern Gulf of Alaska. It is also found in the western Bering Sea, Sea of Okhotsk, Kuril Islands, and northern Sea of Japan (Mecklenburg et al., 2002). Collected at depths of 45–600 m (most commonly at 100–200 m), Nutcracker Prickleback reach a maximum length of 270 mm TL (Tokranov and Orlov, 2004). Little is known of their life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Figs. 4, 5). Larvae of *B. lysimus* (7.4–33.5 mm, mean 19.8 mm) are collected in February–July in bongo tows, with highest abundance in April, over the Bering Sea shelf and slope, west of and around Unimak Pass, in the northern Gulf of Alaska on the shelf south of the Alaska Peninsula, in Shelikof Strait, and north and south of Kodiak Island (Fig. 4). The spatial distribution of larvae collected in neuston tows is similar, but neustonic larvae are more abundant and those larvae in the Bering Sea are found farther west in the Aleutian Islands and into Bristol Bay (Fig. 5). Neustonic larvae are larger, on average, than are larvae collected in bongo tows (14.1–35.6 mm, mean 24.3 mm) and occur in March–July, with greatest numbers collected in May.

Morphology (Table 5). Notochord flexion in *B. lysimus* begins before 12.0 mm and is complete by about 22.0 mm. Postflexion larvae are 21.6–35.6 mm. Transformation begins after 36.0 mm and the juvenile stage begins before 49.0 mm. Larvae are slender-bodied with a mean body depth of 6.4% SL in the preflexion stage (*n*=2), increasing to 8.4% SL in the postflexion stage. Relative head and snout lengths increase throughout larval development, while relative eye diameter decreases. Relative snout to anus length increases from the preflexion stage to the flexion stage, then decreases during the postflexion stage.

Pigmentation (Fig. 6). Larvae of *B. lysimus* are moderately pigmented. Head pigment in the preflexion stage is restricted to several melanophores on the dorsal surface over the midbrain. The gut is pigmented dorsally and ventrally. A double row of internal melanophores, spaced one melanophore per myomere, extends along the dorsal surface of the gut. About four closely spaced melanophores occur along the dorsal surface of the hindgut. About four melanophores are positioned ventrally at midgut and may appear as a solid line in some individuals. A double row of melanophores on either side of the dorsal midline begins just anterior to midbody and extends to the caudal peduncle. Pigment is irregularly spaced anteriorly and becomes more regular posteriorly,

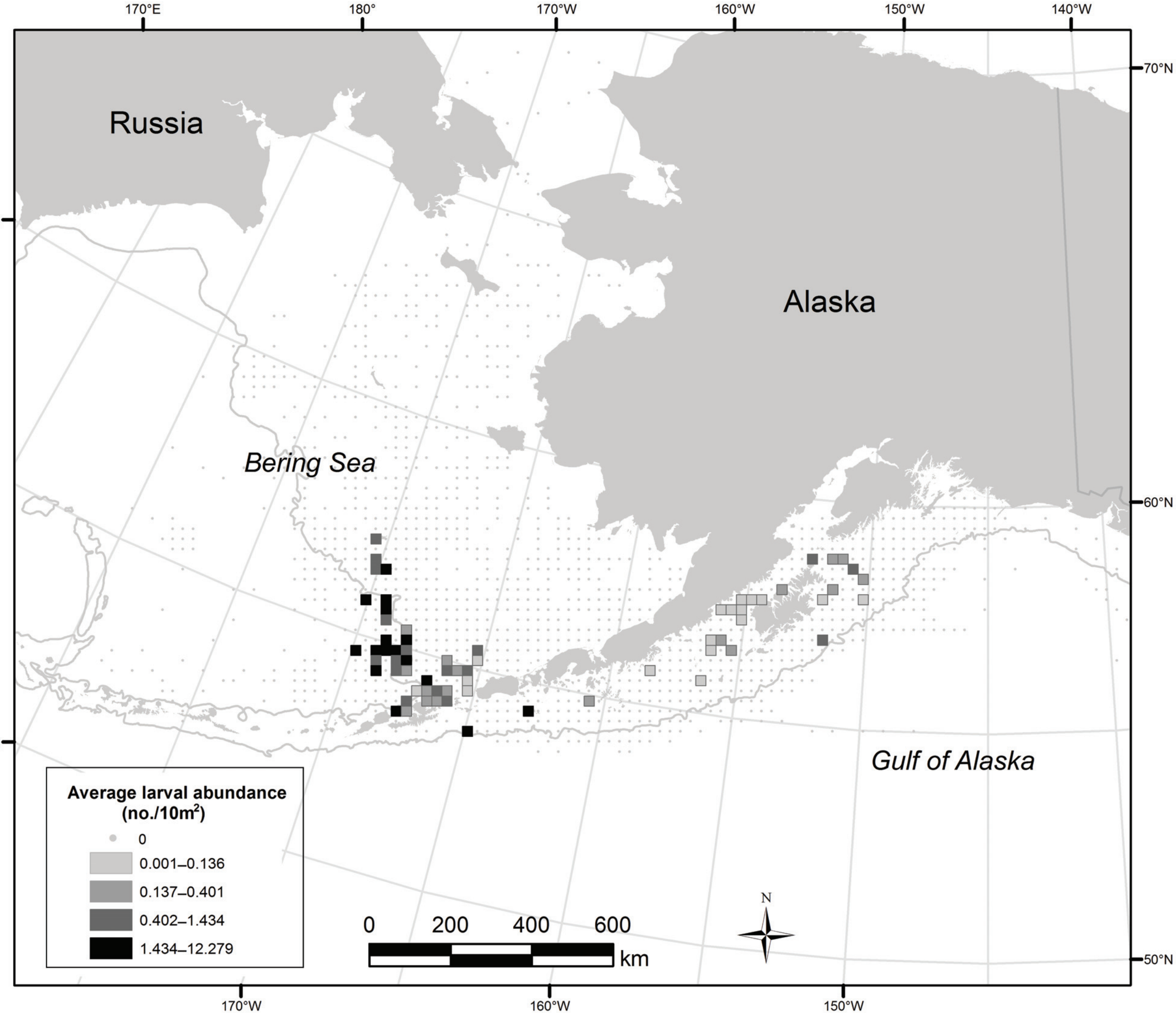

Figure 4

Distribution and abundance of larvae of Nutcracker Prickleback (*Bryozoichthys lysimus*) collected by bongo net in the Bering Sea and Gulf of Alaska. Isobath=1000 m.

about one melanophore per myomere. Internal pigment (one melanophore per myomere) dorsally along the notochord begins as a single row over the hindbrain and extends to the caudal area. A series of about 46–48 PVM begins about 1–3 myomeres posterior to the anus and consists of a melanophore on each myoseptum along the entire length of the postanal body to the caudal peduncle. The number, spacing, and anterior and posterior extent of the PVM are similar at all stages of development. Caudal pigment is restricted to small melanophores around the tip of the notochord and two short streaks of pigment extending at oblique angles dorsad and ventrad from the notochord tip.

In the early flexion stage, larvae develop 2–4 additional melanophores over the midbrain and occasionally develop light pigment over the hindbrain. Internal pigment is visible in the otic area by 17 mm and on the midbrain by 21 mm. Light pigment on the jaw angle is visible by 21 mm. Pigment on the isthmus begins as one pair of melanophores at 17 mm and increases to 2–3 pairs by 20 mm. Pigment on the ventral surface of the gut expands during early flexion to extend along the anterior one-third to one-half of the gut in a continuous line, and 1–3 melanophores are present on the lateral surface of the gut behind the pectoral fin. Internal pigment along the notochord became increasingly

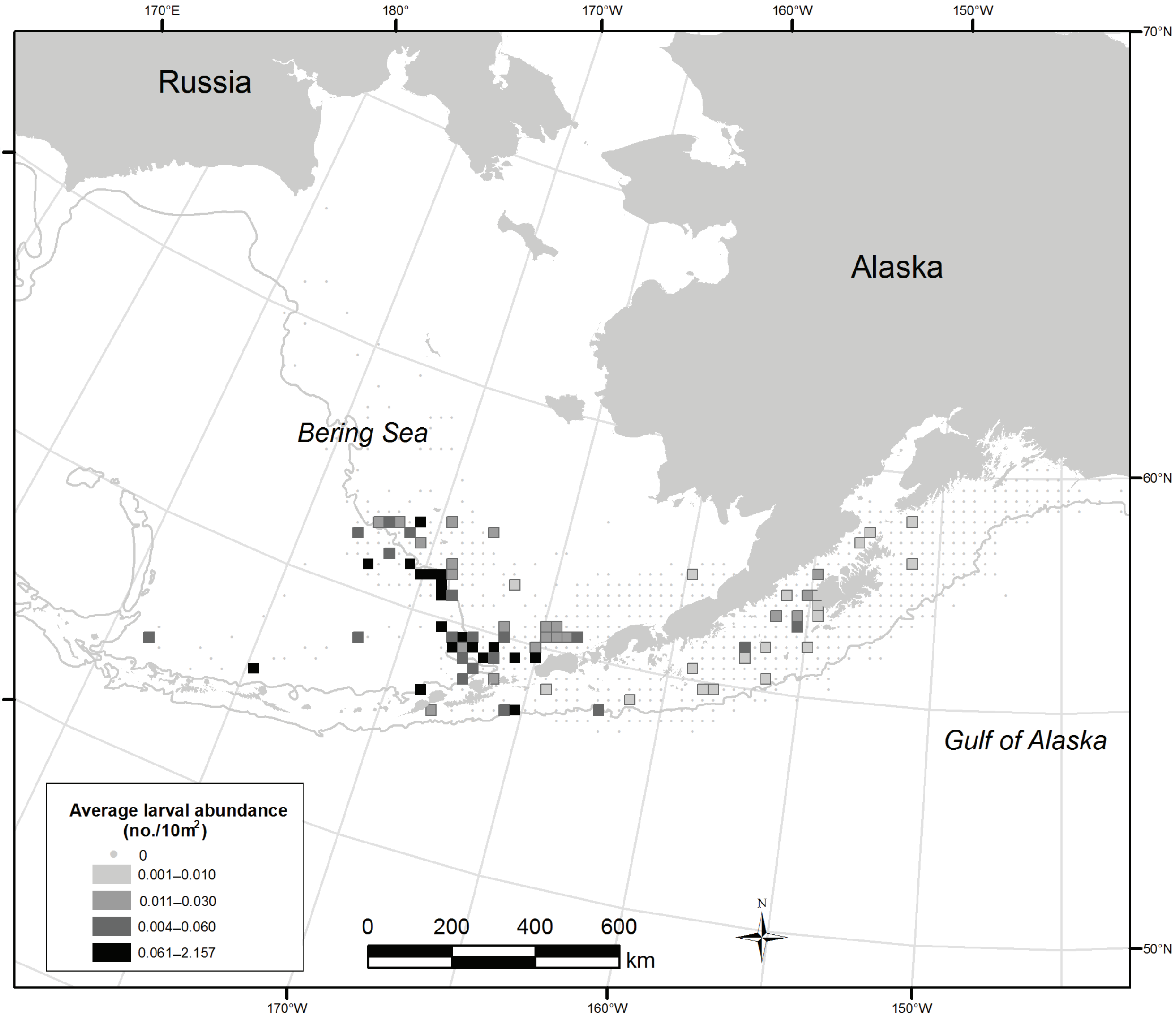

Figure 5

Distribution and abundance of larvae of Nutcracker Prickleback (*Bryozoichthys lysimus*) collected by neuston gear in the Bering Sea and Gulf of Alaska. Isobath=1000 m.

difficult to see during flexion and was visible only at the nape and caudal peduncle in some specimens. Additional PVM that are more closely spaced than the rest of the series are visible in the area of the caudal peduncle. A row of closely spaced small melanophores is present on the lateral surface of the caudal peduncle and upper hypural plate near the notochord in late-flexion larvae. Light caudal-fin pigment was visible in some specimens by 17 mm, but it commonly is not apparent until about 22 mm and is restricted in flexion larvae to a streak that extends from the tip of the notochord toward the dorsoposterior margin of the caudal fin.

Pigment changes in postflexion larvae occur mainly on the head and tail. Additional pigment is present over the midbrain, on the opercle, and, in some specimens, was seen on the snout. Internal pigment on the midbrain increases by 25 mm. In addition to the streak that extends from the tip of the notochord, pigment on the caudal fin is concentrated into a narrow vertical band at the midpoint of the fin rays at about 26 mm; some specimens had an additional band two-thirds of the distance to the posterior margin of the caudal fin. More pigment appears on the caudal fin by about 28 mm, but it is more concentrated on the distal half.

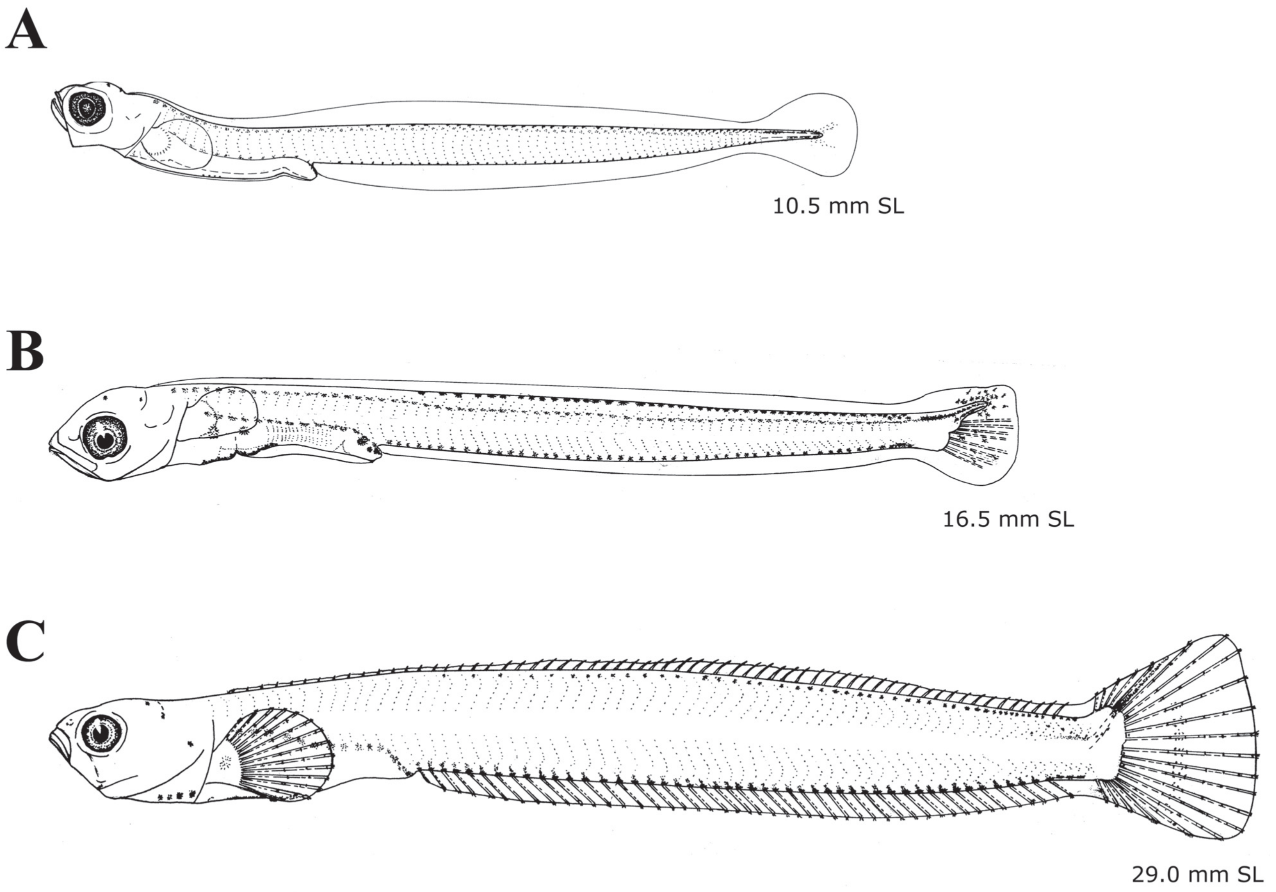

Figure 6

Larvae of Nutcracker Prickleback (*Bryozoichthys lysimus*): (**A**) preflexion stage, 10.5 mm standard length (SL), University of Washington (UW) 33190; (**B**) flexion stage, 16.5 mm SL, UW 144927, previously published as *Bryozoichthys-Chirolophis* (Matarese et al., 1989); and (**C**) postflexion stage, 29.0 mm SL, UW 144936, previously published as *Bryozoichthys-Chirolophis* (Matarese et al., 1989). Illustrations by B. Vinter.

Table 5

Body proportions of Nutcracker Prickleback (*Bryozoichthys lysimus*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	2		33		36	
Standard length (mm)	8.5±2.3	(6.9–10.2)	17.6±3.4	(12.0–22.2)	27.5±3.9	(21.6–35.6)
Head length/SL	11.3±3.1	(9.1–13.5)	13.1±1.9	(9.5–19.0)	14.2±1.6	(11.6–18.1)
Snout length/HL	9.7[1]		18.6±3.7	(8.3–26.0)	22.6±3.6	(13.9–29.9)
Eye diameter/HL	44.1±11.7	(35.8–52.4)	33.1±5.5	(24.2–46.1)[2]	25.0±3.2	(18.2–32.7)
Snout to anus length/SL	23.2±17.5	(10.8–35.6)	35.2±1.9	(31.4–40.2)	33.9±1.1	(31.2–36.5)
Body depth/SL	6.4±2.2	(4.8–8.0)	5.7±0.8	(4.3–8.1)	8.4±1.5	(5.3–11.9)

[1] *n*=1 (6.9-mm specimen)

[2] *n*=32

Table 6

Meristic counts of cleared and stained Nutcracker Prickleback (*Bryozoichthys lysimus*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchi-ostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
8.0													
10.4													
12.0													
14.5													
17.0													
19.0										13	50	63	5+7
21.5										16	53	69	6+7
25.0			14		6	16	53	69	53	16	54	70	6+6
32.0	LXIV	I,53	15		6	16	57	73	57	16	58	74	6,6+7,5
49.0	LXIV	I,50	14	I,3	6	16	52	68	52	16	53	69	6,6+8,3

Meristic features (Table 6). Principal caudal-fin rays are present at 14.5 mm, are developed and begin to ossify by 19.0 mm, and complete ossification by 21.5 mm. Procurrent caudal-fin rays are present at 19.0 mm, developed by 25.0 mm, and ossified by 32.0 mm. Dorsal-fin and anal-fin elements are present at 21.5 mm, developed by 25.0 mm, and ossified by 32.0 mm; the count of I,53 anal-fin elements, observed in the 32.0-mm specimen, is greater than the count previously reported for this species (I,47–50; Mecklenburg et al., 2002). Pectoral-fin rays are present at 17.0 mm, developed by 21.5 mm, and ossified by 25.0 mm. Pelvic-fin elements are developed by 32.0 mm and ossified by 49.0 mm. Vertebral centra are present at 12.0 mm and are developed by 21.5 mm. Ossification of the vertebral centra begins at 19.0 mm, before development is complete, and progresses anteriorly and posteriorly from midbody. Ossification of all vertebral centra is complete by 21.5 mm; the count of 58 caudal centra, as recorded for the 32.0-mm specimen, is greater than the count previously reported for this species (53–54; Matarese et al., 1989). All neural and haemal spines are ossified by 25.0 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larvae of *B. lysimus* resemble species of *Chirolophis*, particularly during the preflexion and flexion stages, but they can be distinguished by the continuous row of evenly spaced internal melanophores dorsally on the notochord from the nape to the hypural region, in contrast to species of *Chirolophis* in which this pigmentation is absent on the preanal body. Melanophores also are present around the notochord tip and on the caudal fin and finfold in *B. lysimus* at all stages of development, but they are absent in species of *Chirolophis*. In addition, *B. lysimus* has more vertebrae (myomeres; 69–75) than all *Chirolophis* species except the Decorated Warbonnet (*C. decoratus*) (65–69).

Larval *B. lysimus* are most likely to be confused with its congener, the Pearly Prickleback (*B. marjorius*), but it can be distinguished by the internal notochord series that begins near the nape as a single rather than double row of melanophores. In addition, ventral melanophores on the gut are restricted to the anterior half rather than the entire length as in *B. marjorius*. *Bryozoichthys lysimus* larvae usually have fewer caudal vertebrae (myomeres; 53–58) than do *B. marjorius* larvae (55–59).

Bryozoichthys marjorius, Pearly Prickleback (Figs. 7–9; Tables 7, 8)

Literature. Haryu et al. (1985), Mecklenburg et al. (2002).

Material examined. 90 specimens (7.7–53.0 mm) from the Bering Sea and Gulf of Alaska (see Appendix for details).

Distribution and life history. *Bryozoichthys marjorius* has been collected in the Bering Sea (RACEBASE), along the entire Aleutian Island Archipelago, in the northern Gulf of Alaska south of the Kenai Peninsula, and from Southeast Alaska to southern British Columbia, Canada. Collected at depths of 80–450 m (most commonly at 100–250 m) (RACEBASE), Pearly Prickleback reach a maximum length of 305 mm TL (Mecklenburg et al., 2002). Little is known of their life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Figs. 7, 8). Larvae of *B. marjorius* (8.8–35.0 mm, mean 21.1 mm) are collected in bongo

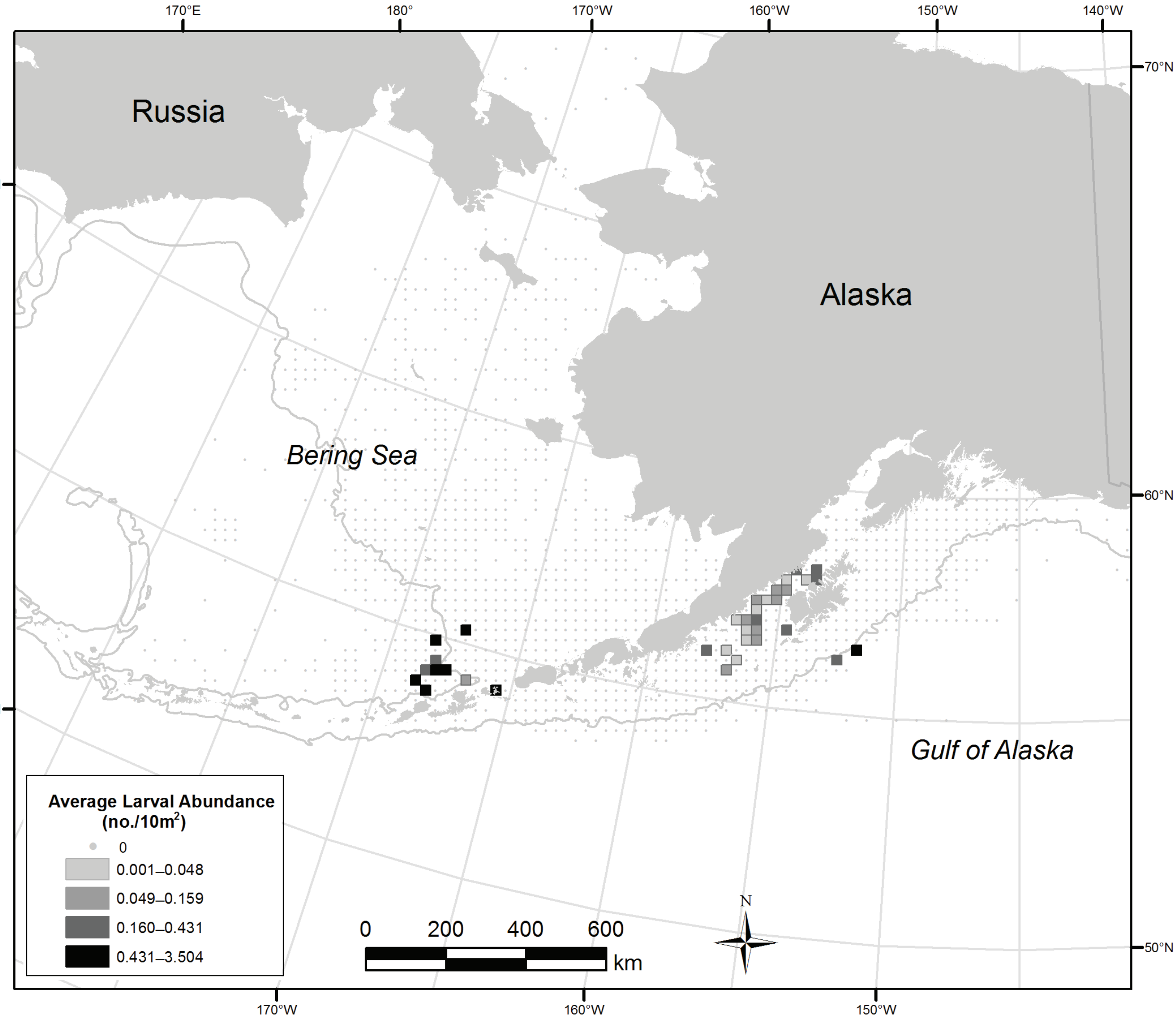

Figure 7

Distribution and abundance of larvae of Pearly Prickleback (*Bryozoichthys marjorius*) collected by bongo net in the Bering Sea and Gulf of Alaska. Isobath=1000 m.

tows over the slope in the southern Bering Sea, Unimak Pass, Shelikof Strait in the northern Gulf of Alaska, and over the slope south of Kodiak Island (Fig. 7) in February–June, with most larvae collected in April–May. Larvae collected in neuston tows are larger, more widely distributed, and more abundant than larvae collected in bongo tows. Neustonic larvae (15.0–38.5 mm, mean 26.0 mm) are found as far north in the Bering Sea as 59° N, typically over the slope and outer shelf, farther west in the Bering Sea north of the central Aleutian Islands, and farther east near Kayak Island in Southeast Alaska in March–July (Fig. 8), with the greatest numbers collected in April–May.

Morphology (Table 7). Notochord flexion in *B. marjorius* begins after 11.0 mm and is complete by 24.0 mm. Postflexion larvae are 21.4–40.0 mm. Transformation begins after 40.0 mm, and the juvenile stage begins before 53.0 mm. Larvae are slender-bodied with a mean body depth of 3.5% SL during the preflexion stage (*n*=2), increasing to 6.3% SL in the postflexion stage. Relative head length decreases from the preflexion stage to the flexion stage, then increases during the postflexion stage. Relative snout length increases during larval development, but relative eye diameter and snout to anus length decrease.

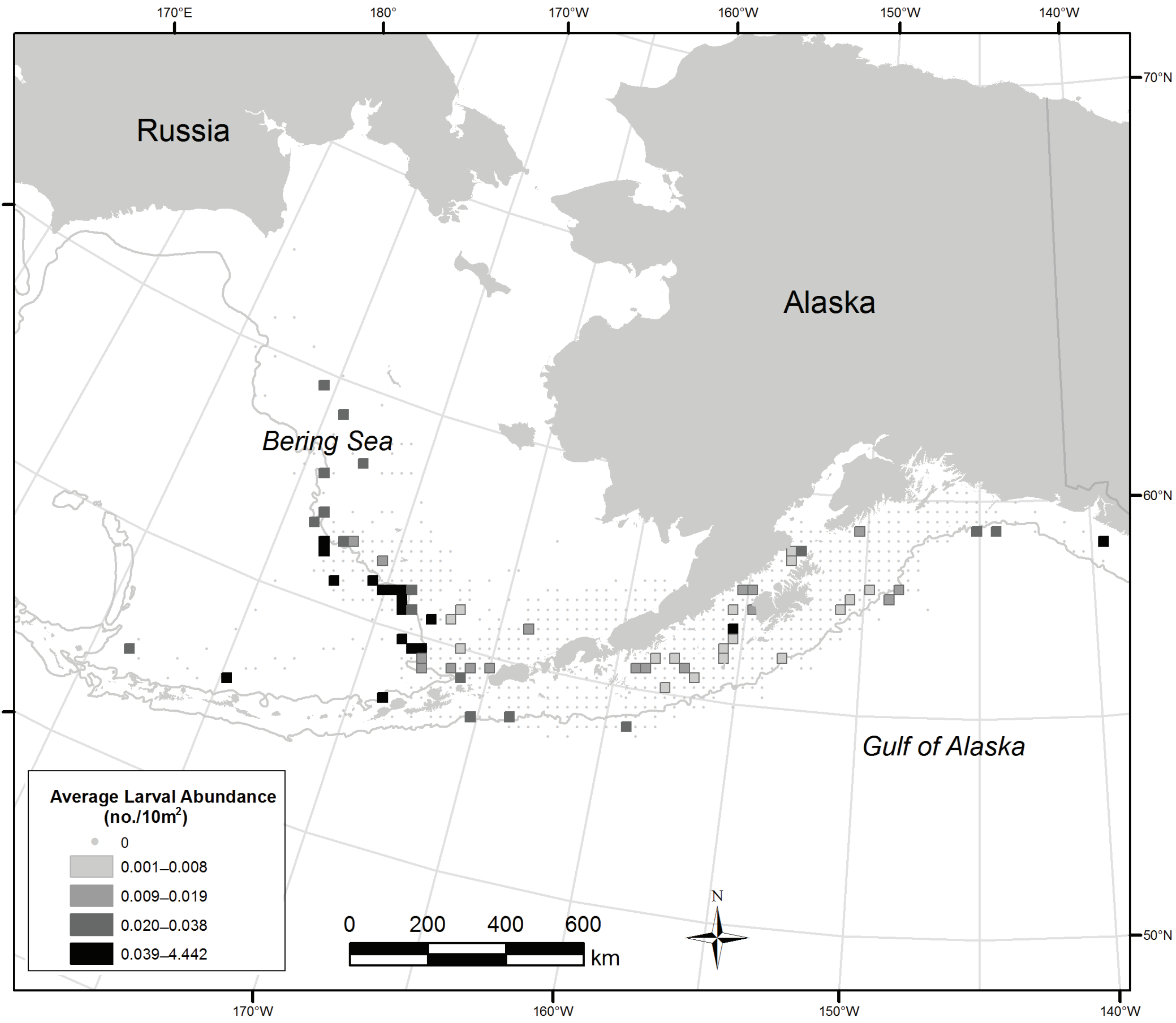

Figure 8

Distribution and abundance of larvae of Pearly Prickleback (*Bryozoichthys marjorius*) collected by neuston gear in the Bering Sea and Gulf of Alaska. Isobath=1000 m.

Pigmentation (Fig. 9). Larvae of *B. marjorius* are moderately pigmented. Head pigment is absent in preflexion larvae. There is one melanophore ventral to the base of the pectoral fin on each side of the body. A single row of closely spaced melanophores extends along the ventral midline of the gut, becoming more widely spaced from about midgut to the anus. A double row of internal melanophores, spaced one per myomere, extends along the dorsal surface of the gut. There are 2–3 melanophores on the lateral surface of the gut near the pectoral fin and an equal number on the dorsal surface of the hindgut. Melanophores form a double row on either side of the dorsal midline, starting just anterior to midbody, and are evenly spaced on every other myomere until about the last 15 myomeres, where they become closer together.

Internally, there are two melanophores on each side of the nape that converge to a single row of internal melanophores along the dorsal midline beginning at the first myomere. This series, consisting of one melanophore per myomere, extends the full length of the body internally along the dorsal midline to the area of the caudal peduncle. A row of PVM (about 46 melanophores) originates about four myomeres posterior to the anus and extends to the last myomere. A single melanophore is associated with each myomere until, at about 75% SL, spacing increases to one melanophore every 2–3

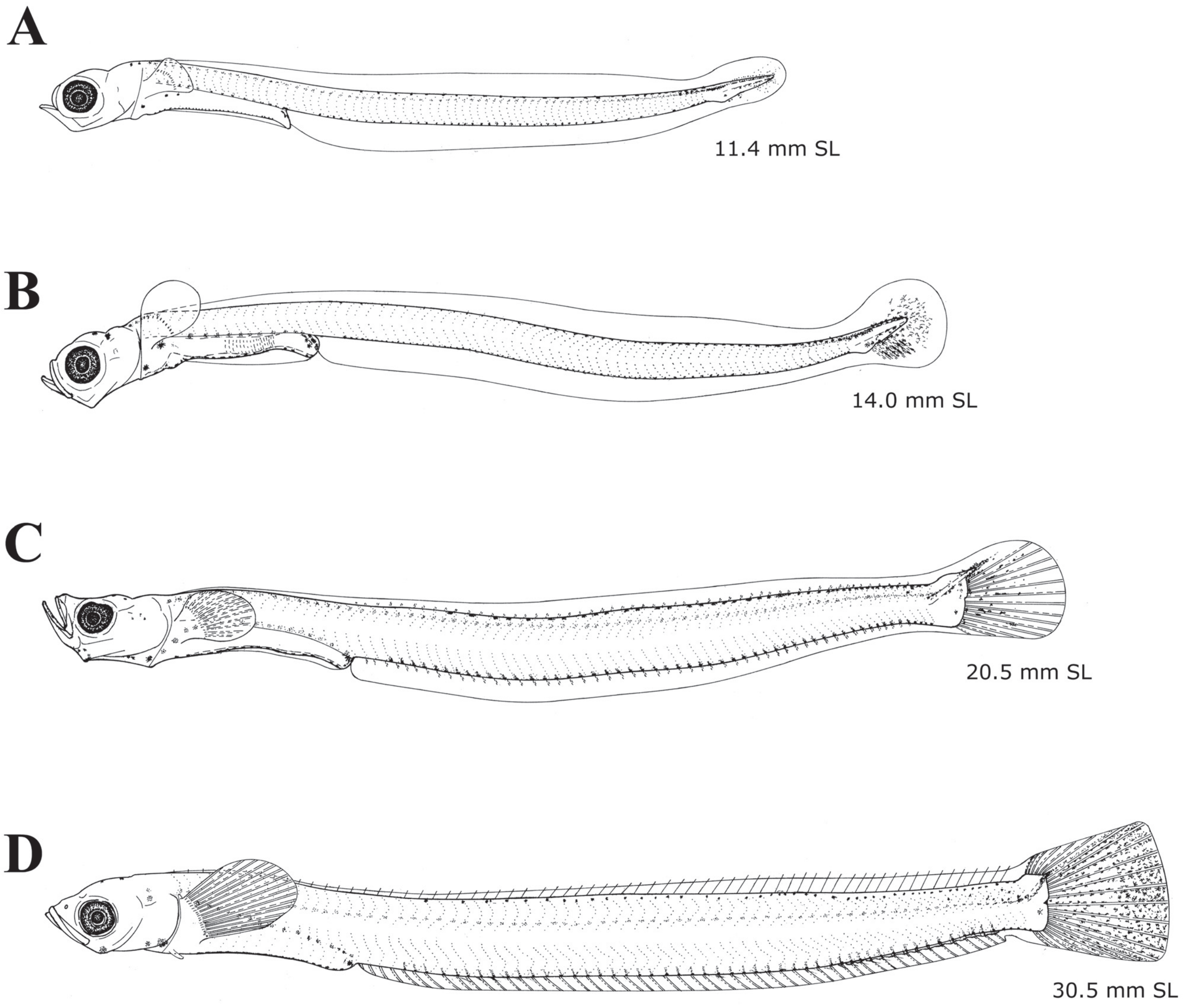

Figure 9

Larvae of Pearly Prickleback (*Bryozoichthys marjorius*): (**A**) preflexion stage, 11.4 mm standard length (SL), University of Washington (UW) 144942; (**B**) early flexion stage, 14.0 mm SL, UW 60255; (**C**) late flexion stage, 20.5 mm SL, UW 82725; and (**D**) postflexion stage, 30.5 mm SL, UW 36366. Illustrations by B. Vinter.

myomeres. Posteriorly, the series ends in the area of the caudal peduncle with four closely spaced melanophores. In the caudal area, pigment extends along the dorsal margin of the notochord, around its tip, and along the posterior half of the ventral margin of the notochord. Light pigment is scattered on the dorsal and ventral caudal finfold.

Bryozoichthys marjorius develops head pigment during the early flexion stage. Two melanophores appear over the hindbrain by about 14 mm. By the midflexion stage (18 mm), these melanophores are embedded and additional external pigment appears over the midbrain. Late flexion-stage larvae develop light pigment on the jaw angle and internal pigment in the otic area. Along the anterior margin of the gut, 2–3 pairs of melanophores appear by about 15 mm and form a curved line with pigment near the base of the pectoral fin on the lateral surface of the gut. By the late flexion stage (21 mm), 2–4 melanophores are visible on the isthmus. Melanophores in the double row along the dorsal midline are on almost every myomere by about 14 mm; those melanophores in the posterior one-fourth of the series are closer

Table 7

Body proportions of Pearly Prickleback (*Bryozoichthys marjorius*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	2		39		44	
Standard length (mm)	11.2±0.3	(10.9–11.4)	18.5±2.6	(13.8–23.6)	29.9±5.0	(21.4–40.0)
Head length/SL	11.9±1.2	(11.1–12.8)	11.2±1.4	(7.8–14.1)	13.0±1.6	(9.4–16.7)
Snout length/HL	17.6±6.6	(12.9–22.3)	19.9±7.2	(11.4–42.2)[1]	23.2±4.7	(15.6–37.5)
Eye diameter/HL	42.4±2.1	(40.9–43.9)	36.7±6.4	(26.8–51.7)[1]	26.5±4.6	(19.6–37.4)
Snout to anus length/SL	34.2±0.3	(34.0–34.4)	32.9±1.4	(30.3–35.6)	32.0±1.4	(29.3–36.7)
Body depth/SL	3.5±1.2	(2.7–4.4)	4.8±0.7	(3.6–6.6)	6.3±1.1	(4.1–9.2)

[1] n=38

Table 8

Meristic counts of cleared and stained Pearly Prickleback (*Bryozoichthys marjorius*) larvae and a juvenile. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
7.7													
11.2													
13.7													
14.8													
16.1						16	56	72	56	16	57	73	
22.5						16	56	74	56	16	57	73	
25.0	XXX				5	16	58	74	58	16	58	74	
28.0	L	35			6	16	55	71	55	16	56	72	4,6+8,3
31.5	LXVI	I,52	15		6	17	54	71	54	17	55	72	6,6+8,4
33.0	LXIX	I,54	15	I,3	6	16	57	73	57	16	58	74	5,6+8,3
38.5	LXX	I,54	*	*	6	16	58	74	58	16	59	75	6,6+7,3
39.5	LXIX	I,55	15	I,3	6	16	58	74	58	16	59	75	6,6+8,4
53.0	LXXI	I,56	15	I,3	6	17	58	75	58	17	59	76	6,6+8,4

* Character damaged or missing.

together. Internal pigment along the notochord was difficult to see in some specimens except near the nape and on the posterior one-fourth of the body. PVM increase to 2–3 per myomere for the anterior three-fourths of the length of the series in larvae in the early flexion stage. Posteriorly, the spacing becomes irregular and then resumes a spacing of 2–3 per myomere in the area of the caudal peduncle; the number of PVM is about 78. Pigment becomes embedded along most of the length of the series at about 16 mm and appears as a continuous row in the area of the caudal peduncle by about 19 mm. By the late flexion stage (22 mm) about 53 PVM are spaced at one melanophore per myomere for most of the series, with pigment aligned along developing anal-fin rays. Caudal pigment around the notochord and on the finfold remains unchanged in flexion-stage larvae; additional pigment appears in the hypural area by 16 mm and above the notochord in the area of the caudal peduncle by about 22 mm.

Changes in head pigment in postflexion larvae included the addition of a few melanophores on the ventroposterior edge of the opercle on some specimens by about 28 mm and of light pigment on the snout by about 38 mm. The tip of the lower jaw is lightly pigmented by 31 mm. Pigment on the jaw angle was not visible in some specimens. Pigment along the ventral midline of the gut appears as a continuous line for three-fourths of its length by 22 mm. Melanophores along the margin of the isthmus increase to 3–4 pairs by 23 mm and to 5 pairs by 31 mm. Caudal-fin pigment is light in larvae in the early postflexion stage (about 22 mm), except for a streak of darker pigment that extends from the tip of the notochord onto the caudal-fin membrane between the fin rays; this pigment was present in all specimens. More pigment develops on the rest of the caudal fin membrane by about 28 mm; by about 34 mm, the posterior one-third of the caudal fin is more heavily pigmented than the remainder. Ventral notochord pigment persisted in all specimens.

Meristic features (Table 8). Principal caudal-fin rays are present before 16.1 mm and are developed and ossified by 28.0 mm. Dorsal-fin spines are present at 22.5 mm and ossification appears to progress nearly synchronously with development, beginning at 25.0 mm and ending by 33.0 mm. Anal-fin elements are present at 25.0 mm. Ossification begins at 28.0 mm before all elements are developed; all elements are developed and ossified at 31.5 mm. Procurrent caudal-fin rays are present by 22.5 mm and are ossified at 28.0 mm before all are developed; all are developed and ossified by 31.5 mm. Pectoral-fin rays are present by 16.1 mm, developed by 25.0 mm, and ossified by 31.5 mm. Pelvic-fin elements are present at 31.5 mm and developed and ossified by 33.0 mm. Vertebral centra are present at 14.8 mm, and all are developed at 16.1 mm. Ossification of the vertebral centra progresses from anterior to posterior and occurs by 16.1 mm. The count of 55 caudal centra, observed in the 31.5-mm specimen, is lower than the count previously reported for this species (56–59; Matarese et al., 1989), and the total count of 76 vertebral centra observed in the 53.0-mm specimen is greater than the total count previously reported for this species (71–73; Mecklenberg et al., 2002). All neural and haemal spines are ossified at 16.1 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. See *Bryozoichthys lysimus* species-comparison section to distinguish larvae from *Chirolophis* species: similar pigment differences apply to *B. marjorius*. Also similarly, *B. marjorius* has more vertebrae (myomeres; 71–76) than all *Chirolophis* species (57–69).

Larval *B. marjorius* are most likely to be confused with *B. lysimus*. However, *B. marjorius* can be distinguished by the internal series of dorsal melanophores that begins near the nape as a double row rather than a single row. In addition, pigment on the ventral surface of the gut extends along nearly its entire length rather than just the anterior half, and *B. marjorius* has more caudal pigment at similar stages of development. Larvae of *B. marjorius* usually have more caudal myomeres (55–59) than do *B. lysimus* larvae (53–58).

Chirolophis decoratus, Decorated Warbonnet (Figs. 10–12; Tables 9, 10)

Literature. Eschmeyer et al. (1983), Shiogaki (1983), Mecklenburg et al. (2002).

Material examined. 70 specimens (8.7–42.5 mm) from the Bering Sea, Gulf of Alaska, and the coasts of British Columbia, Canada, and Washington (see Appendix for details).

Distribution and life history. *Chirolophis decoratus* occurs among rocky bottoms and reef crevices from subtidal areas to depths of 300 m (Eschmeyer et al., 1983) in the eastern Bering Sea shelf region as far north as Norton Sound, along the Aleutian Islands east of Adak Island, throughout the Gulf of Alaska shelf, and south to northern California. Adults reach a maximum length of 420 mm TL (Mecklenburg et al., 2002). Little is known of their life history, but a congener, *Chirolophis japonicus,* spawns in Mutsu Bay, Japan, in late November–December. In the aquarium, *C. japonicus* females guarded egg masses laid in a tube-like hollow of a concrete block. Eggs were 2.5 mm in diameter, had a milky white chorion and light yellow oil globule, and were adhesive to each other but not to the substrate. Time to hatch was about 2 months at 3.5–10.0°C; newly hatched larvae were 12.2–13.5 mm TL (Shiogaki, 1983).

Larval distribution (Figs. 10, 11). Larvae of *C. decoratus* (10.0–32.5 mm, mean 18.4 mm) are collected in bongo tows in January–May, with the greatest numbers collected in April and May, over the shelf in the Gulf of Alaska from south of Unimak Island to Shelikof Strait and east of Kodiak Island, southward off the central Oregon coast to the Oregon–California border (Fig. 10). Larvae collected in neuston tows are more widely distributed in the northern part of their range: on the southeastern Bering Sea shelf and over the shelf in the Gulf of Alaska to just west of Prince William Sound (Fig. 11). Neustonic larvae (12.0–34.0 mm, mean 25.1 mm) are larger than larvae collected in bongo tows and are found in February–June, with the greatest abundances observed in May.

Morphology (Tables 9, 10). Notochord flexion in *C. decoratus* begins after 12.5 mm and is completed by 19.5 mm. Postflexion larvae are 19.5–31.6 mm. Transformation occurs after 32.0 mm; length at the beginning of the juvenile stage is unknown. Larvae are slender-bodied with a mean body depth of 5.4% SL in the preflexion stage, increasing to 8.9% SL in the postflexion stage. Relative head and snout lengths increase, and eye diameter and snout to anus length decrease during larval development (Table 9).

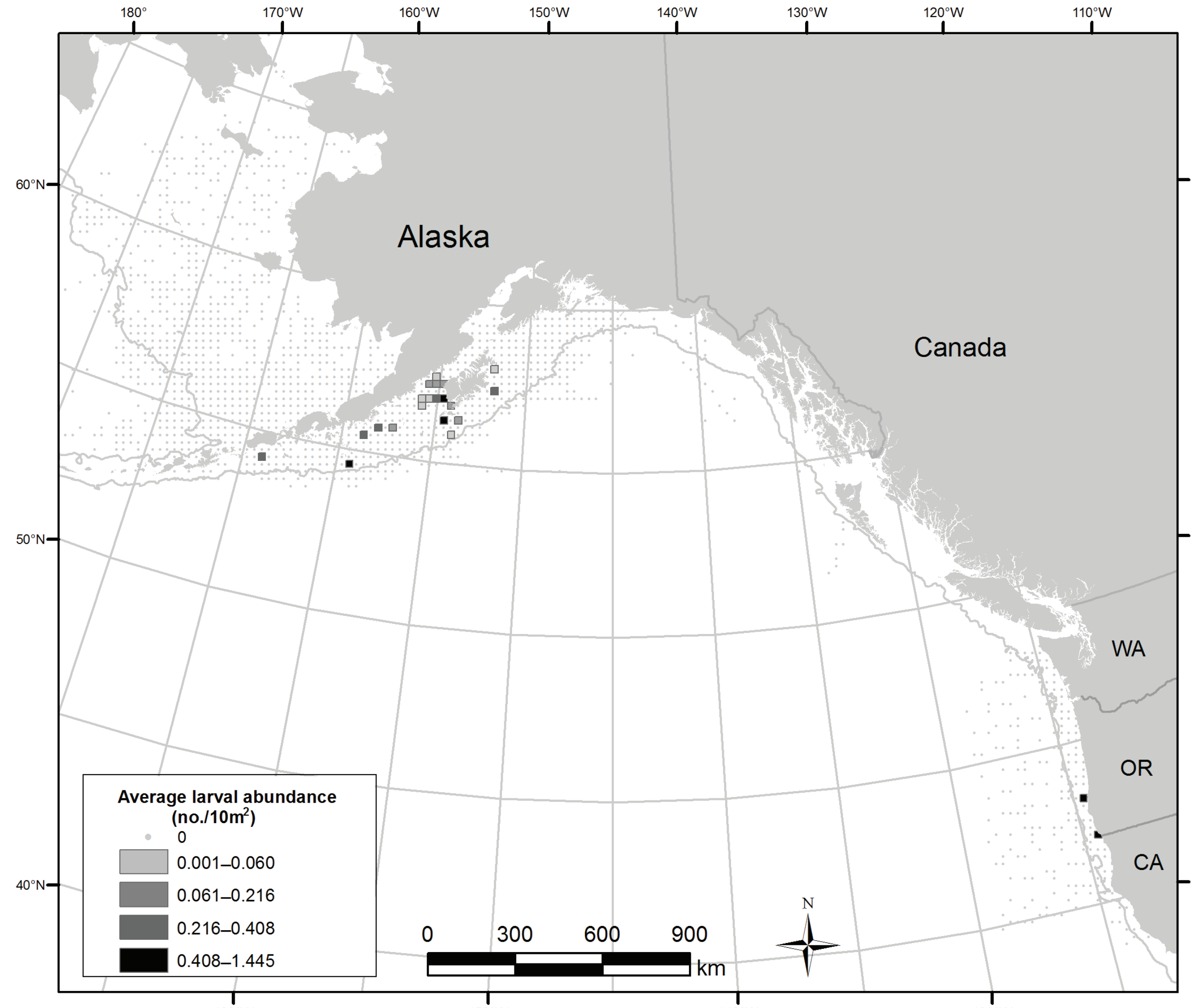

Figure 10

Distribution and abundance of larvae of Decorated Warbonnet (*Chirolophis decoratus*) collected by bongo net in the Bering Sea, Gulf of Alaska, and North Pacific Ocean off the Oregon coast. Isobath=1000 m.

Pigmentation (Fig. 12). Larvae of *C. decoratus* are moderately pigmented. Head pigment is light and variable in the preflexion stage: the nape region has several spots early in this stage, and some larvae have one or two melanophores at the posterior margin of the hindbrain. The gut is pigmented internally along its dorsal surface with 10 or more closely spaced melanophores. Several melanophores occur dorsally on the hindgut. Ventral pigment on the gut, when present, is restricted to a few melanophores anterior to midgut. A PVM series (>40) is present with a melanophore each at most myosepta along the entire length of the postanal body. A series of internal melanophores is present dorsally above the notochord, and a short series of external dorsal midline melanophores (about 8–10) is present posteriorly.

Few changes occur during the flexion and postflexion stages. Two melanophores persist over the hindbrain but may be difficult to see as they become embedded in late postflexion larvae. Melanophores on the dorsal surface of the gut decrease to about six and move dorsad to the lower margin of the body wall over the gut. The spots on the hindgut coalesce into one large spot. A few external hypaxial spots appear on the body in the area of the caudal peduncle.

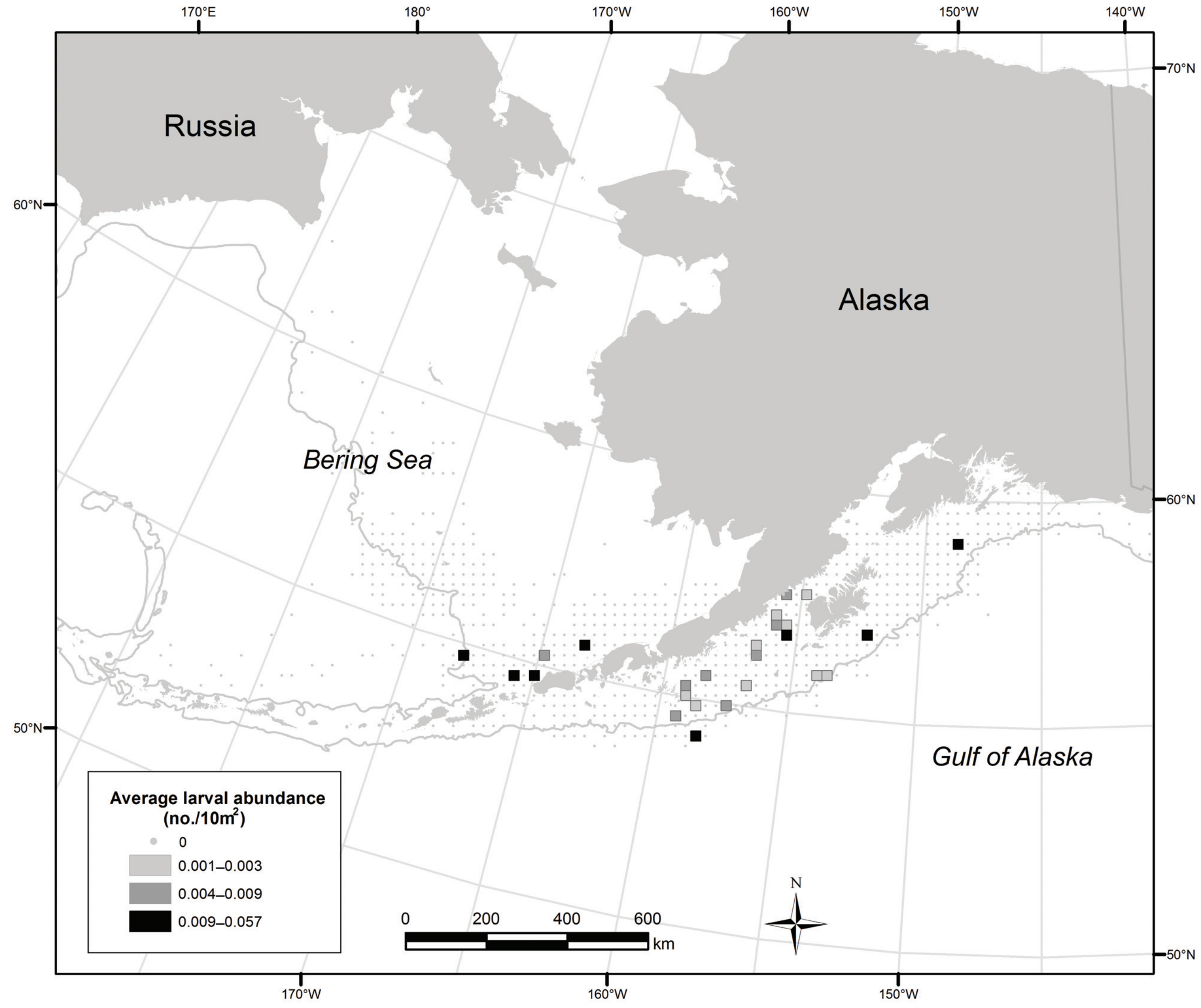

Figure 11

Distribution and abundance of larvae of Decorated Warbonnet (*Chirolophis decoratus*) collected by neuston gear in the Bering Sea and Gulf of Alaska. Isobath=1000 m.

Meristic features (Table 10). Principal caudal-fin rays in *C. decoratus* are present by 10.2 mm and begin to ossify by 13.7 mm before all are developed; development and ossification are complete by 16.8 mm. Procurrent caudal-fin rays are present by 16.8 mm, developed and partially ossified by 17.9 mm, and fully ossified by 25.5 mm. Dorsal-fin and anal-fin elements are present by 17.9 mm. The dorsal-fin spines are ossified posteriorly by 21.0 mm, and all dorsal-fin and anal-fin elements are developed and ossified at 25.5 mm. The count of LX dorsal-fin spines observed on radiographs is lower than the count previously reported for this species, and the count of LXIV dorsal-fin spines observed in the 42.5-mm specimen is greater than the count previously reported for this species (LXI–LXIII; Matarese et al., 1989). Pectoral-fin rays are present by 13.7 mm, developed and partially ossified by 17.9 mm, and fully ossified by 21.5 mm. The count of 16 pectoral-fin rays observed on radiographs is greater than the count previously reported for this species (13–15; Mecklenburg et al., 2002). Pelvic-fin elements are present by 25.5 mm and are developed and ossified by 28.5 mm. Vertebral centra are present at 9.1 mm. Ossification of the vertebral centra begins by 16.8 mm before all are developed; all vertebral centra are developed and ossified from 21.0 to 22.5 mm. Neural and haemal spines begin to ossify by 16.8 mm and

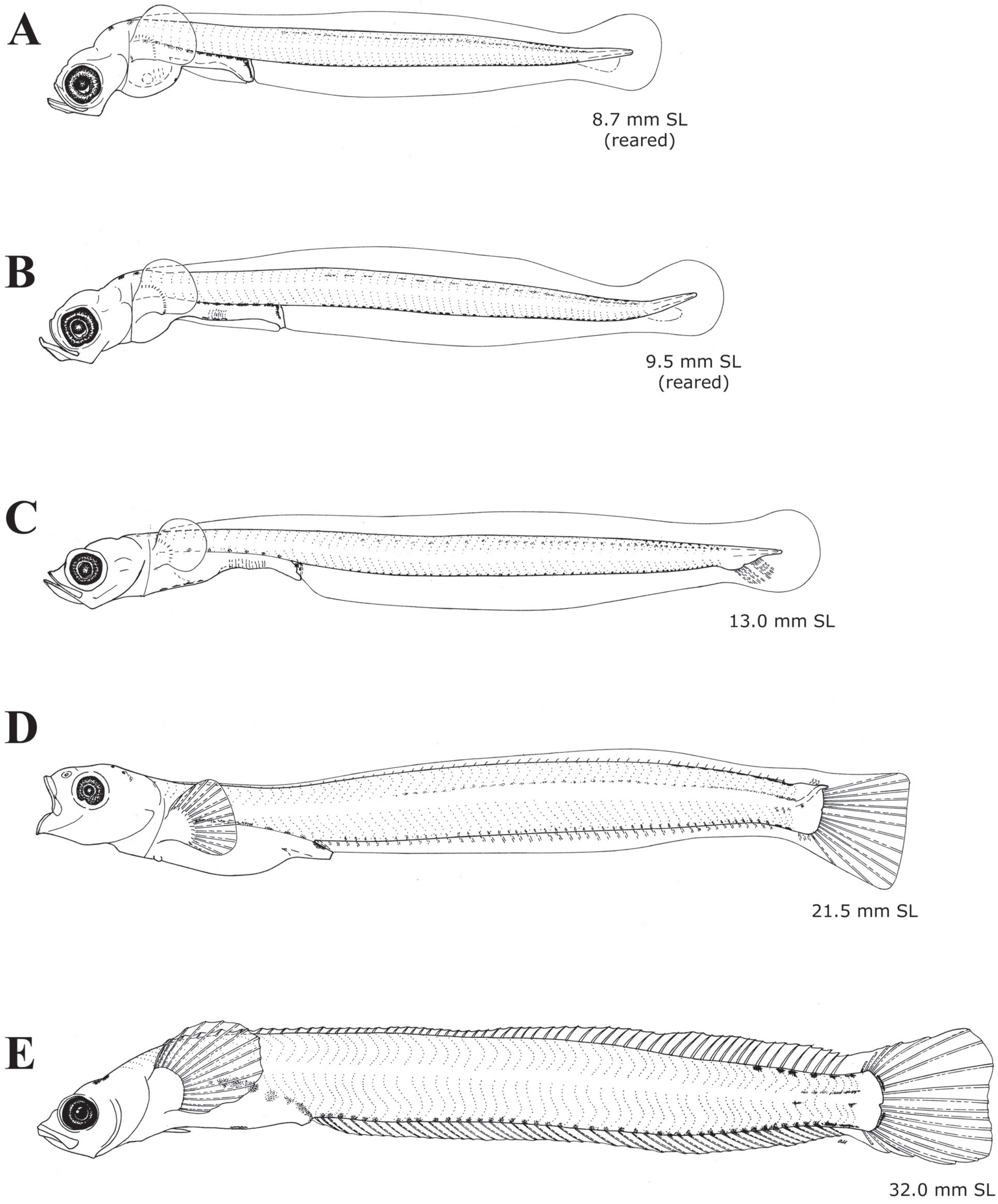

Figure 12

Larvae of Decorated Warbonnet (*Chirolophis decoratus*): (**A**) yolk-sac stage, 8.7 mm standard length (SL), University of Washington (UW) 145169; (**B**) late preflexion stage, 9.5 mm SL, UW 145169; (**C**) flexion stage, 13.0 mm SL, UW 69771; (**D**) early postflexion stage, 21.5 mm SL, composite of 21.5- and 22.0-mm SL specimens, UW 145168 and UW 145161; and (**E**) late postflexion stage, 32.0 mm SL, UW 145160. Illustrations (A–D) by B. Vinter (A–B reared) and (E) by A. Overdick.

Table 9

Body proportions of Decorated Warbonnet (*Chirolophis decoratus*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	21		8		25	
Standard length (mm)	10.3±1.0	(8.9–11.9)	15.6±1.7	(13.1–17.6)	27.1±3.6	(20.9–31.6)
Head length/SL	13.8±1.6	(11.0–17.9)	13.9±0.9	(12.8–15.3)	15.9±1.3	(13.3–19.7)
Snout length/HL	14.8±4.6	(7.1–25.7)[1]	17.5±3.3	(12.8–22.8)	25.1±2.6	(18.7–30.9)
Eye diameter/HL	39.6±5.6	(28.1–49.4)	31.1±2.4	(28.3–34.2)	24.3±2.7	(16.4–29.3)
Snout to anus length/SL	37.8±1.0	(34.7–39.0)	34.3±2.5	(28.3–35.9)	35.4±1.8	(31.8–41.3)
Body depth/SL	5.4±0.7	(4.6–7.4)	6.2±0.8	(4.8–7.0)	8.9±0.8	(7.5–10.9)

[1] *n*=20

Table 10

Meristic counts of cleared and stained Decorated Warbonnet (*Chirolophis decoratus*) larvae. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays				Branchiostegal	Neural spines			Haemal	Centra			Caudal-fin
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	rays	Abdominal	Caudal	Total	spines	Abdominal	Caudal	Total	rays
9.1													
10.2													
11.4													
12.5													
13.7													4+5
14.7													6+7
16.8						4	51	55	51		49	49	6+8
17.9			13[1]			16	37	53	37	16	49	65	3,6+8,2
19.5						17	46	63	46	17	46[2]	63	3,6+8,1
21.0			15		5	17	51	68	52	17	52	69	4,6+8,2
21.0	X		15		6	17	51	68	52	17	52	69	4,6+8,2
21.5			14		4	16	47	50	47	16	47[2]	63	2,6+8,1
22.5			15		6	16	52[3]	68	51	16	52	68	4,6+8,2
23.0			14		6	16	52	67	52	16	52	68	2,6+8,1
25.5	XXXIII	45	15		6	16	50	66	50	16	51	67	5,6+8,3
28.5	LXIII	I,48	15	I,3	6	16	51	67	51	16	52	68	6,6+8,4
31.5	LXIII	I,48	15	I,3	6	16	52[3]	68	52	16	52	68	6,6+8,4
42.5	LXIV	I,49	15	I,3	*	16	52	68	52	16	53	69	*

[1] Dorsal-fin and ventralmost pectoral-fin rays not completely formed or ossified.

[2] Posteriormost 4–5 vertebral centra, neural and haemal spines unossified. Ural centra ossified in both specimens.

[3] Two neural spines on preural centra.

* Character damaged or missing.

are developed and ossified by 21.0 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larvae of *C. decoratus* resemble species of *Bryozoichthys,* particularly during the preflexion and flexion stages, but they can be distinguished by the absence of a continuous row of evenly spaced, internal melanophores that extend from the nape to the hypural region on the dorsal surface of the notochord. Species of *Chirolophis* have a row of internal dorsolateral pigment similar to species of *Bryozoichthys,* but in *Chirolophis* species it is present only on the postanal body. Melanophores around the notochord tip, caudal finfold, and caudal fin in *Bryozoichthys* species are absent in *C. decoratus* at all stages of development. *Chirolophis decoratus* usually has fewer vertebrae (myomeres; 65–69) than do *Bryozoichthys lysimus* (69–75) and *B. marjorius* (71–76).

Larval *C. decoratus* are most likely to be confused with Mosshead Warbonnet (*C. nugator*) but can be distinguished in the preflexion and flexion stages by the presence of a row of several evenly spaced melanophores along the dorsal midline on the caudal peduncle; this row is absent in *C. nugator.* Pigment may be present or absent on the ventral surface of the gut in *C. decoratus*, but it is always present in *C. nugator* as a row of several melanophores or a continuous line throughout development. Also, preflexion *C. decoratus* have >40 PVM, whereas *C. nugator* have <40 PVM during the preflexion stage. Larvae of *C. decoratus* are more slender-bodied than are larvae of *C. nugator* throughout development (mean body depth: 5.4–8.9% SL vs. 6.9–9.9% SL) and have a shorter mean snout length during the preflexion and flexion stages (14.8–17.5% HL vs. 20.0–22.9% HL). In addition, *C. decoratus* has more vertebrae (myomeres; 65–69) than does *C. nugator* (55–61) and more dorsal-fin and anal-fin elements (LX–LXIV; I–II,44–49 vs. LIII–LVI; I–II,37–42).

Chirolophis nugator, Mosshead Warbonnet (Figs. 13, 14; Tables 11, 12)

Literature. Hart (1973), Eschmeyer et al. (1983), Mecklenburg et al. (2002).

Material examined. 76 specimens (8.7–25.0 mm) from the Bering Sea; Gulf of Alaska; the coast of British Columbia, Canada; Straits of Georgia, Canada; Puget Sound, Washington; and the coasts of Oregon and California (see Appendix for details).

Distribution and life history. *Chirolophis nugator* ranges throughout the Aleutian Islands and along the Alaska Peninsula to southern California in the North Pacific Ocean in intertidal and subtidal areas to a depth of 80 m (Eschmeyer et al., 1983), although it is usually found in water less than 20 m deep, sometimes in holes or inside empty shells. Adults reach 150 mm TL (Mecklenburg et al., 2002). Eggs are 2 mm in diameter, and spawning may occur in January (Hart, 1973); larvae are pelagic.

Larval distribution (Fig. 13). Larvae of *C. nugator* have been collected over the shelf in the Bering Sea, in Unimak Pass, and eastward into the Gulf of Alaska to Kodiak Island, as well as off the coast of British Columbia, Canada, to northern California. Larvae (11.0–26.0 mm, mean 16.4 mm) are collected in the plankton in January–June with the highest abundances observed in May.

Morphology (Tables 11, 12). Notochord flexion in *C. nugator* begins by 12.3 mm and is complete around 17.0 mm. Postflexion larvae are 17.1–25.0 mm. Transformation begins after 25.0 mm; length at the beginning of the juvenile stage is unknown. Larvae are slender-bodied with mean body depth of 9.2% SL in the preflexion stage, decreasing to 6.9% SL in the flexion stage and increasing to 9.9% SL in the postflexion stage. Relative head length increases slightly, and snout length increases more, during larval development. Relative eye diameter decreases during development while snout to anus length remains relatively constant.

Pigmentation (Fig. 14). Larvae of *C. nugator* are moderately pigmented. A large spot on the hindbrain persists throughout development. Initially, the nape region has several spots. About six internal, stellate melanophores occur on the dorsal surface of the gut, and several external melanophores occur dorsally on the hindgut. Internal pigment occurs in the area of the cleithrum. Pigment on the ventral surface of the gut is restricted to a series or continuous line of melanophores at midgut. A series of about 33 PVM begins about five myomeres posterior to the anus with a melanophore on almost every myoseptum along the entire length of the postanal body. Internal melanophores are present dorsally above the notochord.

Several pigmentation changes occur during the flexion and postflexion stages. The large spots on the head become more prominent, and pigment on the nape becomes internal. One or more additional spots are present in the opercular area in postflexion larvae. The melanophores on the dorsal surface of the gut become spaced farther apart as the larvae develop. The cleithral pigment becomes more prominent during the flexion stage, and then it is no longer visible in the postflexion stage. The ventral midline pigment on the gut is highly variable: some larvae have discrete melanophores at midgut, and others have some discrete melanophores together with a continuous line of pigment. PVM remain <40 (35–37), and internal pigment above the notochord remains visible posteriorly. Large melanophores appear along the dorsal midline, restricted mostly to the posterior region but occasionally extend anteriorly. A few small spots may appear along the hypural edge.

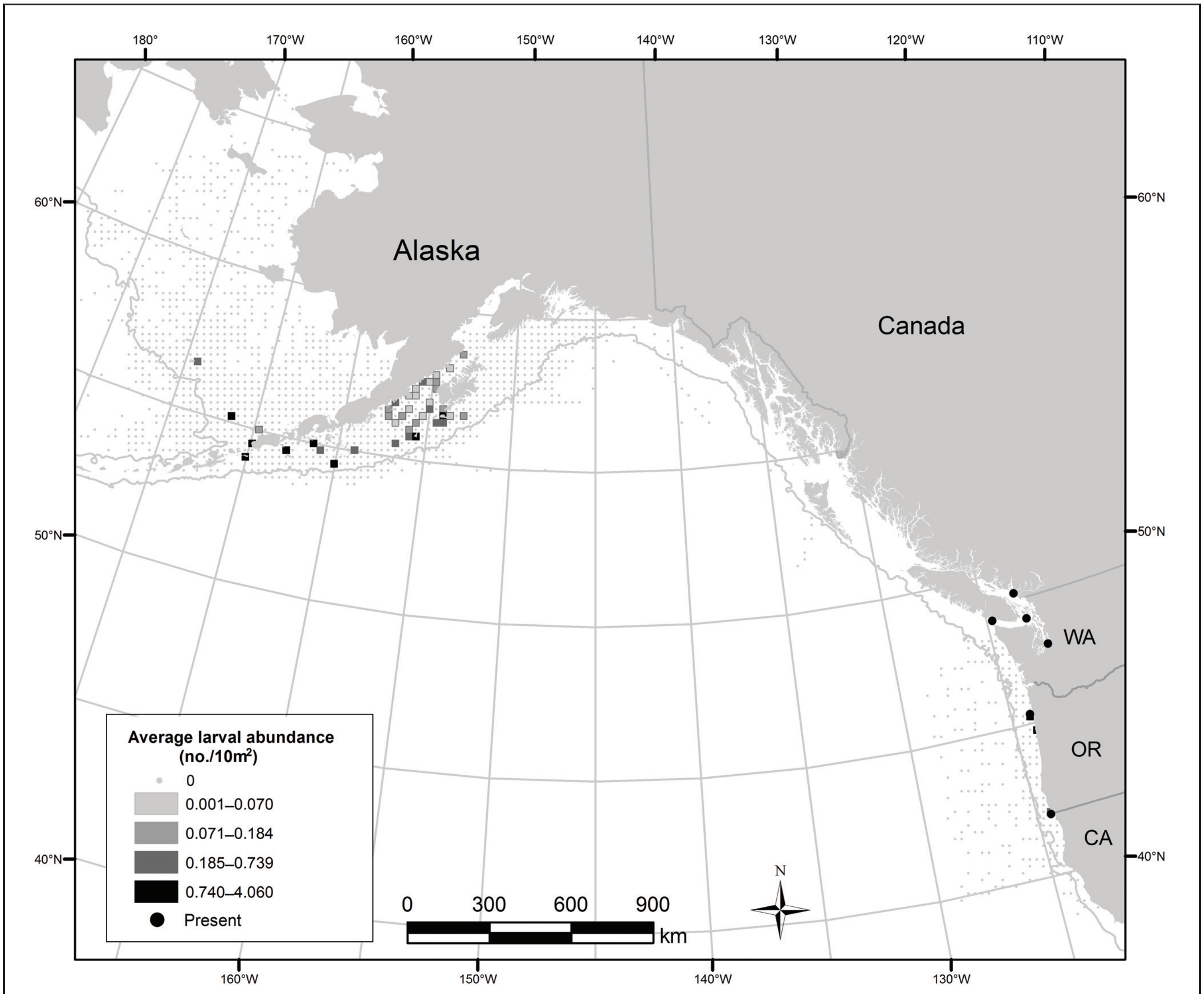

Figure 13

Distribution and abundance of larvae of Mosshead Warbonnet (*Chirolophis nugator*) collected in the Bering Sea; Gulf of Alaska; North Pacific Ocean off the coasts of British Columbia, Canada, and Oregon; and Puget Sound, Washington. Squares indicate collections made by bongo net; black circles indicate additional nonquantitative collections (presence only) and may represent more than one occurrence. Isobath=1000 m.

Meristic features (Table 12). Principal caudal-fin rays are present in *C. nugator* by 10.1 mm and are all developed and weakly ossified at 14.3 mm. The count of 8 inferior principal caudal-fin rays observed in the 17.1-mm specimen is greater than the count previously reported for this species (7; Watson, 1996). Procurrent caudal-fin rays are present by 16.1 mm, begin to ossify by 17.1 mm, and are developed and ossified by 23.0 mm. The counts of 3 superior and 1 inferior procurrent caudal-fin rays observed on radiographs are lower than the counts previously reported for this species (5–6, 3–4; Watson, 1996). By 17.1 mm, the dorsal-fin and anal-fin elements are present. Development and ossification of the anal-fin elements can be complete as early as 18.5 mm. The count of II anal-fin spines observed on radiographs is greater than the count previously reported for this species (I; Mecklenburg et al., 2002). The dorsal-fin spines are developed by 18.5 mm and ossified by 23.0 mm. The count of LVI dorsal-fin spines observed on radiographs is greater than the count previously reported for this species (LIII–LV; Mecklenburg et al., 2002). Pectoral-fin rays are present by 10.1 mm, developed by 16.1 mm, and weakly ossified by 17.1 mm. The pelvic-fin buds are first discernable at 17.1 mm. Individual elements are present by 18.5

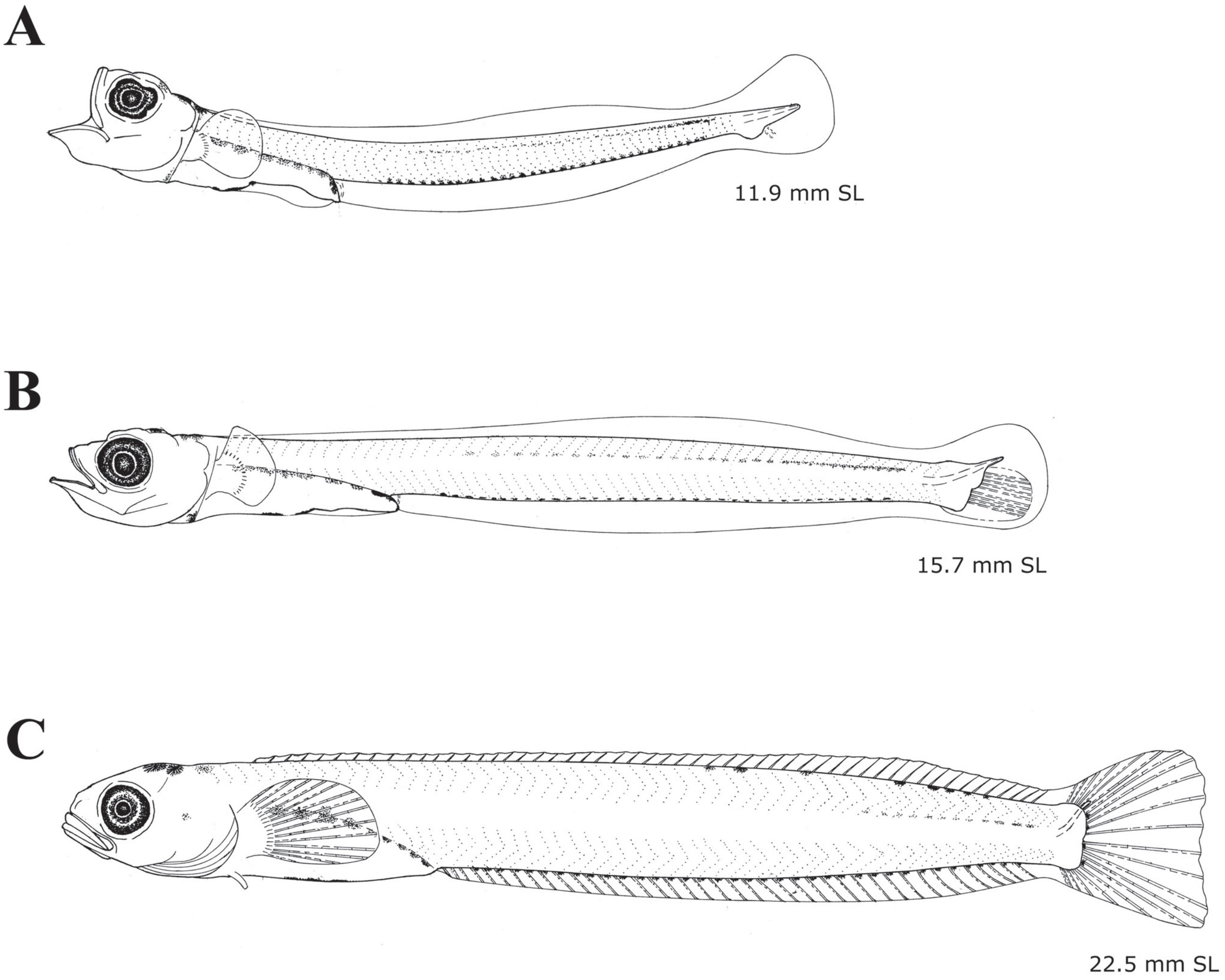

Figure 14

Larvae of Mosshead Warbonnet (*Chirolophis nugator*): (**A**) preflexion stage, 11.9 mm standard length (SL), University of Washington (UW) 145053; (**B**) flexion stage, 15.7 mm SL, UW 145053; and (**C**) postflexion 22.5 mm SL, UW 145053. Illustrations by B. Vinter.

mm and developed and ossified by 23.0 mm. Vertebral centra are present at 12.0 mm and developed and ossified by 17.1 mm. The count of 16 precaudal centra, the range of 42–46 caudal centra, and the total count of 61 vertebral centra observed on radiographs are greater than the counts previously reported for this species (14–15+43–44=55–59; Watson, 1996). Neural and haemal spines are present by 10.1 mm and ossified by 12.0 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. See the species comparison section for *Chirolophis decoratus* to distinguish larvae from species of *Bryozoichthys;* similar pigment differences apply to *C. nugator*. Also similar to *C. decoratus*, *C. nugator* has fewer vertebrae (myomeres: 55–61) than both *Bryozoichthys* species (69–76).

Larvae of *C. nugator* are most similar to *C. decoratus*, but they can be distinguished in the preflexion and flexion stages by the absence of a row of several evenly spaced melanophores along the dorsal midline of the caudal peduncle; this row is present in *C. decoratus*. Ventral pigmentation on the gut is always present as a row of several melanophores or a continuous line throughout development, but in *C. decoratus* it may be present or absent. In the preflexion stage, *C. nugator* has <40 PVM, whereas *C. decoratus* has >40. Larvae of *C. nugator* are deeper bodied than are larvae of *C. decoratus* throughout development (mean body depth: 9.2–9.9% SL vs.

Table 11

Body proportions of Mosshead Warbonnet (*Chirolophis nugator*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	19		17		29	
Standard length (mm)	10.1±0.8	(8.7–11.4)	13.9±1.2	(12.3–16.8)	20.9±2.0	(17.1–24.8)
Head length/SL	15.1±1.5	(13.2–18.1)[1]	15.7±1.1	(14.5–18.4)	16.4±1.6	(13.9–22.9)
Snout length/HL	20.0±3.6	(11.6–26.5)[2]	22.9±2.8	(16.9–27.1)	25.2±3.1	(18.8–30.8)
Eye diameter/HL	38.5±5.2	(29.6–46.2)[1]	34.9±3.4	(27.8–36.9)	30.8±2.8	(24.7–35.8)
Snout to anus length/SL	36.6±1.4	(33.8–39.5)	36.8±1.0	(35.2–39.5)	37.1±1.0	(35.9–41.3)
Body depth/SL	9.2±1.9	(6.3–12.2)[2]	6.9±0.7	(5.7–8.1)[3]	9.9±1.4	(7.8–12.1)

[1] *n*=18
[2] *n*=17
[3] *n*=16

Table 12

Meristic counts of cleared and stained Mosshead Warbonnet (*Chirolophis nugator*) larvae. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

Standard length (mm)	Spines, rays: Dorsal fin	Spines, rays: Anal fin	Spines, rays: Pectoral fin	Spines, rays: Pelvic fin	Branchiostegal rays	Neural spines: Abdominal	Neural spines: Caudal	Neural spines: Total	Haemal spines	Centra: Abdominal	Centra: Caudal	Centra: Total	Caudal-fin rays
10.1													
10.9													
12.0						16	42	58	42				
13.2						15	43	58	43				
14.3						15	43[1]	58	42				6+7
15.5													*
16.1													6+7
17.1			14		6	15	44[1]	59	43	15	44	59	5,6+8,2
18.5	XXV	I,40	13		6	15	44[1]	59	43	15	44	59	4,6+7,2
19.0					6	14	44[1]	59	43	15	44	59	4,6+7,2
20.5					6[2]	14	44[1]	58	43				6+7
23.0	LIV	I,40	14	I,3	6	15	43	58	43	15	44	59	5,6+7,4
25.0	LIV	I,40	14	I,3	6	15	43	58	43	15	44	59	6,6+7,5

[1] Two neural spines on preural centra.
[2] Right side of specimen counted.
*Character missing.

5.4–8.9% SL) and have a longer mean snout length during the preflexion and flexion stages (20.0–22.9% HL vs. 14.8–17.5% HL). In addition, *C. nugator* has fewer vertebrae (myomeres; 55–61 vs. 65–69) and fewer dorsal-fin and anal-fin elements (LIII–LVI; I–II,37–42 vs. LX–LXIV; I–II,44–49) than does *C. decoratus*.

***Chirolophis snyderi*, Bearded Warbonnet**

See "Other material" section of this guide.

***Gymnoclinus cristulatus*, Trident Prickleback (Fig. 15; Tables 13, 14)**

Literature. Shiogaki (1988; reported by Tokuya and Amaoka (1980) as *Chirolophis otohime*), Mecklenburg et al. (2002).

Material examined. Eight specimens (18.8–26.8 mm) from the Sea of Japan (see Appendix for details).

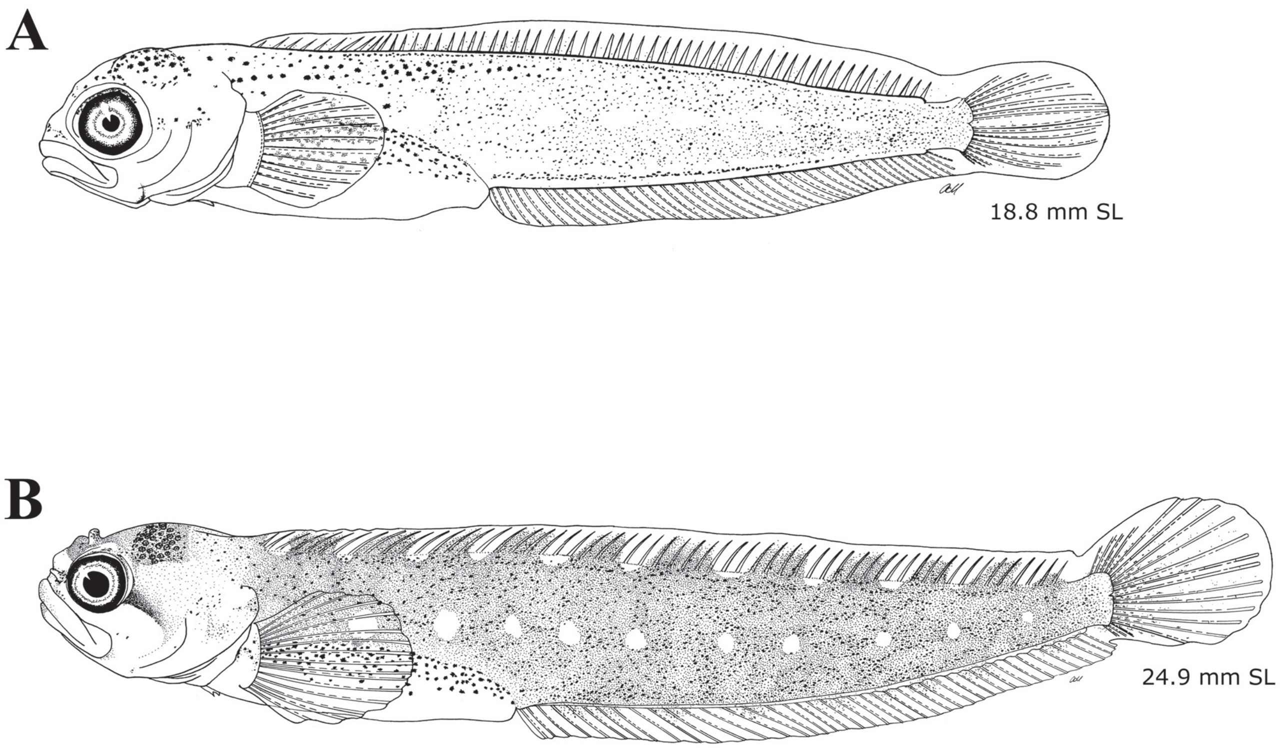

Figure 15

Larvae of Trident Prickleback (*Gymnoclinus cristulatus*): (**A**) postflexion stage, 18.8 mm standard length (SL), Hokkaido University Museum of Zoology (HUMZ-L) 03113; and (**B**) transformation stage, 24.9 mm SL, HUMZ-L 02569. Illustrations by A. Overdick.

Distribution and life history. *Gymnoclinus cristulatus* is found in intertidal areas to a depth of about 40 m (mainly <20 m) in the Sea of Japan near Hokkaido, eastern Kamchatka, Kuril and Commander Islands, and Amchitka Island in the western Aleutian Island Archipelago; it has not been collected during AFSC adult surveys. Adults can grow to 116 mm TL (Mecklenburg et al., 2002). Little is known of its life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution. Larvae of Trident Prickleback have not been collected from our study area. Eight larvae (18.8–26.8 mm) collected in April at one location off Usujiri, southwest Hokkaido, Japan, were in the postflexion, transformation, and juvenile stages; specimens in the preflexion and flexion stages were not available.

Morphology (Table 13). Length at the end of notochord flexion in *G. cristulatus* is unknown; transformation begins by 19.0 mm. Juvenile stage begins after 23.2 mm but before 25.0 mm. Postflexion larvae are deep-bodied (mean body depth 16.0% SL) with a relatively large head (head length 21.2% SL, snout length 19.7% HL), large eyes (eye diameter 30.2% HL), and long gut (snout to anus length 47.2% SL).

Pigmentation (Fig. 15). Pigment description is based in part on Tokuya and Amaoka (1980). Larvae of *G. cristulatus* are heavily pigmented. The single postflexion-stage larva examined (18.8 mm SL) was already developing some initial juvenile pigmentation. The head has a prominent dorsal patch and spots along the snout, lower jaw, and opercular area. The nape region is lightly pigmented with small melanophores. The gut is pigmented with small melanophores along the dorsal and lateral surfaces, in addition to one large internal dorsal spot at midgut. The ventral surface of the gut is unpigmented. The dorsal finfold is lightly pigmented with small, scattered melanophores. Laterally, anterior pigment consists of large punctate melanophores above the gut; postanal lateral pigment is fine and scattered over most of the body. A line of pigment extends along the dorsal margin of the body from midgut to the caudal peduncle. A similar line extends along the ventral margin from the anus to about 80% SL. Light pigment is visible on the anal and caudal-fin membranes.

Table 13

Body proportions of Trident Prickleback (*Gymnoclinus cristulatus*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion	Flexion	Postflexion
Sample size	0	0	7
Standard length (mm)			21.9±1.9 (18.8–24.9)
Head length/SL			21.2±1.5 (19.0–23.1)
Snout length/HL			19.7±2.0 (17.1–22.7)
Eye diameter/HL			30.2±2.3 (26.9–32.9)
Snout to anus length/SL			47.2±1.8 (44.5–48.9)
Body depth/SL			16.0±1.1 (14.1–17.2)

Table 14

Meristic counts of cleared and stained Trident Prickleback (*Gymnoclinus cristulatus*) postflexion larva (21.0 mm) and juvenile (26.8 mm). Counts are of ossified elements only.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
21.0	LX	42	14		6	18	47[1]	65	47[1]	18	47	65	5,6+7,3
26.8	LXI	42	15[2]	I[3]	7	19	46	65	47[1]	19	47	66	5,6+7,2

[1] Two neural or haemal spines on second preural centra.
[2] Ventralmost pectoral-fin ray (16) not ossified.
[3] Two pelvic-fin rays present but not ossified.

Pigmentation increased in early transformation specimens. The juvenile pigment pattern on the head, with large dark melanophores on the crown and a streak of pigment that extends posterioventrally from the eye, is visible by about 20 mm SL. Additional melanophores are present along the pectoral-fin base. The postanal body is almost entirely pigmented with tiny spots. Along the body midline, up to 10 circular spots are unpigmented. Patches of pigment occur throughout the dorsal-fin rays; similar pigment patches are just beginning to extend onto the anal-fin rays.

Meristic features (Table 14). Vertebral centra, neural and haemal spines, and all fin elements except the pelvic fins are developed and ossified by 21.0 mm. The count of LVIII dorsal-fin spines observed in the 24.9-mm illustrated transformation-stage specimen is lower than the count previously recorded for this species (LXI–LXIII: Shiogaki, 1988; LXI: Mecklenburg et al., 2002). Two pelvic-fin rays are present and the single pelvic-fin spine is developed and ossified by 26.8 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Preflexion and flexion larvae of *G. cristulatus* are unknown, but postflexion larvae are distinguished from all presently known stichaeid larvae by melanophores scattered over the entire dorsal region of the gut and lateral body. They also have the greatest body depth during postflexion (16.0% SL vs. 6.3–12.3% SL). The absence of an anal-fin spine is useful in identification of transformation-stage *G. cristulatus*.

Subfamily Lumpeninae

Acantholumpenus mackayi, Blackline Prickleback

See "Other material" section of this guide.

Lumpenella longirostris, Longsnout Prickleback (Figs. 16, 17; Tables 15, 16)

Literature. Amaoka et al. (1983), Mecklenburg et al. (2002).

Material examined. 126 specimens (8.0–64.0 mm) from the Bering Sea and Gulf of Alaska (see Appendix for details).

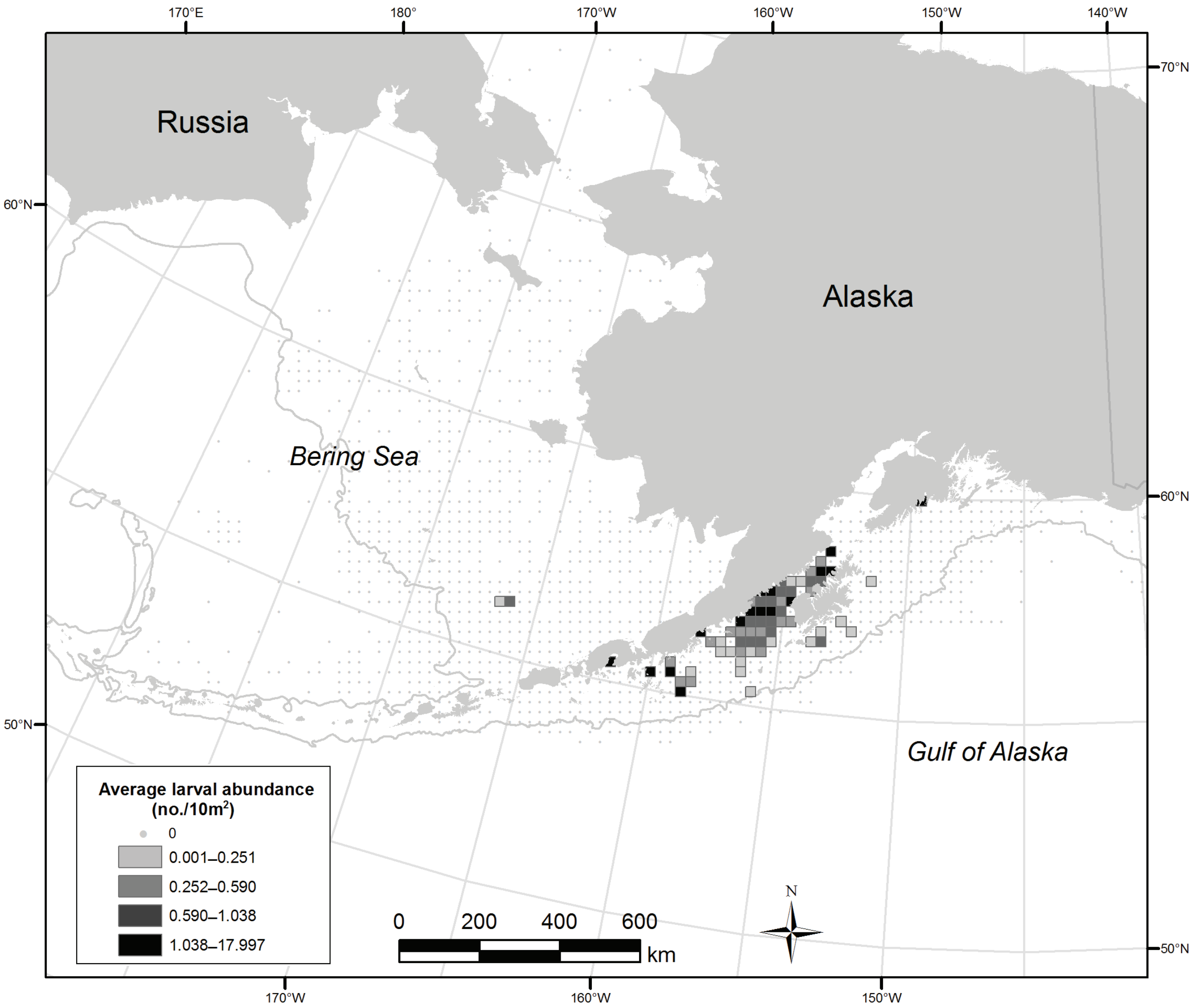

Figure 16

Distribution and abundance of larvae of Longsnout Prickleback (*Lumpenella longirostris*) collected by bongo net in the Bering Sea and Gulf of Alaska. Isobath=1000 m.

Distribution and life history. *Lumpenella longirostris* adults occur in the Sea of Okhotsk to northern Japan, the Bering Sea, Aleutian Islands to southern British Columbia, and in the North Atlantic Ocean near Greenland. Although found most commonly at depths of 100–200 m (RACEBASE), Longsnout Prickleback have been collected at depths of 22–1140 m. Maximum length is 411 mm TL (Mecklenburg et al., 2002). Little is known of its life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Fig. 16). Larvae of the fourth-most abundant stichaeid in our study area, Longsnout Prickleback (8.4–41.0 mm), are found during April–June, with the highest abundance observed in May, on the shelf in the Gulf of Alaska south of the Alaska Peninsula, in Shelikof Strait, and along the shelf east of Kodiak Island to the Kenai Peninsula. Although adults occur in the central and southeastern Bering Sea, larvae are collected infrequently in these regions.

Morphology (Table 15). The smallest preflexion larval *L. longirostris* examined (8.0 mm) had a small yolk sac. Notochord flexion begins at about 13.0 mm and is complete by 25.0 mm. Postflexion larvae are 24.9–40.4 mm. Transformation begins after 40.4 mm, and the juvenile

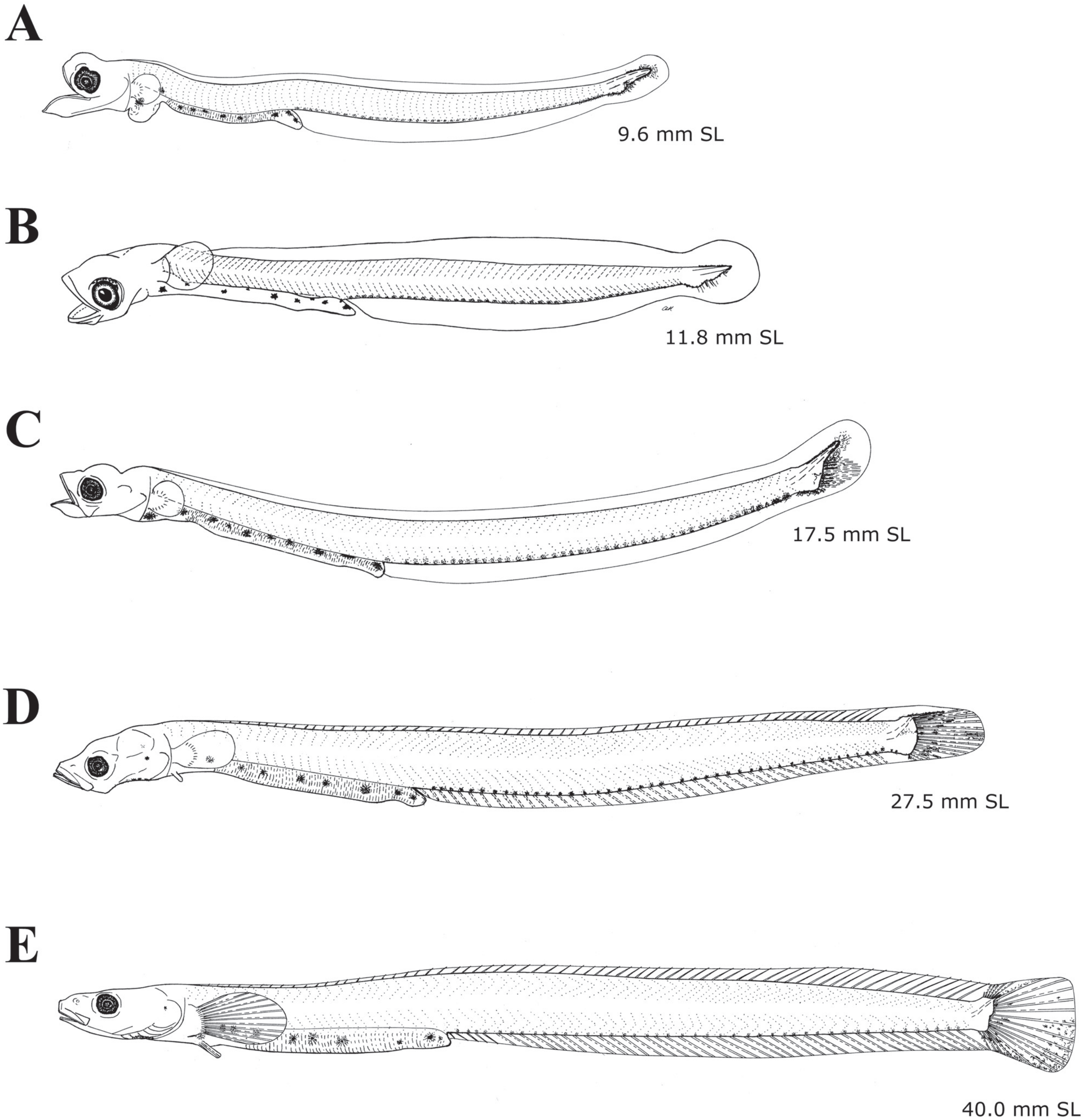

Figure 17

Larvae of Longsnout Prickleback (*Lumpenella longirostris*): (**A**) preflexion stage, 9.6 mm standard length (SL), University of Washington (UW) 67120; (**B**) flexion stage, 11.8 mm SL, UW 94969; (**C**) flexion stage, 17.5 mm SL, UW 145094; (**D**) postflexion stage, 27.5 mm SL, UW 68867; and (**E**) late postflexion stage, 40.0 mm SL, UW 145093. Illustrations (A, C–E) by B. Vinter and (B) by A. Overdick.

Table 15

Body proportions of Longsnout Prickleback (*Lumpenella longirostris*) larvae and juveniles. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	40		51		14	
Standard length (mm)	10.3±1.3	8.0–12.9)	18.2±4.0	(13.1–24.9)	29.9±5.4	(24.9–40.4)
Head length/SL	14.0±2.1	(10.0–19.3)	12.7±1.2	(9.2–15.8)	13.1±1.1	(11.0–15.6)
Snout length/HL	26.1±6.9	(13.0–42.2)[1]	22.5±4.9	(9.3–35.0)	28.4±2.8	(23.6–33.0)
Eye diameter/HL	33.4±5.5	(24.2–46.7)	25.0±4.5	(16.9–34.7)[2]	19.5±1.6	(16.9–22.2)
Snout to anus length/SL	44.8±3.4	(32.2–50.7)	42.8±1.5	(38.1–45.8)	42.6±1.0	(40.7–44.8)
Body depth/SL	7.6±1.9	(3.9–9.9)	5.7±0.7	(4.0–7.0)	6.5±0.4	(5.8–7.0)

[1] *n*=37
[2] *n*=50

Table 16

Meristic counts of cleared and stained Longsnout Prickleback (*Lumpenella longirostris*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
9.0													
9.4													
9.7													
10.1													
12.0													
12.9													
13.3													
15.9													
17.6													
19.8													
20.0										23	20	43	
22.5										22	48	70	3,6+6,1
26.5										23	48	71	6+6,1
32.5	XL	IV,42			6	22	47	69	47	22	48	70	4,6+6,4
38.0	LXIV	V,42	13	I	6	22	47	69	47	22	48	70	5,6+6,5
49.0	LXVI	IV,41	12	I,3	6	23	49	72	49	23	49	73	5,6+6,4
64.0	LXVI	IV,41	13	I,3	6	23	48	71	48	23	49	72	5,6+6,6

stage begins by 50.0 mm. Larvae are slender-bodied with mean body depth of 7.6% SL in the preflexion stage, decreasing to 5.7% SL during the flexion stage and increasing slightly to 6.5% SL in the postflexion stage. Both relative head length and snout length decrease from the preflexion stage to the flexion stage and increase again in the postflexion stage. Relative eye diameter decreases throughout larval development, and relative snout to anus length is nearly constant, decreasing only slightly.

Pigmentation (Fig. 17). Larvae of *L. longirostris* are lightly pigmented (pigment on postanal body is limited to PVM). The head is unpigmented in preflexion larvae. The gut is pigmented on its lateral surface with about 5–6 melanophores. One anterior spot is initially located on the ventral body margin. Two melanophores occur on the dorsal surface of the hindgut. A single melanophore appears ventral to the pectoral fin base. A series of about 50 PVM, consisting of a melanophore at each myoseptum, begins just after the anus and extends to the caudal peduncle. Caudal pigment is restricted to small melanophores around the notochord tip and in the hypural area.

In flexion larvae, the melanophore ventral to the pectoral fin is larger and more prominent. The number of melanophores along the lateral surface of the gut behind the pectoral fin increases up to 10, including 1–2 on the hindgut. The number of PVM decreases to <50. Light caudal-fin pigment was visible in some specimens by 17 mm.

Pigment changes in postflexion larvae occur mainly on the head and tail. Pigment forms in the otic area. Additional pigment is visible on the caudal fin by about 28 mm, but it is more concentrated on the distal half. Larger specimens had essentially the same pigment pattern, with a series of melanophores on the isthmus as well as a melanophore at the pectoral-fin base. About six melanophores remain on the lateral surface of the gut, with another two spots that extend onto the hindgut. Although PVM (42–44) become embedded, they are still visible to about 40 mm. Pigment remains visible around the notochord tip and continues to increase on the caudal fin.

Meristic features (Table 16). Principal caudal-fin rays are present between 9.7 and 10.1 mm, developed by 20.0 mm, and ossified by 22.5 mm. Procurrent caudal-fin rays are present by 20.0 mm, and ossification begins at 22.5 mm before all are developed; development and ossification are complete by 32.5 mm. Dorsal-fin spines and anal-fin rays are present by 22.5 mm. Anal-fin elements are developed by 26.5 mm and ossified by 32.5 mm. Ossification of dorsal fin spines begins at 32.5 mm, progresses from posterior to anterior, and is complete at 38.0 mm. Pectoral-fin rays are present by 20.0 mm, developed by 22.5 mm, and ossified by 38.0 mm. Pelvic-fin elements are present at 32.5 mm. The pelvic-fin spine is developed and ossified by 38.0 mm, and the pelvic-fin rays are developed and ossified by 49.0 mm. Vertebral centra are present at 15.9 mm. All centra and neural and haemal spines are developed by 19.8 mm. Ossification of vertebral centra begins at 20.0 mm and progresses from anterior to posterior; all vertebral centra are ossified by 22.5 mm. The count of 22 precaudal centra observed in the 32.5- and 38.0-mm specimens is lower than the count previously reported for this species (23–25; Amaoka et al., 1983). The total count of 70 vertebral centra observed in the 32.5- and 38.0-mm specimens is lower than the total count previously reported for this species (71–75; Mecklenburg et al., 2002). All neural and haemal spines are ossified by 32.5 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larvae in the subfamily Lumpeninae (*Lumpenella, Lumpenus,* and *Poroclinus*) can be distinguished from other stichaeids by a combination of characters that include typically slender bodies at all stages of development (mean body depth 5.7–9.5% SL; *Lumpenus medius* has a mean body depth during the flexion stage of 10.0% SL), long guts (snout to anus length 42.5–50.4% SL), and sparse pigmentation typically restricted to the lateral or dorsal surfaces of the gut, PVM, and caudal fin region.

Larval *Lumpenella longirostris* are similar to larvae of *Lumpenus* species and Whitebarred Prickleback (*Poroclinus rothrocki*). Preflexion- and flexion-stage *L. longirostris* can be distinguished by the presence of fine melanophores around the notochord tip; postflexion larvae have pigment along the dorsal edge of the hypural. Species of *Lumpenus* and *P. rothrocki* have no pigment around the notochord tip at any stage and no pigment along the dorsal edge of the hypural. *Poroclinus rothrocki* has an irregularly spaced row of embedded melanophores, both above and below the notochord on the caudal peduncle; this row is absent in *L. longirostris*. Larvae of *L. longirostris* are more slender-bodied than are larvae of *P. rothrocki* at all stages of development (mean body depth: 7.6% SL, 5.7% SL, 6.5% SL vs. 9.5% SL, 6.3% SL, 8.5% SL). *Lumpenella longirostris* has more total vertebrae (70–75) than does *P. rothrocki* (64–68), usually has more vertebrae than does *Lumpenus medius* (65–70), and usually has fewer vertebrae than does Snake Prickleback (*Lumpenus sagitta*; 75–82). It is worth noting that among late-postflexion-through-transformation-stage stichaeid larvae only *L. longirostris* has 4–5 anal-fin spines.

Lumpenus fabricii, Slender Eelblenny (Figs. 18, 19; Tables 17, 18)

Literature. Grigor'ev (1992b), MacDonald (2001), Mecklenburg et al. (2002), Mecklenburg and Sheiko (2004).

Material examined. 22 specimens (12.1–57.0 mm) from the Chukchi, Beaufort, and Bering seas and Gulf of Alaska (see Appendix for details).

Distribution and life history. *Lumpenus fabricii* is a circumarctic species. It is found in the seas of Japan and Okhotsk; Beaufort, Chukchi, and Bering seas; in the Aleutian Islands as far west as Unimak Island; along shelf areas of the Gulf of Alaska to southeastern Alaska; and in the Arctic and North Atlantic oceans. Slender Eelblenny have been collected over sandy to rocky bottoms to depths of 175 m, but this species is usually found on the inner shelf <50 m deep, often in seagrass or algae (Mecklenburg et al., 2002; Mecklenburg and Sheiko, 2004). Adults can grow to 365 mm TL (Mecklenburg et al., 2002). Little is known of their life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Fig. 18). Larvae of Slender Eelblenny (11.9–46.0 mm) have been collected infrequently during

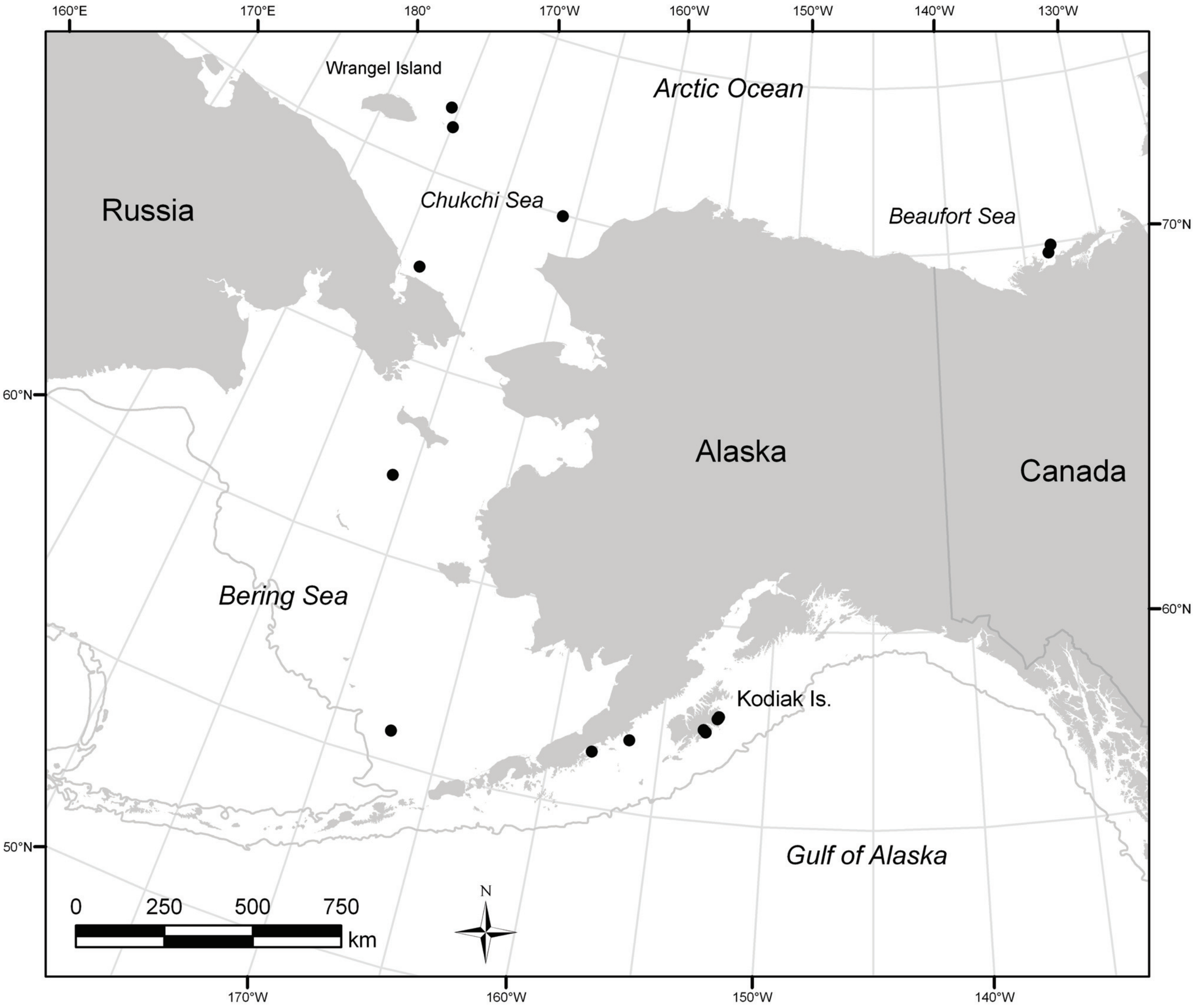

Figure 18

Distribution of larvae of Slender Eelblenny (*Lumpenus fabricii*) collected by bongo and Tucker gear in the Chukchi and Bering seas and Gulf of Alaska. Each symbol may indicate more than one occurrence. Isobath=1000 m.

May–July in the Chukchi Sea near Wrangel Island and the Chukchi Peninsula; Beaufort Sea off the coast of Northwest Territories, Canada; on the Bering Sea shelf; along the shelf in the northern Gulf of Alaska east of Unimak Pass; and close to shore along the southeast side of Kodiak Island. Juveniles (55.0–57.0 mm) have been collected in the Chukchi Sea in September. Larvae also have been collected in June–July in the Sea of Okhotsk near the Kamchatka Peninsula (Grigor'ev, 1992b).

Morphology (Table 17). Notochord flexion in *L. fabricii* begins at 13.0 mm and is complete by 21.0 mm. Postflexion larvae are 20.0–46.0 mm. Transformation begins after 45.0 mm, and the juvenile stage begins after 55.0 mm. Larvae are slender-bodied with a mean body depth of 8.3% SL and 6.5% SL for the preflexion (*n*=1) and flexion stages, respectively, increasing slightly to 6.9% SL in the postflexion stage. Relative head length changes little through the flexion stage, and then it increases in postflexion larvae. Relative snout length increases from the flexion stage to the postflexion stage, and relative eye diameter and snout to anus length decrease throughout larval development.

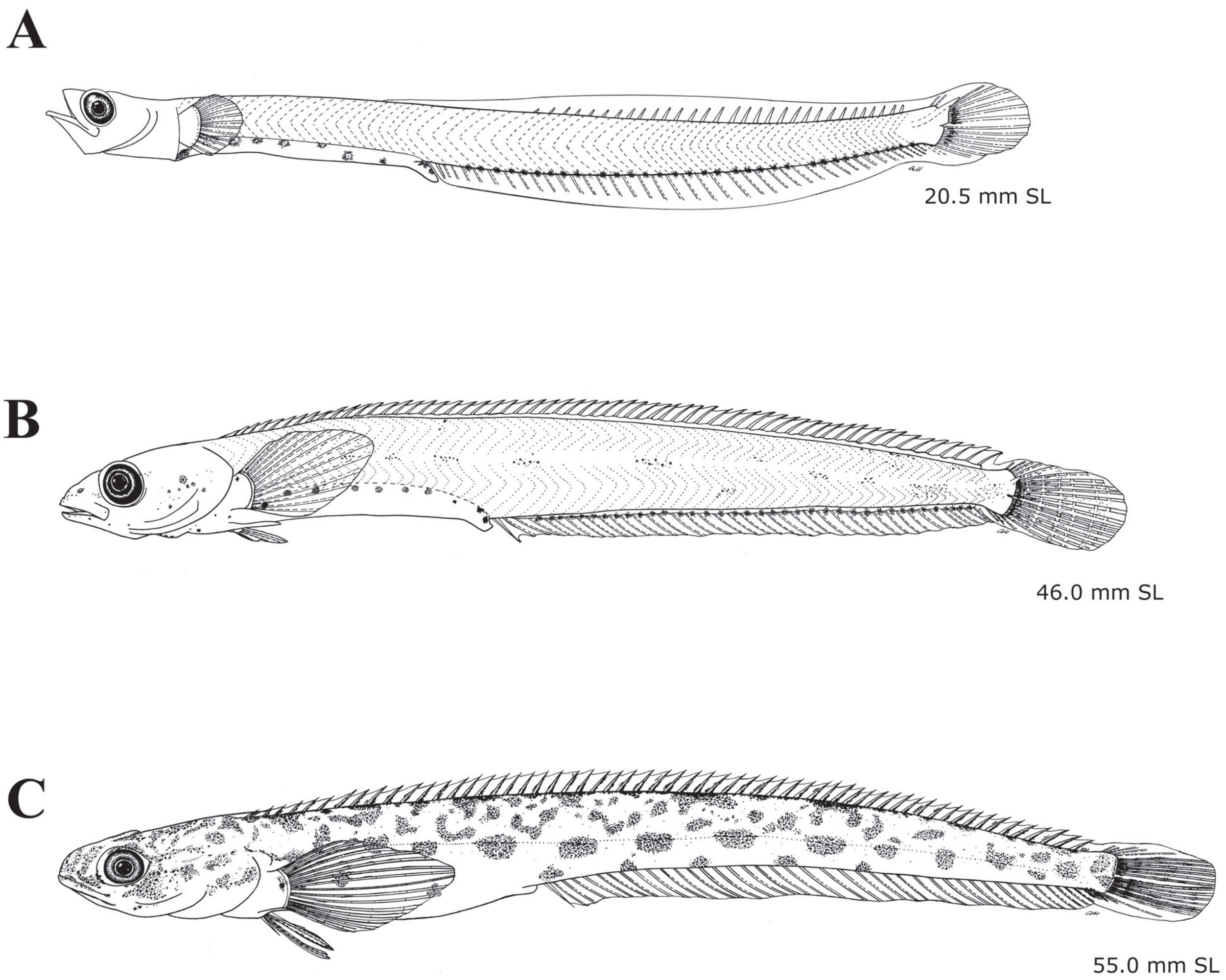

Figure 19

Larvae of Slender Eelblenny (*Lumpenus fabricii*): (**A**) postflexion stage, 20.5 mm standard length (SL), University of Washington (UW) 145063; (**B**) early transformation stage, 46.0 mm SL, composite of 41.0 and 46.0 mm SL specimens, UW 145896 and UW 94975; and (**C**) juvenile, 55.0 mm SL, UW 145069. Illustrations by A. Overdick.

Pigmentation (Fig. 19). Larvae are lightly pigmented. In the only preflexion larva available for examination, the head was unpigmented, a single melanophore appeared ventral to each pectoral fin, the gut had a row of melanophores along its dorsolateral and lateral surface that included the hindgut (about 6–7 + 1–2 hindgut melanophores spaced irregularly throughout), and a PVM series (about 40–45) that consisted of one melanophore per myoseptum extended from near the anus to the caudal peduncle. Caudal pigment is restricted to several small melanophores in the hypural area.

In the flexion and postflexion stages, the melanophore below the pectoral-fin base becomes larger and more prominent, and up to 12 melanophores appear along the dorsolateral and lateral surface of the gut posterior to the pectoral fin, including several spots on the hindgut. PVM decrease in number to 33–37. A band of pigment is present along the base of the developing caudal-fin rays.

Transformation-stage larvae develop melanophores on the upper jaw tip and cheek. Preanal pigment consists of a series of 3–4 ventral dashes on the isthmus, 1–2 spots near the base of the pelvic fins, and lateral spots along the gut (4–8 + 2 on hindgut); the spot below the pectoral-fin base that was prominent in flexion and postflexion larvae becomes deeply embedded and difficult to see. The number of PVM increases to 37–39, beginning several myomeres posterior to the anus; melanophores are embedded in tissue at the base of the anal-fin elements. Clusters of pigment are present along the lateral line and scattered in 2–3 areas above and below it on

Table 17

Body proportions of Slender Eelblenny (*Lumpenus fabricii*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion	Flexion		Postflexion	
Sample size	1	3		11	
Standard length (mm)	12.1	16.2±4.3	(13.0–21.0)	33.5±8.9	(20.0–46.0)
Head length/SL	11.6	11.4±0.9	(10.8–12.4)	15.3±3.1	(10.4–19.1)
Snout length/HL	–[1]	23.2±2.5	(21.4–24.9)[2]	27.2±4.3	(21.6–32.7)[3]
Eye diameter/HL	35.7	31.2±10.7	(19.0–38.9)	21.3±5.2	(16.2–32.7)
Snout to anus length/SL	50.4	46.1±2.0	(43.9–47.6)	43.1±4.0	(33.7–49.8)
Body depth/SL	8.3	6.5±1.0	(5.6–7.7)	6.9±1.2	(5.4–9.3)[3]

[1] *n*=0
[2] *n*=2
[3] *n*=9

Table 18

Meristic counts of cleared and stained Slender Eelblenny (*Lumpenus fabricii*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchi-ostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
12.5													
13.3													
19.5*													
22.5													
41.0	LXIII	I,42	14	I,3	6	24	45	69	45	24	46	70	5,6+7,4
57.0	LXIII	I,42	16	I,3	6	26	45	71	45	26	46	72	6,6+7,6

* Damaged caudal fin.

the posterior one-third of the body; scattered melanophores along the dorsal midline are present at 40% and 80–90% SL. Pigment at the hypural edge extends onto the caudal-fin rays.

In juveniles, irregularly shaped, diffuse patches and streaks of melanophores are present on the snout, crown, and lateral surfaces of the head and opercle, but there is little pigment ventrally on the head. A single melanophore is present on the pectoral-fin base near the insertion of the medial rays. Irregularly spaced blotches and patches of pigment along the dorsal midline extend into the dorsal fin around many of the spines. The body is covered dorsolaterally with irregularly shaped patches of pigment and with uniform, oval-shaped patches spaced regularly along the lateral line. Five or more evenly spaced clusters of melanophores are present along the postanal ventral midline. Additional patches of pigmentation at the hypural edge extend onto the caudal-fin rays.

Meristic features (Table 18). Few larvae of *L. fabricii* were available to clear and stain. All median and paired fin elements, vertebral centra, and neural and haemal spines are developed and ossified by 41.0 mm during postflexion. The count of LX dorsal-fin spines observed in the 55.0-mm illustration specimen is lower than the count previously reported for this species (LXI–LXVI; Mecklenburg et al., 2002). The count of 38 anal-fin rays obtained from MacDonald (2001) is lower than the count otherwise reported for this species (40–44; Mecklenburg et al., 2002). The count of 23 precaudal centra obtained from MacDonald (2001) is lower than the count previously reported for this species (26–28; Matarese et al., 1989). The range of 43–49 caudal centra obtained from MacDonald (2001) is greater than the range previously reported for this species (44–48; Matarese et al., 1989). By 57.0 mm, scales begin to form. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Pigmentation patterns are not useful for species-level identification of larvae of the genus *Lumpenus*; species are distinguished primarily by a combination of morphological and meristic differences that are present in older, more developed larvae. Larval *L. fabricii* are most similar to other species of *Lumpenus*, particularly *L. medius*. Although this measurement was based on one specimen, mean body depth appeared greater in preflexion *L. fabricii* (8.3% SL) than in preflexion *L. medius* and *L. sagitta* (7.0% SL, 7.7% SL). During the flexion and postflexion stages, larvae of *L. fabricii* have a shorter gut (mean snout to anus length: 46.1% SL, 43.1% SL) than do larvae of *L. maculatus* (49.4% SL, 50.3% SL) and are more slender-bodied (mean body depth: 6.5% SL, 6.9% SL) than are larvae of *L. maculatus* (mean body depth: 7.9% SL, 7.5% SL) and *L. medius* (mean body depth: 10.0% SL, 7.9% SL). Transformation in *L. fabricii* begins at a larger size (>45 mm) than it does in *L. medius* (>35 mm). In transformation-stage and early juvenile *L. fabricii*, the dorsal and anal fins are not connected to the caudal fin as they are in *L. medius* (Mecklenburg et al., 2002). Counts of precaudal, caudal, and total myomeres or vertebrae (23–28+43–49=70–75) distinguish larvae and juveniles of *L. fabricii* from other species of *Lumpenus*. *Lumpenus fabricii* typically has more precaudal vertebrae (23–28) than does *L. medius* (21–25), typically fewer precaudal vertebrae than does *L. sagitta* (26–29), more caudal vertebrae (43–49) than does *L. maculatus* (39–43), and usually fewer total vertebrae (70–75) than does *L. sagitta* (75–82).

Lumpenus maculatus, Daubed Shanny (Figs. 20, 21; Tables 19, 20)

Literature. Faber (1976), Eschmeyer et al. (1983), Grigor'ev (1992b), MacDonald (2001), Mecklenburg et al. (2002).

Material examined. 80 specimens (8.1–72.1 mm) from the Bering Sea and Gulf of Alaska (see Appendix for details).

Distribution and life history. *Lumpenus maculatus* is found over mud, sand, stone, or pebble bottoms at depths of 2–475 m (almost always <170 m) (Mecklenberg et al., 2002) in the seas of Okhotsk and Japan, Beaufort and Bering seas, in the Aleutian Islands as far west as Unalaska Island, throughout the Gulf of Alaska, and south to Puget Sound, Washington. It also has been reported in the North Atlantic Ocean to Spitsbergen Island. Adults can grow to 180 mm TL (Eschmeyer et al., 1983) in the North Pacific Ocean and to 200 mm TL near Iceland (Mecklenburg et al., 2002). Little is known of its life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Fig. 20). Larvae of Daubed Shanny have the highest frequency of occurrence of any stichaeid in our study area. Daubed Shanny at lengths of 8.0–64.0 mm (mostly 10–25 mm) are collected in March–October, with the highest abundance observed in May, from the Chukchi Sea near Wrangel Island, the Beaufort Sea, Bering Strait and on the Bering Sea shelf, throughout the shelf in the northern Gulf of Alaska east of Unimak Pass, around Kodiak Island, and eastward to the mouth of Cook Inlet. Larvae also have been collected in June in the Sea of Okhotsk near the Kamchatka Peninsula and in the Gulf of Anadyr (Grigor'ev, 1992b).

Morphology (Tables 19, 20). Size of larvae at the beginning and end of developmental stages was more variable in *L. maculatus* than in other species examined in this study. Notochord flexion begins at 13.0–15.0 mm and can be complete at 20.0–25.0 mm. Postflexion larvae are 20.0–66.2 mm. Transformation begins at about 50 mm, and the juvenile stage begins by 72.1 mm. Larvae are slender-bodied and become more so with development, with mean body depth decreasing from 8.3% SL in the preflexion stage to 7.5% SL in the postflexion stage. Relative head length is constant through the flexion stage, and then it increases in postflexion larvae. Relative snout length increases and relative eye diameter decreases throughout larval development. Snout to anus length is long (49.4–50.4% SL) and remains relatively constant throughout development.

Pigmentation (Fig. 21). Larvae of *L. maculatus* are lightly pigmented. The head is unpigmented through the flexion stage. Preflexion larvae have a row of melanophores (about 5–9 spots) along the lateral surface of the gut, 2–3 melanophores on the protruding hindgut, a row of 34–41 PVM beginning just posterior to the anus, a single melanophore ventral to the base of each pectoral fin, and a patch of melanophores in the caudal region ventral to the notochord.

As development continues, body pigmentation increases gradually. By the early flexion stage, a patch of melanophores is present at the base of the caudal rays. Flexion larvae also develop 2–3 small melanophores on the isthmus on each side of the ventral midline.

Most pigmentation develops during the postflexion and transformation stages. By 20 mm, the melanophores on the isthmus are more prominent. As the gut becomes enclosed by the body wall (about 24 mm), the number of melanophores on its dorsal surface increases dramatically to 15–20 by 28 mm. The number of melanophores on the isthmus also increases to four, and the hypural edge and caudal fin rays are heavily pigmented. A series of groups of 1–5 pigment spots begins to develop posteriorly along the lateral midline of the body; within these groups, melanophores are sometimes arranged in a line. With development, more of these groups appear,

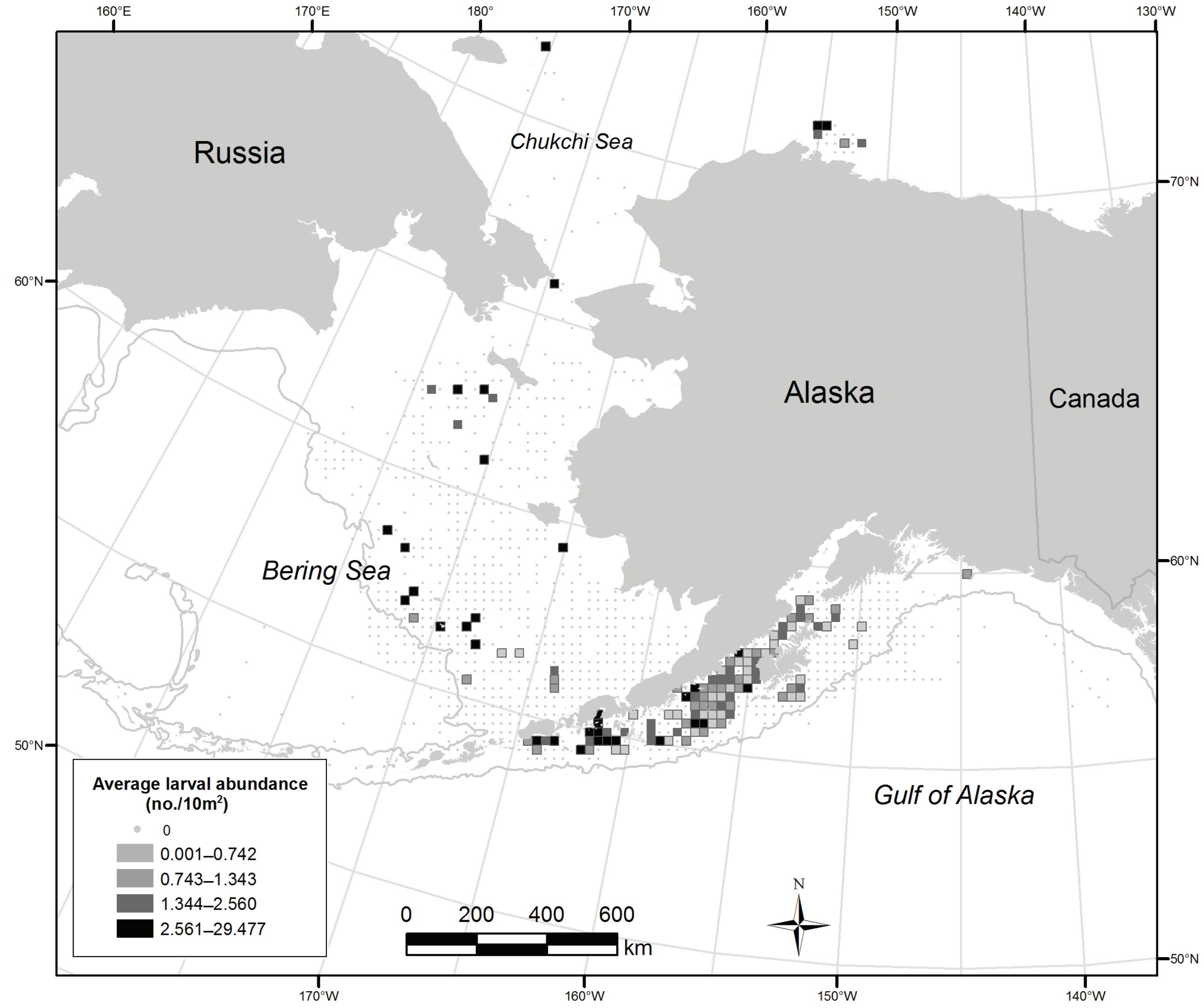

Figure 20

Distribution and abundance of larvae of Daubed Shanny (*Lumpenus maculatus*) collected by bongo net in the Chukchi and Bering seas and Gulf of Alaska. Isobath=1000 m.

advancing anteriorly as far forward as the posterior edge of the pectoral fin. By 41 mm, larvae have developed a patch of melanophores at the anterior tips of the upper and lower jaws, and multiple short groups of melanophores are present along the entire lateral midline of the body; pigment is added along the margins of both jaws with further development. By 58 mm, a row of five melanophores has developed across the lateral surface of the cheek and operculum, and a single melanophore forms posterior to the base of the pectoral fin. By the end of the transformation stage (about 70 mm), the adult pigment pattern is present, although residual larval gut melanophores and PVM are still visible.

Meristic features (Table 20). Principal and inferior procurrent caudal-fin rays begin ossifying at 19.4 mm before they are fully developed; superior procurrent caudal-fin rays begin ossifying at 25.2 mm before they are fully developed. Principal caudal-fin rays are developed and ossified by 25.2 mm; procurrent caudal-fin rays are developed and ossified by 44.0 mm. With the exception of the pelvic fins, all fin elements are developed and ossified by 25.2 mm (postflexion stage). Pelvic-fin buds are present by 31.0 mm, and all elements are developed and ossified by 54.0 mm. By 25.2 mm, all vertebral centra are developed with the exception of the three posterior caudal centra; however, all of them, including the urostyle,

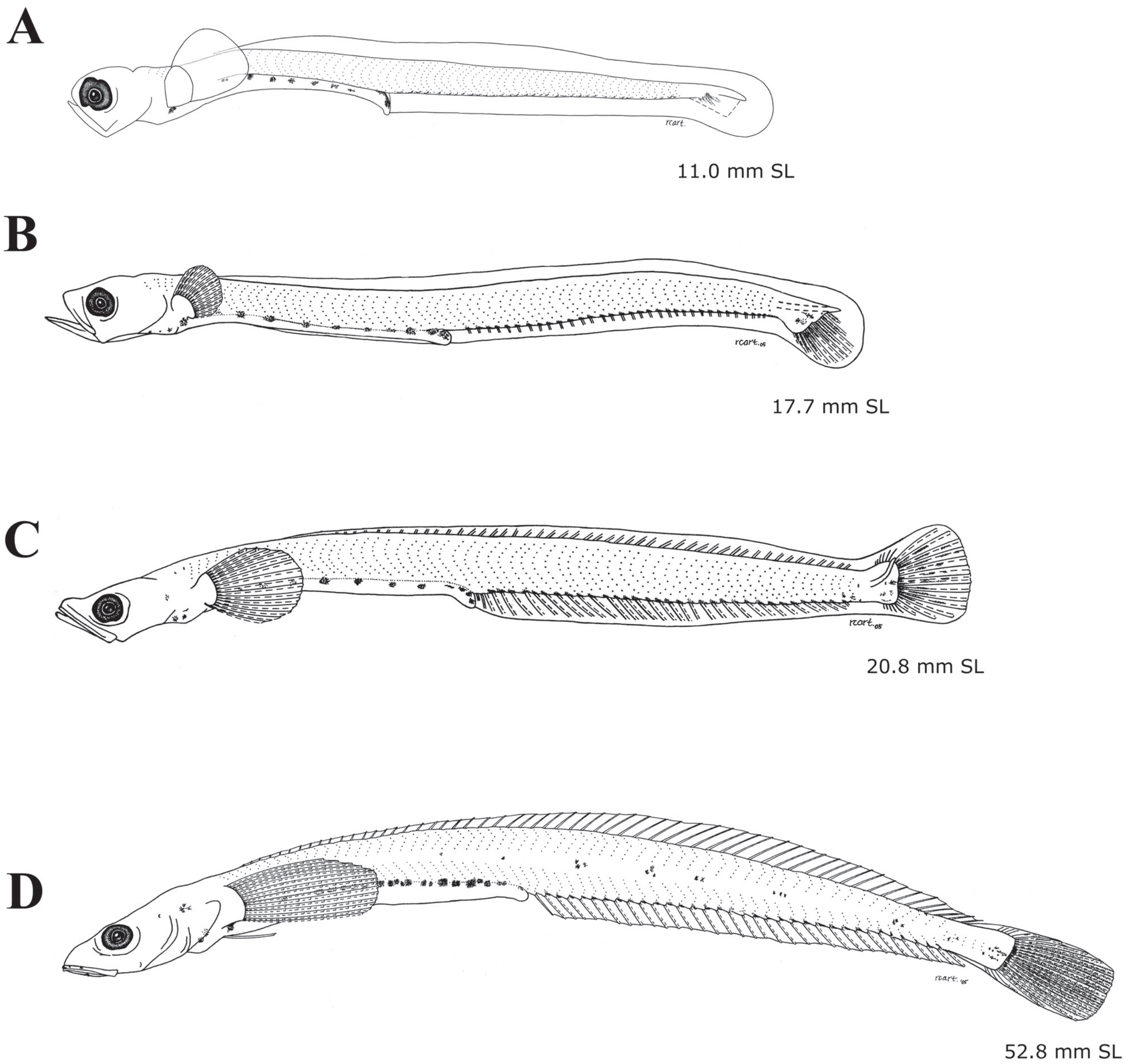

Figure 21

Larvae of Daubed Shanny (*Lumpenus maculatus*): (**A**) preflexion stage, 11.0 mm standard length (SL), University of Washington (UW) 95036; (**B**) flexion stage, 17.7 mm SL, composite of 17.7- and 16.0-mm SL specimens, UW 145099 and UW 145098; (**C**) postflexion stage, 20.8 mm SL, UW 145101; and (**D**) transformation stage, 52.8 mm SL, UW 145102. Illustrations by R. Cartwright.

Table 19

Body proportions of Daubed Shanny (*Lumpenus maculatus*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	10		13		27	
Standard length (mm)	10.8±0.9	(9.5–12.1)	15.5±2.2	(13.0–18.8)	41.5±12.4	(20.0–66.2)
Head length/SL	14.1±1.3	(11.5–16.3)	14.1±0.7	(12.8–15.4)	17.7±1.8	(14.5–21.3)
Snout length/HL	16.3±2.9	(12.8–20.8)[1]	21.0±2.5	(16.7–24.5)[2]	26.2±4.4	(17.6–41.7)[3]
Eye diameter/HL	35.7±4.2	(30.8–41.7)	30.3±2.6	(26.1–33.3)	20.5±3.1	(15.5–29.3)
Snout to anus length/SL	50.4±1.2	(48.9–53.0)	49.4±1.7	(46.8–52.2)	50.3±1.3	(48.8–54.2)
Body depth/SL	8.3±0.6	(7.3–9.4)	7.9±0.6	(6.9–8.8)	7.5±0.7	(6.5–9.5)[3]

[1] *n*=8
[2] *n*=12
[3] *n*=23

Table 20

Meristic counts of cleared and stained Daubed Shanny (*Lumpenus maculatus*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
8.1													
8.2													
10.5													
11.8													
13.5													
13.9													
15.5													
17.0													
19.4													6+6,2
22.4													
25.2	XVI	I,35	15		5					26	40	66	4,7+6,4
31.0													
42.7	LIX	I,36											
44.0	LX	I,37	15		6	26	39	65	39	26	40	66	7,7+7,5
44.0[1]						27	41	68	41	27	42	69	*
54.0	LXI	I,35	15	I,3	6	27	40	67	40	27	41	68	6,7+6,5
72.1	LIX	I,35	15	I,3	6	27	38	65	38	27	39	66	7,7+7,6

[1] Paired and median-fin elements completely developed but unossified (counts XII; I,37;15; I,3). Elements of vertebral column very weakly ossified.
* Character damaged.

are at least partially ossified. The count of 25 precaudal centra obtained from MacDonald (2001) is lower than the count previously reported for this species (26–30; Matarese et al., 1989). Neural and haemal spines are developed by 25.2 mm and ossified by 44.0 mm. By 55.0 mm, scale pockets begin to form. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Pigmentation patterns are not useful for species-level identification of larvae of the genus *Lumpenus*; species are distinguished primarily by a combination of morphological and meristic differences that are present in older, more developed larvae. Larvae of *L. maculatus* have a longer gut (mean snout to anus length of about 50% SL) than do larvae of other *Lumpenus* species (42–47% SL). Counts of precaudal, caudal, and total myomeres or vertebrae (25–30+39–43=66–72) distinguish larvae and juveniles of *L. maculatus* from other species of *Lumpenus* in most cases. *Lumpenus maculatus* has more precaudal vertebrae (25–30) than does *L. medius* (21–25), fewer total vertebrae (66–72) than does *L. sagitta* (75–82), and usually fewer vertebrae than does *L. fabricii* (70–75). The number of caudal vertebrae is usually lower in *L. maculatus* (39–43) than in all other species of *Lumpenus* (42–55).

Lumpenus medius, Stout Eelblenny (Figs. 22, 23; Tables 21, 22)

Literature. Makushok (1986), Grigor'ev (1992b), Mecklenburg et al. (2002), Novikov et al. (2002).

Material examined. 78 specimens (9.6–46.5 mm) from the Arctic Ocean, Beaufort Sea, and Gulf of Alaska (see Appendix for details).

Distribution and life history. *Lumpenus medius* is circumarctic over muddy bottom from nearshore waters to a depth of 150 m (Mecklenberg et al., 2002) in the seas of Okhotsk and Japan; Beaufort, Chukchi, and Bering seas; in the Aleutian Islands as far west as Unimak Island; along shelf areas of the Gulf of Alaska to southeastern Alaska; and in the Arctic and North Atlantic oceans. It is typically found at depths <100 m (Mecklenburg et al., 2002), and in the Northeast Atlantic is commonly found in areas where temperatures are <0°C (Makushok, 1986). Adults can grow to 180 mm TL (Mecklenburg et al., 2002), although there is one record of an adult that was 300 mm TL (Novikov et al., 2002). Little is known of the life history of this species. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Fig. 22). Only two larvae of Stout Eelblenny have been found during standard AFSC ichthyoplankton surveys; most larvae (72) were collected in 1978–79 during special studies in which sampling was conducted inshore and in bays in the Gulf of Alaska. Larvae 9.6–46.5 mm in length are found in March–August at depths of 30–130 m in the Gulf of Alaska near Unimak Island and close to shore along the southeast side of Kodiak Island. Larvae 32.0–40.0 mm in length are found in August–September at depths of 4–57 m in the Arctic Ocean and the Beaufort Sea off the coast of Canada. No larvae have been collected in the Bering Sea in Alaskan waters. Larvae have been collected in June in the Sea of Okhotsk near the Kamchatka Peninsula and in the Bering Sea near the Russian coast (Grigor'ev, 1992b).

Morphology (Table 21). Notochord flexion in *L. medius* begins at 10.7–12.1 mm. Our largest flexion specimen was 14.4 mm, and the smallest postflexion larva was 31.0 mm, so it is unknown when notochord flexion is complete. Postflexion larvae from our material were 31.0–46.5 mm, and transformation begins after 35.0 mm. Our largest specimen (46.5 mm) was at transformation stage, and it is unknown when the juvenile stage begins. Larvae are slender-bodied during the preflexion and postflexion stages (mean body depth: 7.0% SL, 7.9% SL), but they have a moderate mean body depth during the flexion stage (10% SL). Relative head and snout length increase throughout larval development. Relative eye diameter and snout to anus length initially increase, and then they decrease in postflexion larvae.

Pigmentation (Fig. 23). Larvae of *L. medius* are lightly pigmented. The head is unpigmented throughout the early stages of development. Preflexion larvae have a row of melanophores (about five spots) along the dorsolateral surface of the gut, one melanophore on the hindgut, a melanophore near the anterior ventral midline of the gut, 27–35 PVM beginning two myomeres posterior to the anus, and a single melanophore ventral to the base of each pectoral fin. There is a patch of melanophores in the caudal region ventral to the notochord that, with development, is positioned at the base of the developing caudal-fin rays in late preflexion larvae.

Body pigmentation increases little during the flexion stage. A few melanophores form along the margin of the lower jaw. Melanophores on the dorsal surface of the gut are smaller. The caudal-fin pigment extends along the margin of both developing hypural plates, with a few melanophores on the base of the caudal-fin rays.

Postflexion larvae have a single melanophore on the opercle and a short row of pigment on the isthmus. Preanal pigment is limited to the melanophore below the pectoral-fin base and lateral spots along the gut; 1–2 spots are on the hindgut. The PVM (now 29–38) originate several myomeres posterior to the anus and are associated with the anal-fin pterygiophores. Pigment at the hypural edge extends onto the caudal-fin rays.

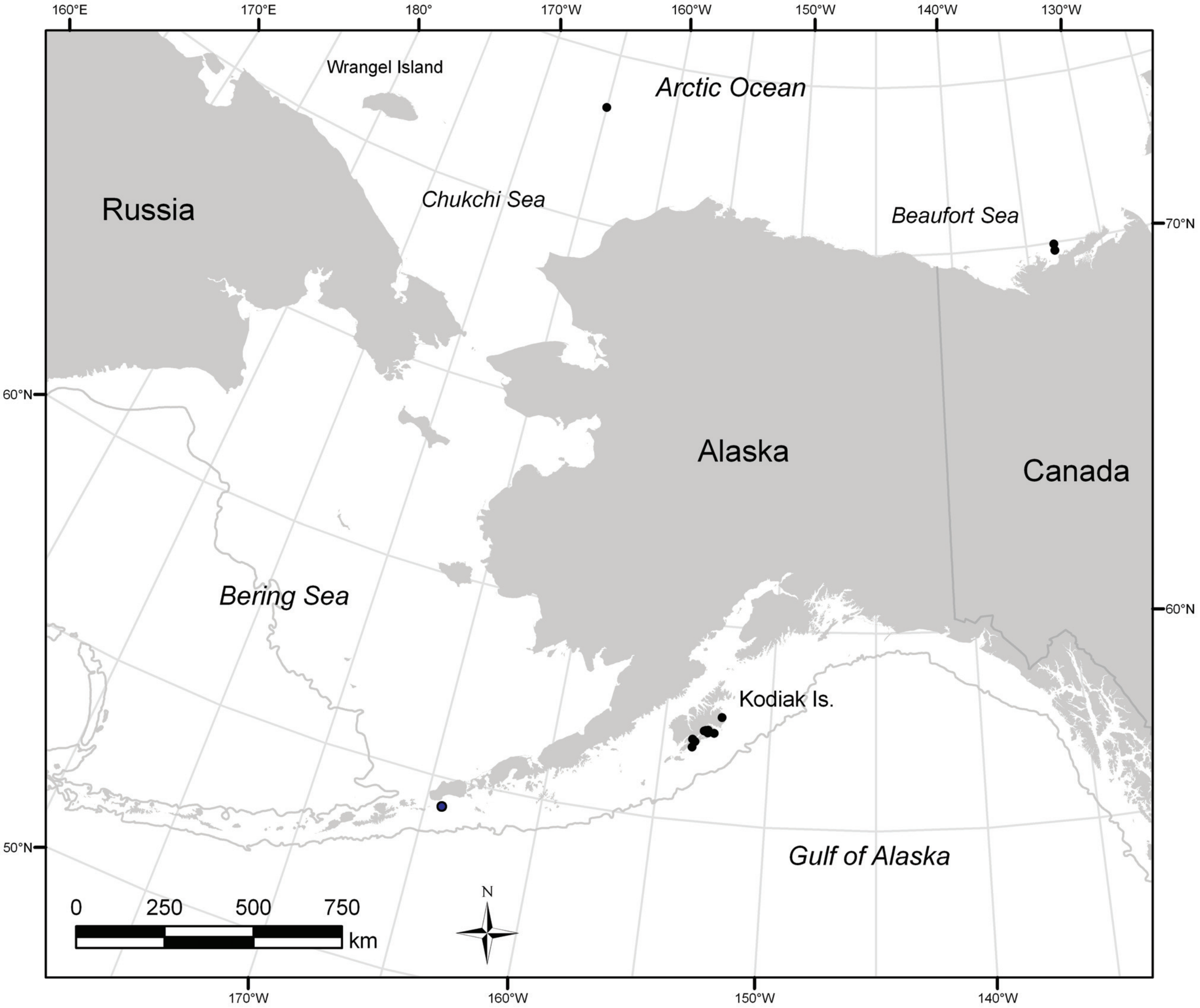

Figure 22

Distribution of larvae of Stout Eelblenny (*Lumpenus medius*) collected by bongo, Tucker, and sled gear in the Arctic Ocean, Beaufort Sea, and Gulf of Alaska. Each symbol may indicate more than one occurrence. Isobath=1000 m.

Diffuse patches of melanophores are present on the snout, crown, area between the maxilla and eye, ventrolateral surfaces of the head, and medial area of the opercle during the juvenile stage; very little ventral pigment is present on the head. A single melanophore is present on the pectoral-fin base, and another diffuse patch is present above the insertion of the pelvic fin. Approximately eight regularly spaced melanophore patches are present along the dorsal midline, with some that extend slightly onto the dorsal fin. The lateral body is covered with widely spaced, irregularly shaped pigment patches of variable size. A row of five or more regularly spaced embedded melanophores is present above the notochord on the caudal peduncle. Small patches of pigment are present on the caudal fin near its base.

Meristic features (Table 22). Nearly all of the larvae of *L. medius* available to clear and stain were in the postflexion stage. All fin elements, vertebral centra, and neural and haemal spines are developed and ossified by 33.0 mm. The count of LXIV dorsal-fin spines observed in one of the 40.0-mm specimens is greater than the count previously reported for this species (LVIII–LXIII; Matarese et al., 1989). The counts of 21 precaudal centra and 42

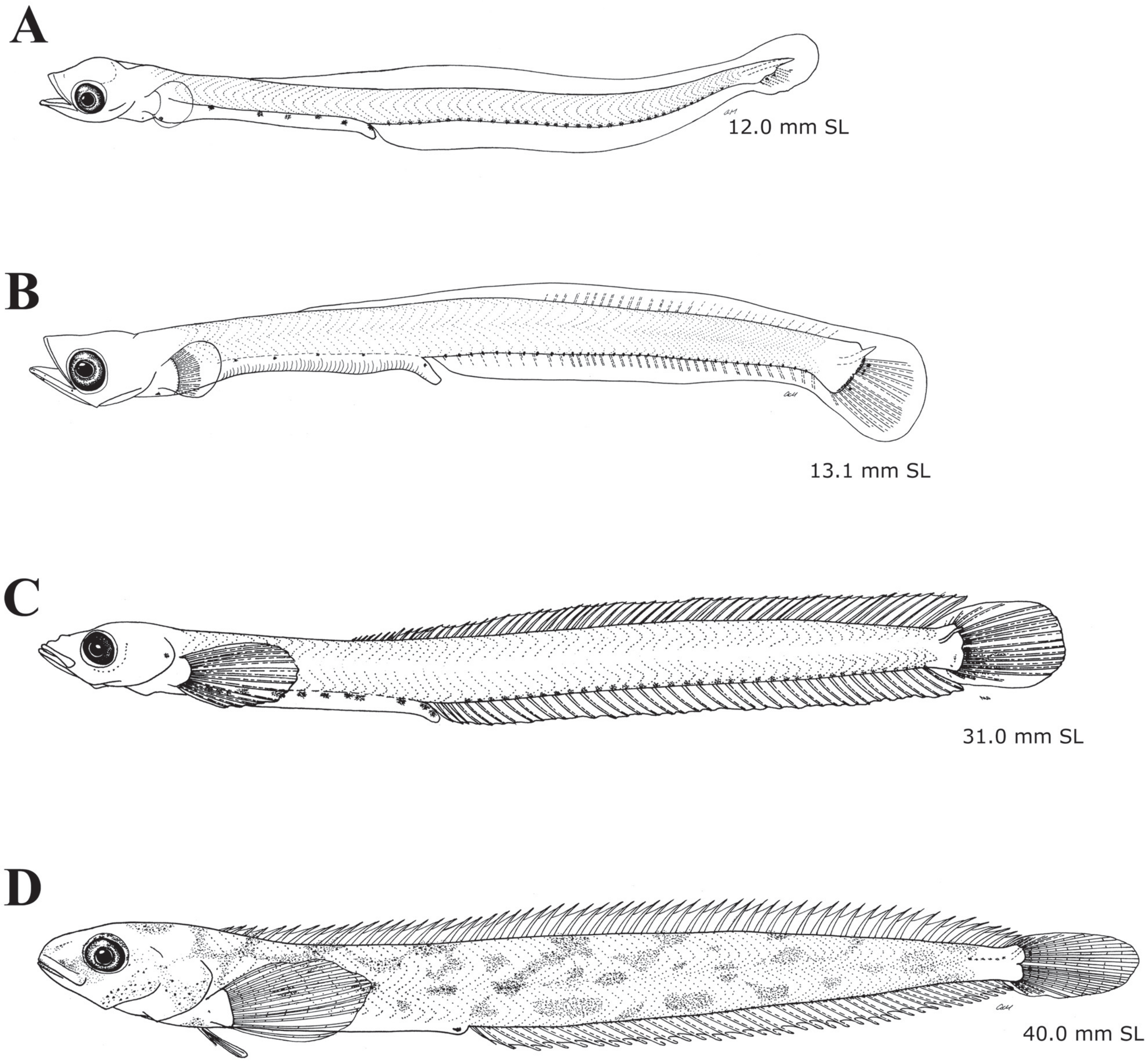

Figure 23

Larvae of Stout Eelblenny (*Lumpenus medius*): (**A**) preflexion stage, 12.0 mm standard length (SL), University of Washington (UW) 33080; (**B**) flexion stage, 13.1 mm SL, UW 33044; (**C**) postflexion stage, 31.0 mm SL, UW 145885; and (**D**) transformation stage, 40.0 mm SL, UW 33064. Illustrations by A. Overdick.

caudal centra obtained from MacDonald (2001) are lower than the counts previously reported for this species (23–25+43–50; Matarese et al., 1989). Small, early scale pockets were present on a 44.0-mm specimen that was not cleared and stained. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Pigmentation patterns are not useful for species-level identification of larvae of the genus *Lumpenus*; species are distinguished primarily by a combination of morphological and meristic differences that are present in older, more developed larvae. Preflexion-stage larvae of *L. medius*, compared to larvae of *L. fabricii* and *L. maculatus*, have a shorter gut (mean snout to anus length: 43.6% SL vs. 50.4% SL for both *L. fabricii* and *L. maculatus*) and more slender body (mean body depth: 7.0% SL vs. 8.3% SL for both of these other species). Flexion-stage larvae of *L. medius*

Table 21

Body proportions of Stout Eelblenny (*Lumpenus medius*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	24		13		33	
Standard length (mm)	11.1±0.7	(9.6–12.1)	12.3±1.1	(10.7–14.4)	38.6±4.3	(31.0–46.5)
Head length/SL	12.6±1.7	(10.7–18.8)	13.0±1.0	(11.9–15.8)	17.2±1.6	(13.6–19.9)
Snout length/HL	20.4±4.2	(15.2–29.6)[1]	20.9±5.1	(15.9–27.9)[2]	27.3±3.9	(18.9–37.9)[3]
Eye diameter/HL	32.7±4.6	(26.1–42.5)[4]	35.7±5.1	(26.8–41.7)	18.9±1.6	(16.9–23.7)
Snout to anus length/SL	43.6±1.8	(40.6–46.9)	47.2±2.1	(42.1–49.2)	44.0±1.0	(42.4–46.6)
Body depth/SL	7.0±0.8	(5.7–8.7)[5]	10.0±2.3	(6.2–12.7)[6]	7.9±0.9	(6.6–9.8)[7]

[1] *n*=18

[2] *n*=4

[3] *n*=26

[4] *n*=23

[5] *n*=22

[6] *n*=9

[7] *n*=25

Table 22

Meristic counts of cleared and stained Stout Eelblenny (*Lumpenus medius*) larvae. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

Standard length (mm)	Spines, rays				Branchi-ostegal rays	Neural spines			Haemal spines	Centra			Caudal-fin rays
	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin		Abdominal	Caudal	Total		Abdominal	Caudal	Total	
11.2													
11.8													
33.0	LVIII	I,42[1]	13	I,3	6	22	42	64	42	22	43	65	5,6+7,4
34.0	LX	I,40	13	I,3	6	23	42	65	41	23	43	66	4,6+7,3
35.0	LXII	I,40	14	I,3	6	24	44	68	44	24	45	69	4,6+7,2
40.0	LXIV	I,42	15	I,3	6	23	44	67	44	23	45	68	5,7+7,3
40.0	LXII	I,41	14	I,3	6	23	44	67	44	23	45	68	4,7+6,2

[1] Two rays on posteriormost anal-fin pterygiophore.

have a longer gut (mean snout to anus length 47.2% SL) than do larvae of *L. sagitta* (42.5% SL), and postflexion-stage larvae of *L. medius* have a shorter gut (mean snout to anus length 44.0% SL) than do larvae of *L. maculatus* (50.3% SL). During the flexion and postflexion stages, *L. medius* is deeper bodied (mean body depth: 10.0% SL, 7.9% SL) than all other species of *Lumpenus*. Counts of precaudal, caudal, and total myomeres or vertebrae (21–25+42–50=65–70) distinguish larvae and juveniles of *L. medius* from other species of *Lumpenus*. *Lumpenus medius* usually has fewer precaudal vertebrae (21–25) than do *L. maculatus* (25–30), *L. fabricii* (23–28), and *L. sagitta* (26–29) and usually has fewer total vertebrae (65–70) than do *L. fabricii* (70–75) and *L. sagitta* (75–82). Transformation in *L. medius* begins at a smaller size (>35 mm) than it does in *L. fabricii* (>45 mm). In transformation-stage and early juvenile *L. medius*, the dorsal and anal fins are connected to the caudal fin, but this connection is not observed in *L. fabricii* (Mecklenburg et al., 2002).

Lumpenus sagitta, Snake Prickleback (Figs. 24, 25; Tables 23, 24)

Literature. Blackburn (1973), Hart (1973), Shiogaki and Sasaki (1988), Mecklenburg et al. (2002).

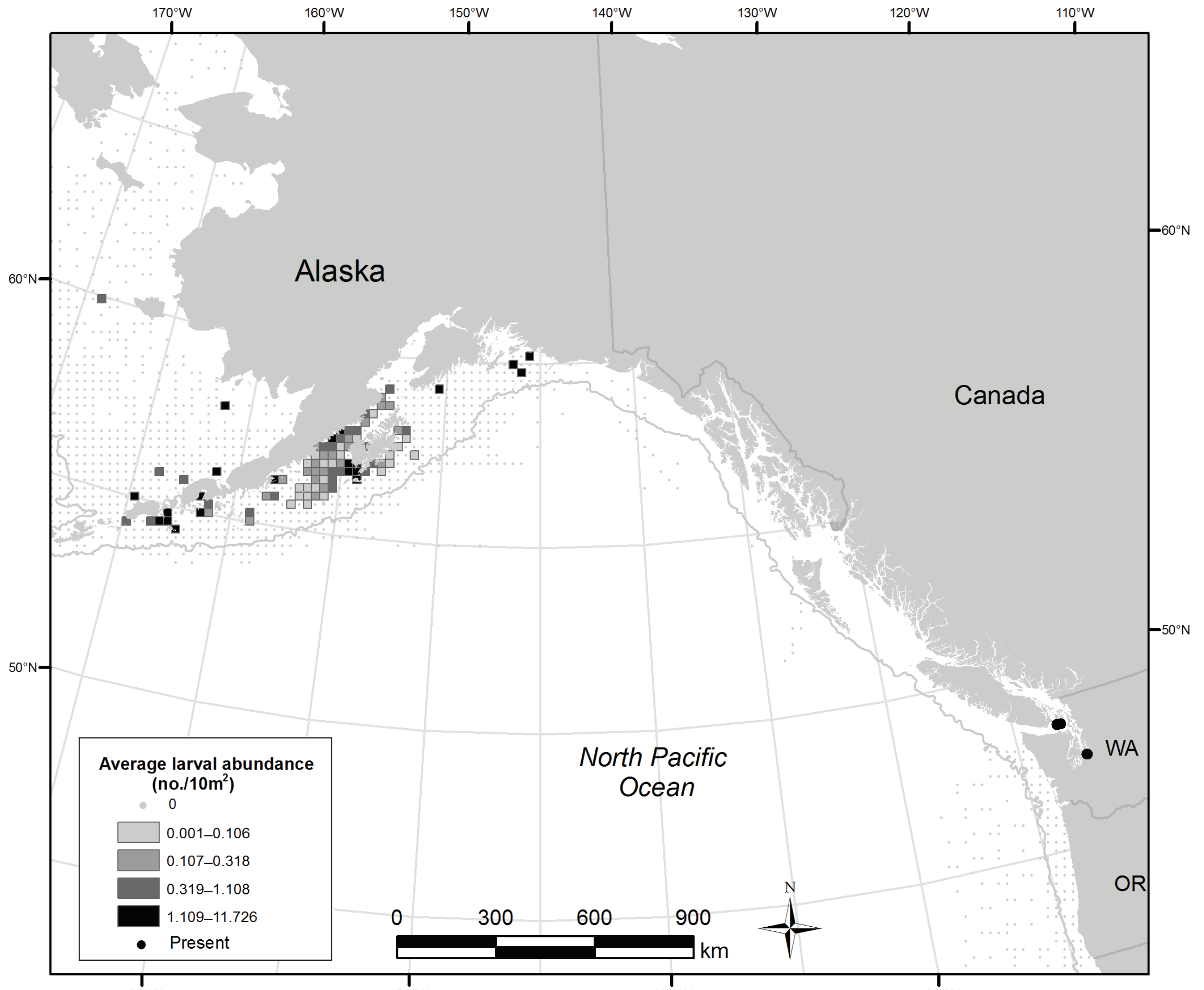

Figure 24

Distribution and abundance of larvae of Snake Prickleback (*Lumpenus sagitta*) collected in the Bering Sea, Gulf of Alaska, and Puget Sound, Washington. Squares indicate collections made by bongo net; black circles indicate additional nonquantitative collections (presence only) and may represent more than one occurrence. Isobath=1000 m.

Material examined. 93 specimens (5.8–53.0 mm) from the Bering Sea, Gulf of Alaska, and Puget Sound, Washington (see Appendix for details).

Distribution and life history. *Lumpenus sagitta* lives in demersal habitats ranging from shallow bays to offshore waters 435 m deep (but almost always <200 m) in the seas of Okhotsk and Japan, over the shelf from Norton Sound in the Bering Sea and along the Aleutian Islands, to Humboldt Bay in northern California. Adults can reach 510 mm TL but are usually less than 250 mm TL (Mecklenburg et al., 2002). Little is known of its life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic. Larvae of Snake Prickleback have been collected in February–April in Puget Sound, Washington (Blackburn, 1973); larvae 5–52 mm in length are abundant near the surface in April and May off the outlet of the Fraser River in British Columbia (Hart, 1973).

Larval distribution (Fig. 24). Larvae of Snake Prickleback of lengths 6.7–56.1 mm (mostly 17–21 mm) are collected in March–June, with the highest abundances observed in April–May, in the Bering Sea along the shelf

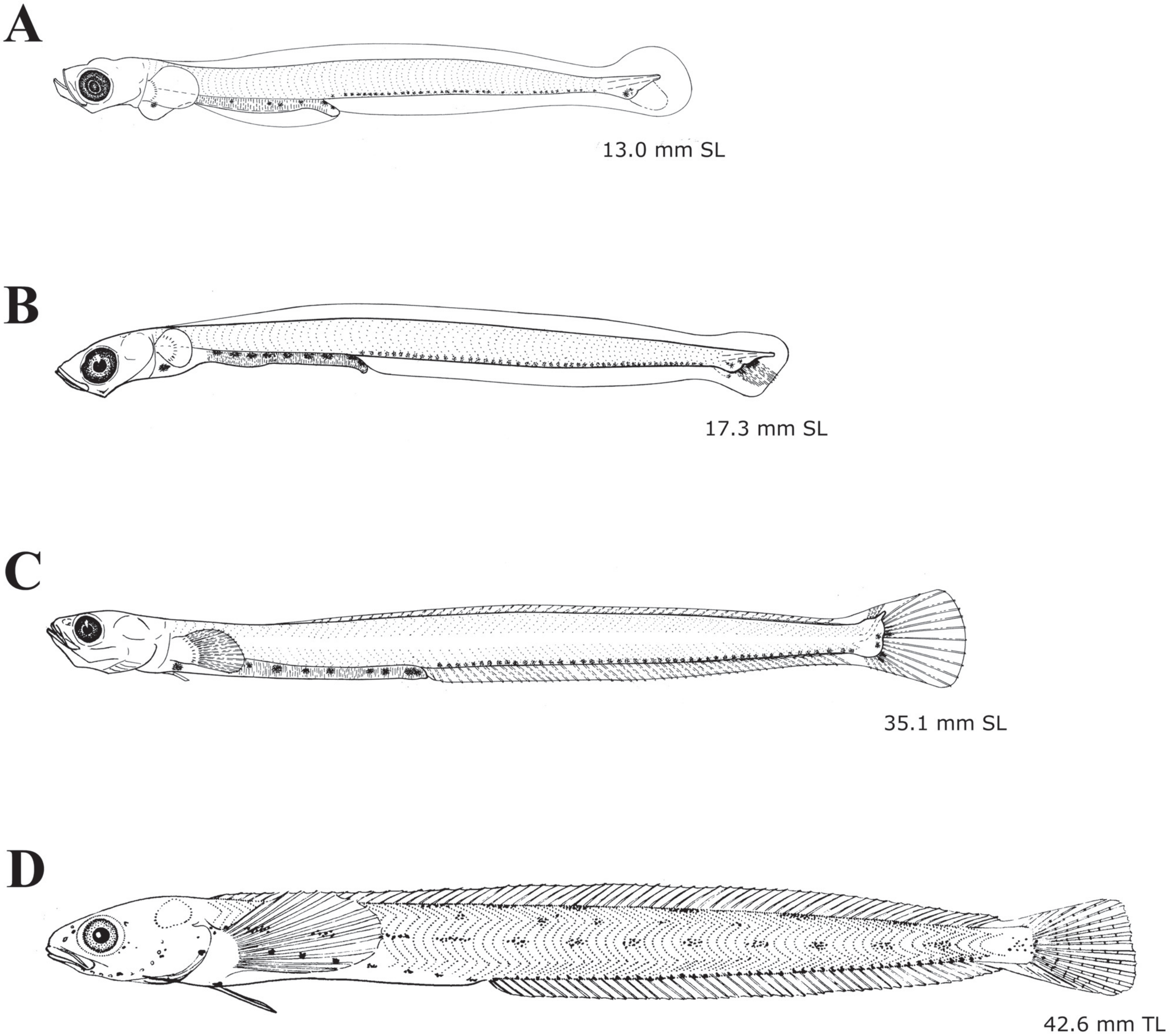

Figure 25

Larvae of Snake Prickleback (*Lumpenus sagitta*): (**A**) yolk-sac stage, 13.0 mm standard length (SL), University of Washington (UW) 95112; (**B**) flexion stage, 17.3 mm SL, UW 37176; (**C**) postflexion stage, 35.1 mm SL, UW 70841; and (**D**) transformation stage, 42.6 mm total length (TL). Illustrations (A–C) by B. Vinter and (D) from Shiogaki and Sasaki (1988).

of the Alaska Peninsula, in Unimak Pass, on the shelf in the northern Gulf of Alaska, Shelikof Strait, and around Kodiak Island to just east of Prince William Sound. Larvae are frequently collected in and around Shelikof Strait. Neither adults nor larvae have been collected during AFSC surveys off the west coast of the United States, but larvae have been collected in February–April in Puget Sound, Washington (this study; Blackburn, 1973). Larvae (5–52 mm) are abundant near the surface in April and May off the outlet of the Fraser river in British Columbia (Hart, 1973).

Morphology (Table 23). Notochord flexion in *L. sagitta* begins at 15.5 mm and is complete by 25.5 mm. Postflexion larvae are 26.0–53.0 mm. Length at the beginning of transformation is 42–44 mm; the juvenile stage begins at >53.0 mm. Larvae are slender-bodied and become more so with development, with mean body depth

Table 23

Body proportions of Snake Prickleback (*Lumpenus sagitta*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	17		21		32	
Standard length (mm)	13.3±1.7	(9.2–15.4)	19.0±3.4	(15.5–25.5)	37.5±8.5	(26.0–53.0)
Head length/SL	12.4±1.6	(9.8–16.2)	11.9±1.0	(9.9–13.4)	15.1±1.7	(11.7–17.5)
Snout length/HL	20.0±4.9	(13.0–32.3)[1]	20.1±4.6	(10.2–26.8)[2]	24.7±2.6	(17.1–29.4)[3]
Eye diameter/HL	35.5±5.8	(27.3–47.7)	36.1±5.2	(28.1–43.8)[4]	21.2±4.7	(15.0–30.3)
Snout to anus length/SL	44.4±3.2	(39.9–49.1)	42.5±1.6	(40.5–45.8)	43.8±1.4	(41.5–46.7)
Body depth/SL	7.7±0.7	(6.4–9.3)	6.4±0.5	(5.1–7.1)[5]	6.4±0.4	(5.7–7.0)[6]

[1] *n*=15

[2] *n*=16

[3] *n*=28

[4] *n*=20

[5] *n*=18

[6] *n*=29

Table 24

Meristic counts of cleared and stained Snake Prickleback (*Lumpenus sagitta*) larvae. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
5.8													
9.1													
11.7													
12.1													
12.9						2							
14.9						2							
15.3						4							
15.5													
15.9													
16.1													
17.9						3							
18.7			13										5+6
19.0													
19.5										27[1]	15[1]	42	6+7
22.0										26	55	81	6+8
25.0			16			4				27	53	80	6+8,2
25.5		20	16		4					28	52	80	2,6+8,1
27.0													
29.5						27	51	78	51	27	52	78	3,6+8,4
31.2	LX[2]	I,49	16	I,3	6	27	52	79	52	27	53	80	6,6+8,5
34.3	LXIV[2]	I,47	16	I,3	6	27	50	76	50				5,6+8,4
40.0	XLI[2]	I,51	17	I,3	6	27	54	81	54	27	55	82	6,6+8,5
42.5	LXXI	I,48	16	I,3	6	28	51	79	51	28	52	80	7,6+8,5
46.0	LXX	I,50	16	I,3	6	26	52	78	52	26	53	79	7,6+8,4

[1] Count estimated, first haemal spine not distinguishable.

[2] Dorsal-fin spines not completely developed or ossified.

declining from 7.7% SL during the preflexion stage to 6.4% SL in later stages. Relative head length initially decreases, and then it increases in postflexion larvae. Relative snout length is constant through the flexion stage but increases in the postflexion stage. Relative eye diameter increases slightly from the preflexion stage to the flexion stage, and then it decreases in postflexion larvae. Relative snout to anus length decreases from the preflexion stage to the flexion stage and then increases slightly in postflexion larvae.

Pigmentation (Fig. 25). Larvae of *L. sagitta* are lightly pigmented. The head is unpigmented in larvae prior to transformation. A single melanophore appears ventral to the pectoral-fin base in the preflexion stage. About 5–6 melanophores are spaced irregularly over the dorsolateral surface of the gut and hindgut. A PVM series (≤40), sometimes irregularly spaced, extends from about the anus to the caudal peduncle. Caudal pigment is restricted to several small melanophores in the hypural area.

The melanophore below the pectoral-fin base becomes larger and more prominent in the flexion stage. Up to 10 (usually 5–8 + 2 on hindgut) melanophores appear along the dorsolateral surface of the gut. The number of PVM increases to 44–53, with about one melanophore per myoseptum in late flexion. Several spots appear in the hypural and caudal finfold areas and at the base of the developing caudal-fin rays.

Pigmentation changes are minimal in postflexion larvae. Preanal pigment is limited to the large melanophore below the pectoral-fin base and the dorsolateral spots on the gut. The PVM series begins several myomeres posterior to the anus. Pigment remains at the hypural edge and on the base of the caudal-fin rays.

During transformation, melanophores are present on the snout, the area posterior to the orbit, and the medial area of the opercle. A single, large melanophore is present at the edge of the gill cover, and another is present above the insertion of the pelvic fin. Approximately six regularly spaced clusters of melanophores are present along the dorsal midline. The mediolateral body is covered with regularly spaced, dash-like clusters of melanophores above the gut, with patches of variable size positioned posteriorly along the lateral line. Additional small, regularly spaced clusters or series of melanophores are present between the lateral and dorsal midline. A loose aggregation or cluster of melanophores is present at the caudal-fin base and hypural region with a row of melanophores that radiate onto the ventral caudal fin.

Meristic features (Table 24). Principal caudal-fin rays are present by 12.1 mm and developed by 20.0 mm. Ossification begins before all principal caudal-fin rays are developed; some of these rays are weakly ossified before 19.0 mm. The count of 8 inferior principal caudal-fin rays found in most of the cleared and stained specimens is greater than the count previously reported for this species (7; Watson, 1996). Procurrent caudal-fin rays are present by 19.0 mm and are developed and ossified by 31.2 mm. The count of 5 superior procurrent caudal-fin rays observed in the 34.3-mm specimen is lower than the count previously reported for this species (6–7; Watson, 1996). Anal-fin elements are present after 22.0 mm, begin to ossify by 25.5 mm, and are developed and ossified by 31.2 mm. Dorsal-fin spines are present by 25.0 mm and begin to ossify by 31.2 mm; development and ossification are complete by 40.0 mm. The anteriormost dorsal-fin spines were only partially developed and weakly ossified in the largest larva examined (46.0 mm). Pectoral-fin rays are present by 18.0 mm and can begin to ossify by 19.0 mm, but they more typically are developed and ossified by 25.0 mm. The pelvic-fin elements are first present as fleshy buds at 27.0 mm and are developed and ossified by 31.2 mm. Vertebral centra are present by 19.0 mm and begin to ossify at around 19.5 mm before development is complete. By 22.0 mm, all vertebral centra were developed and ossified in most specimens. The count of 55 caudal centra observed in the 22.0- and 40.0-mm specimens is greater than the count previously reported for this species (46–54; Watson, 1996). Neural and haemal spines are ossified by 29.5 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Species of *Lumpenus* can be distinguished primarily by a combination of morphological and meristic differences that are present in older, more developed larvae. Mean snout to anus length is shorter for larval *L. sagitta* (44.4% SL, 42.5% SL, and 43.8% SL at preflexion, flexion, and postflexion stages) than for *L. fabricii* during preflexion stage (50.4% SL) and for *L. maculatus* at all stages (50.4% SL, 49.4% SL, and 50.3% SL at preflexion, flexion, and postflexion stages). Larval *L. sagitta* are more slender (mean body depth 7.7% SL) than are larvae of *L. fabricii* (8.3% SL) during the preflexion stage, *L. medius* during the flexion and postflexion stages (mean body depth: 6.4% SL vs. 10.0–7.9% SL), and *L. maculatus* at all stages (mean body depth: 7.7–6.4% SL vs. 8.3–7.5% SL). Counts of precaudal, caudal, and total myomeres or vertebrae (26–29+46–55=75–82) can in most cases distinguish larvae and juveniles of *L. sagitta* from other species of *Lumpenus*. Larvae of *L. sagitta* have more precaudal vertebrae (26–29) than do larvae of *L. medius* (21–25), more total vertebrae (75–82) than do larvae of *L. maculatus* (66–72) and *L. medius* (65–70), and usually more total vertebrae than do larvae of *L. fabricii* (70–75). In addition, larvae of *L. sagitta* have more PVM during postflexion (44–53, usually ≥50) than do larvae of other species of *Lumpenus* (*L. fabricii* 33–37, *L. medius* 29–38, *L. maculatus* 34–41).

Poroclinus rothrocki, Whitebarred Prickleback (Figs. 26, 27; Tables 25, 26)

Literature. Miller and Lea (1972), Eschmeyer et al. (1983), Mecklenburg et al. (2002).

Material examined. 70 specimens (5.5–48.0 mm) from the Bering Sea, Gulf of Alaska, the coast of British Columbia, Canada, and the Washington and Oregon coasts (see Appendix for details).

Distribution and life history. *Poroclinus rothrocki* is commonly found at depths of 46–128 m (Mecklenberg et al., 2002), but it has been found as deep as 420 m (Miller and Lea, 1972) in the southeastern Bering Sea and Aleutian Islands to southern California. Maximum length is 250 mm TL (Eschmeyer et al., 1983). Little is known of its life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Fig. 26). Larvae of Whitebarred Prickleback are the most abundant of any stichaeid in

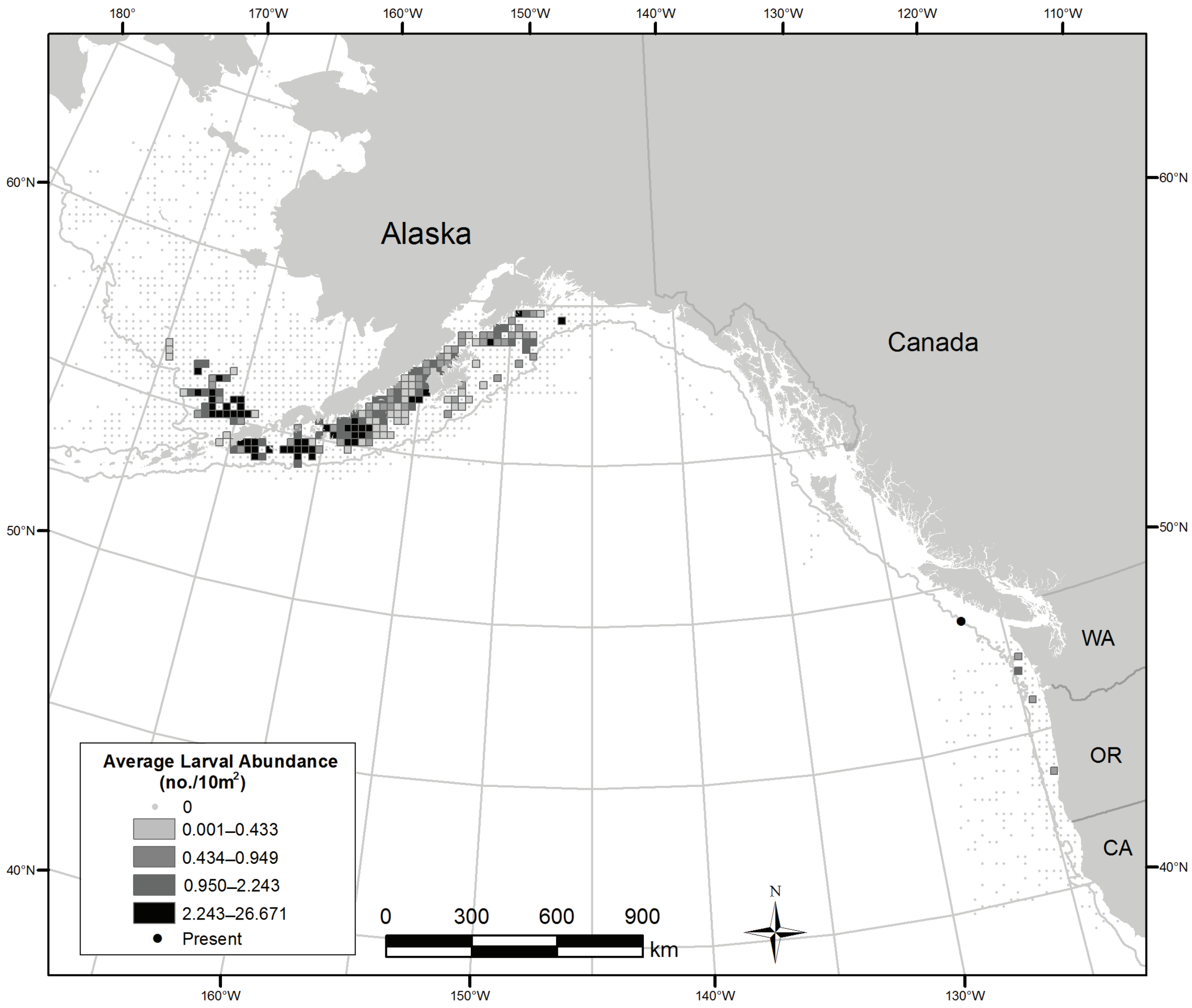

Figure 26

Distribution and abundance of larvae of Whitebarred Prickleback (*Poroclinus rothrocki*) collected in the Bering Sea, Gulf of Alaska, and North Pacific Ocean off the coasts of British Columbia, Canada, and Washington and Oregon. Squares indicate collections made by bongo net; black circle indicates additional nonquantitative collection (presence only) and may represent more than one occurrence. Isobath=1000 m.

our study area and are distributed throughout the outer shelf regions from the Bering Sea and Unimak Pass areas to Shelikof Strait, around Kodiak Island eastward to Prince William Sound, and along the western coast of North America off British Columbia, Washington, and Oregon. Larvae (6.1–30.2 mm) are found in late March–July, with the highest abundances observed in May and June.

Morphology (Tables 25, 26). Notochord flexion in *P. rothrocki* begins at 9.6–10.8 mm and is complete by 20.0 mm. Postflexion larvae are 19.9–28.1 mm. Transformation can begin by 28 mm, and the juvenile stage begins by 38 mm. Larvae are slender-bodied with a mean body depth of 9.5% SL in the preflexion stage, decreasing to 6.3% SL in the flexion stage and increasing to 8.5% SL in the postflexion stage. Relative head length remains constant through development, but relative snout length first decreases then increases during development. Relative eye diameter and snout to anus length decrease with development.

Pigmentation (Fig. 27). Larvae of *P. rothrocki* are moderately pigmented. Among stichaeids, they have a unique caudal pigment pattern. The head is unpigmented through the early postflexion stage (<25 mm). In preflexion larvae, the gut is distinctly pigmented laterally with a large spot just below the pectoral fin. Continuing along the gut posteriorly from this spot, 2–3 large melanophores are present on the dorsal surface, followed by a break and then 3–4 more large melanophores along the hindgut. Preflexion larvae have a series of large PVM (about 38–39) beginning 3–4 myomeres posterior to the anus. Distinct from the PVM are about four larger melanophores in the area of the caudal peduncle just below the notochord. Larvae usually have about 4–12 dorsal midline melanophores that begin at about the posteriormost 15 myomeres.

Late preflexion larvae develop a spot on the isthmus, and the large melanophore below the pectoral fin spreads onto the fin base. The anteriormost dorsal midline melanophores become embedded.

By the flexion stage, larvae develop the distinctive postanal melanophore pattern that easily distinguishes them from most other stichaeids. PVM increase in number to about 40–41 spots that remain through the postflexion stage. Although still visibly larger, the posteriormost spots below the notochord in the peduncle area merge with the PVM. The dorsal midline melanophores migrate internally to just above the notochord and decrease in number from a maximum of 12 in preflexion larvae to about 5–6 in flexion larvae.

During the postflexion stage, larvae ≤25 mm have several small melanophores in the isthmus area. A few internal melanophores are visible in the area of the hindbrain. The large melanophore at the base of the pectoral fin remains but is more internal. The gut has about 4–6 large, variably spaced spots along its entire dorsal length, including the hindgut. The caudal peduncle area is distinctly pigmented with 3–5 large melanophores above and below the notochord. External pigment is present in the hypural area.

Transformation-stage individuals have a covering of fine melanophores on the crown. Aggregations of larger melanophores on the snout and a dense patch posterior of the orbit give the appearance of a diagonally oriented streak passing through the eye. Additional melanophores are present in an arc-shaped patch on the medial area of the opercle. Five evenly spaced, irregularly shaped patches are present in an arc that extends from the lower jaw along the outer edge of the operculum to a point near the dorsal insertion of the pectoral fin. Nine large connected patches of melanophores that resemble triangles or irregularly shaped diamonds are present on the dorsal half of the body, extending from just posterior of the head to the caudal peduncle. The apex of each patch is more heavily pigmented than the remainder, with some melanophores extending onto the dorsal fin membrane. A crescent-shaped patch is present on the hypural region and is connected to the adjacent patch on the caudal peduncle. Pigmentation from this crescent-shaped patch extends dorsally and ventrally onto the caudal fin. Irregularly spaced aggregations of melanophores are present along the distal margin of the dorsal fin.The anal fin is completely unpigmented. Several smaller, irregularly shaped and unevenly spaced ventrolateral patches are present from the pectoral-fin base to the caudal peduncle. The patches posterior to the insertion of the first anal-fin spine are close to or touch the ventral midline of the body. The series of internal melanophores below the notochord described for earlier stages remains visible. These melanophores are small and closely spaced, extending farther anteriad than before because of their increased number (8–10).

Meristic features (Table 26). Principal caudal-fin rays are present between 10.0 and 12.0 mm, developed by 18.8 mm, and ossified by 24.0 mm. Procurrent caudal-fin rays are present by 22.5 mm. Ossification begins at 24.0 mm before all procurrent caudal-fin rays are developed. All procurrent caudal-fin rays are developed and ossified by 26.0 mm. Anal-fin elements are present by 17.9 mm, and dorsal-fin spines are present by 18.8 mm. Both are developed at 20.0 mm and ossified by 22.5 mm. Pectoral-fin rays are present by 12.0 mm, developed by 14.3 mm, and begin to ossify at 22.5 mm; ossification is complete by 24.0 mm. Pelvic-fin elements are present at 18.8 mm. The pelvic-fin spine is developed and ossified by 24.0 mm, as are the rays by 28.0 mm. Vertebral centra are present at 12.0 mm. All

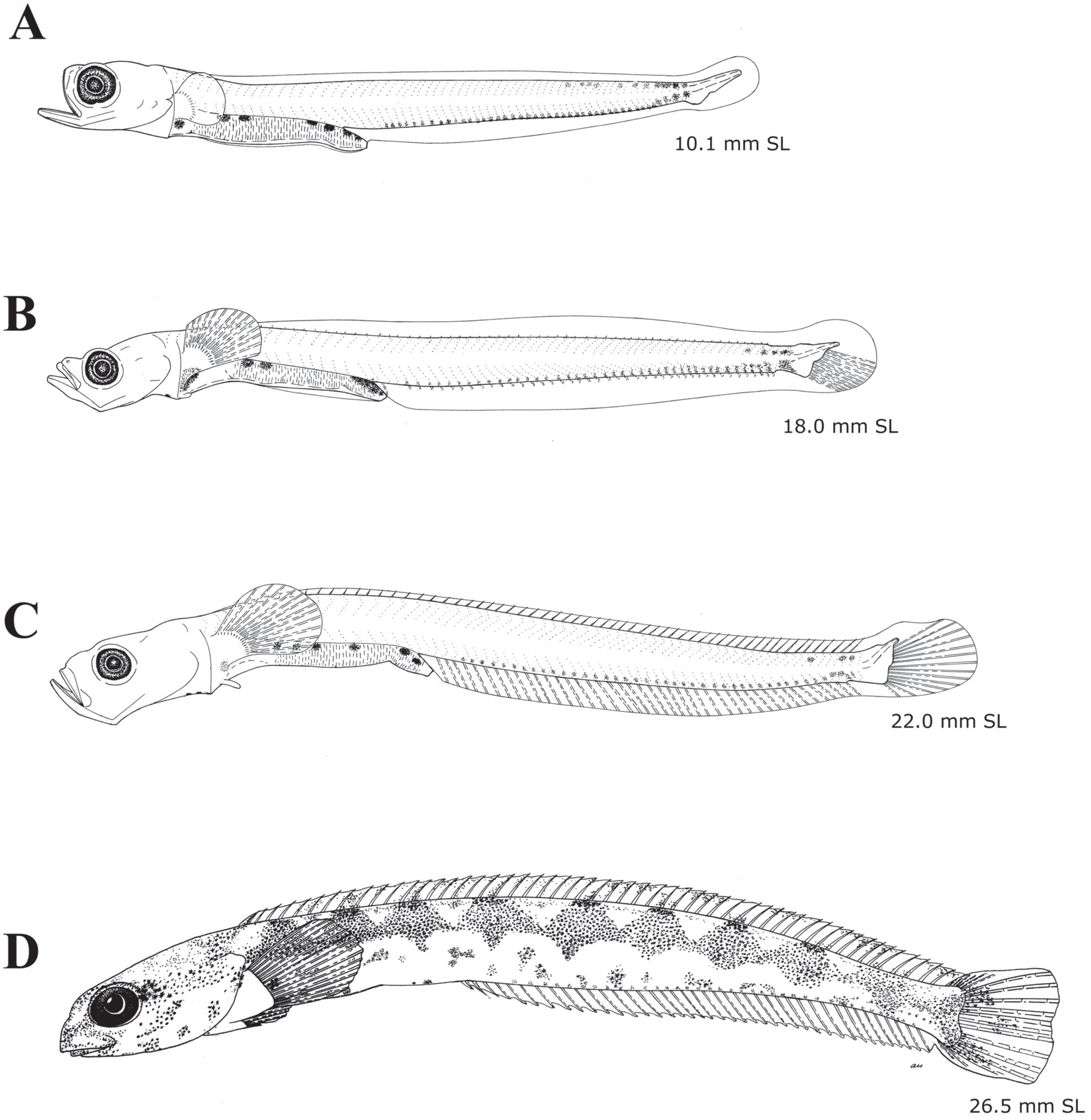

Figure 27

Larvae of Whitebarred Prickleback (*Poroclinus rothrocki*): (**A**) preflexion stage, 10.1 mm standard length (SL), University of Washington (UW) 145127; (**B**) flexion stage, 18.0 mm SL, UW 145128; (**C**) postflexion stage, 22.0 mm SL, UW 72252; and (**D**) transformation stage, 26.5 mm SL, UW 145891. Illustrations by B. Vinter.

vertebral centra and neural and haemal spines are developed by 16.1 mm and ossified by 20.0 mm. The total count of 64 vertebral centra observed in the 22.5- and 26.0-mm specimens is lower than the total count previously reported for this species (65–68; Watson, 1996). Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larval *P. rothrocki* are similar to species of *Lumpenus* and *Lumpenella longirostris* but can be distinguished by the irregularly spaced row of embedded melanophores above and below the notochord on the caudal peduncle. The break in the spacing of the melanophores dorsally along the gut in preflexion and flexion larvae is unique to *P. rothrocki*.

Table 25

Body proportions of Whitebarred Prickleback (*Poroclinus rothrocki*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	9		50		31	
Standard length (mm)	9.5±0.8	(8.6–10.8)	13.5±2.3	(9.6–18.4)	23.8±2.3	(19.9–28.1)
Head length/SL	16.5±1.6	(14.4–18.7)[1]	16.3±1.4	(12.2–21.5)	16.6±1.0	(14.4–19.0)[2]
Snout length/HL	23.9±3.7	(18.7–28.8)[1]	20.4±5.0	(9.8–29.8)[3]	29.0±3.4	(19.9–36.2)[2]
Eye diameter/HL	39.3±4.9	(29.9–46.2)[1]	31.0±4.9	(20.9–42.8)[3]	24.1±2.5	(17.5–28.6)[2]
Snout to anus length/SL	45.6±4.4	(42.0–55.7)	43.4±2.1	(38.8–50.3)	43.7±1.6	(39.1–47.2)[4]
Body depth/SL	9.5±1.0	(7.8–11.5)	6.3±0.9	(4.7–9.6)	8.5±0.6	(7.4–9.9)

[1] *n*=8

[2] *n*=30

[3] *n*=49

[4] *n*=29

Table 26

Meristic counts of cleared and stained Whitebarred Prickleback (*Poroclinus rothrocki*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
5.5													
10.0													
12.0													
12.5													
14.3													
16.1													
17.9													
18.8													
20.0					5	19	36	55	36	19	48	67	6+5
22.5	LIX	III,42	2		6	4[1]	44	48	44	19	45	64	6+6
24.0	LIX	III,42	14	I	6	19	46	65	46	19	47	66	4,7+6,3
26.0	LX	III,43	14	I	6	19	44	63	44	19	45	64	5,7+6,4
28.0	LIX	III,42	14	I,3	6	19	45	64	45	19	46	65	5,7+6,4
38.0	LIX	III,*	14	I,3	6	18	46	64	46	18	47	65	*
48.0	LIX	III,43	14	I,3	6	19	46	65	47	19	48	67	5,7+6,4

[1] All neural spines present but only four with stain noted as ossified.

* Character damaged or missing.

Subfamily Opisthocentrinae

Lumpenopsis hypochroma, Y-prickleback

See “Other material” section of this guide.

Opisthocentrus ocellatus, Ocellated Blenny (Fig. 28, Table 27)

Literature. Tokuya and Amaoka (1980), Shiogaki (1981, 1982), Mecklenburg et al. (2002).

Material examined. Seven specimens (13.6–15.8 mm) from the Sea of Japan (see Appendix for details).

Distribution and life history. *Opisthocentrus ocellatus* is found in the Sea of Okhotsk off southeastern Kamchatka, the Sea of Japan off North Korea, and the Kuril and Commander Islands; it has not been reported from North America. Ocellated Blenny has been collected at depths >300 m off Hokkaido, but this species is usually found among seaweed in shallow coastal areas <70 m deep (Mecklenburg et al., 2002). Adults can grow to 200 mm TL (Mecklenburg et al., 2002) and reach maturity at 1 year (Shiogaki, 1982). Adhesive masses of 700–3300 eggs are spawned in narrow cavities under stones on muddy sand bottoms and guarded by the female. Eggs are 1.9–2.0 mm in diameter with one large and many small, yellow oil globules. Eggs hatch after 48 days at 5–10°C; larvae hatch at 9–10 mm (Shiogaki, 1982).

Larval distribution. Larvae of Ocellated Blenny have not been collected from our study area. Five preflexion-stage and two flexion-stage larvae (13.6–15.8 mm) collected at one location in April off Usujiri, southwest Hokkaido, Japan, were available for examination (see Appendix).

Morphology (Table 27). Notochord flexion in *O. ocellatus* begins at 14.4–15.8 mm, and it is unknown from available material when it is complete. As illustrated by Tokuya and Amaoka (1980), transformation appears to begin at about 19.5 mm before notochord flexion is complete; the juvenile stage appears to begin before 22.0 mm. Larvae are initially slender (mean body depth 9.0% SL), becoming moderately deep-bodied (11.8% SL) in the flexion stage. Relative head and snout lengths and snout to anus lengths all increase through the flexion stage, while relative eye diameter decreases.

Pigmentation (Fig. 28). Pigment description is based in part on Shiogaki (1982) and Tokuya and Amaoka (1980). Larvae of *O. ocellatus* are lightly pigmented. The head is unpigmented in preflexion larvae. Initially, the nape region has several spots. A single spot occurs on the cleithrum. About six stellate melanophores are arrayed dorsolaterally along the gut, and several melanophores occur dorsally on the hindgut. A ventral series of evenly spaced melanophores extends along the midline of the gut from the cleithral pigment and continues to the anus. A PVM series (<40) of one melanophore per myoseptum extends from the second postanal myomere to the caudal peduncle. A melanophore occurs in the area where the hypural bones are forming.

The pigment pattern changes little in flexion-stage larvae. Several spots are added in the opercular area, and a few PVM extend into the hypaxial area.

In juveniles, melanophores completely cover the snout, crown, nape, and lateral body. Two darker streaks radiate posteriorly outward from the eye, with one projecting towards the crown and the other projecting ventrally onto the opercular region. In general, the opercular region is lightly pigmented, with the exception of this streak and some irregularly spaced melanophores scattered between the streak and heavier pigmentation that covers the crown and nape. Another dark streak of pigment that resembles a vertically projecting arc is present below the eye; an arc-shaped row of single melanophores connects it with the streak on the operculum. A triangular-shaped patch of melanophores with the tip pointing ventrally is present on the pectoral-fin blade that is otherwise unpigmented. The lateral and ventral surfaces of the gut also are unpigmented. Numerous irregularly spaced areas on the lateral body, where the melanophore covering is slightly less dense, give the appearance of lighter spots. The base of the dorsal fin is covered with a continuous line of dark pigment with four evenly spaced spots. The continuous line of dorsal pigmentation becomes increasingly thicker posteriorly over the caudal peduncle, covering from one-half to more than three-fourths of the dorsal fin. The anal fin below the caudal peduncle is similarly pigmented but to a lesser extent. A large blotch extends posteriorly from the hypurals and covers about two-thirds of the caudal fin surface.

Meristic features. In the single cleared and stained preflexion larva (12.5 mm), pectoral-fin rays were present, but no development of other fin elements was observed. Neural and haemal spines were developed but unossified, and vertebral centra were present. Hypurals were present, but no caudal-fin rays were present. All paired and median fins, except for the caudal fin, are developed in the 22.1-mm juvenile illustrated by Tokuya and Amaoka (1980). Pelvic fins are absent. All fins are developed in the 33.0-mm juvenile illustrated by Tokuya and Amaoka (1980). Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larvae of *O. ocellatus* are similar to most species in the subfamily Xiphisterinae, particularly species of *Anoplarchus,* but can be distinguished by the evenly spaced row of large stellate melanophores that

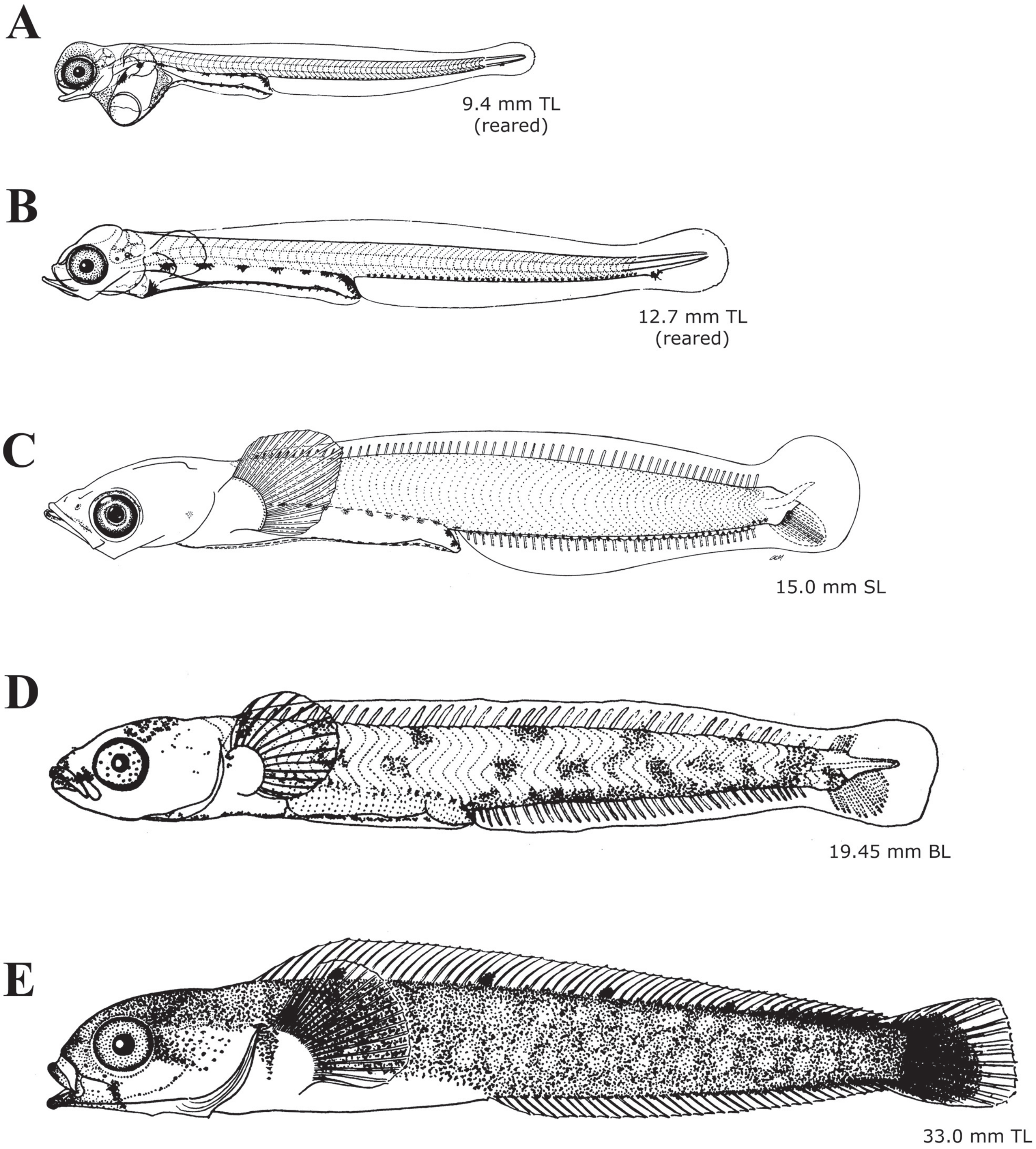

Figure 28

Larvae of Ocellated Blenny (*Opisthocentrus ocellatus*): (**A**) preflexion stage, 9.4 mm total length (TL); (**B**) late preflexion stage, 12.7 mm TL; (**C**) flexion stage, 15.0 mm standard length (SL), composite of 14.4- and 15.2-mm TL specimens, Hokkaido University Museum of Zoology (HUMZ-L) 02671; (**D**) flexion stage, 19.5 mm body length (BL); and (**E**) juvenile, 33.0 mm TL. Illustrations (A–B, E) from Shiogaki (1982, A–B reared), (C) by A. Overdick, and (D) from Tokuya and Amaoka (1980).

Table 27

Body proportions of Ocellated Blenny (*Opisthocentrus ocellatus*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion
Sample size	5		2		
Standard length (mm)	14.5±0.9	(13.6–15.8)	14.8±0.6	(14.4–15.2)	
Head length/SL	14.6±0.9	(13.4–15.4)	19.8±0.3	(19.6–19.9)	
Snout length/HL	24.8±5.3	(18.3–32.4)	28.0±1.6	(26.9–29.1)	
Eye diameter/HL	35.7±4.1	(31.4–42.1)	28.1±0.3	(27.8–28.3)	
Snout to anus length/SL	48.2±1.1	(47.1–49.5)	53.2±1.6	(52.0–54.3)	
Body depth/SL	9.0±0.6	(8.6–10.0)	11.8±0.4	(11.5–12.1)	

occur ventrally along the entire length of the gut; in species of *Anoplarchus,* a line or row of small punctate melanophores extends only over the anterior two-thirds to three-fourths of its length. In addition, *O. ocellatus* has a longer mean snout to anus length (48.2–53.2% SL vs. 41.1–43.2% SL) and more precaudal vertebrae (21–23) than species of *Anoplarchus* (17–19). These comparisons were made on the basis of examination of very few specimens.

Plectobranchus evides, Bluebarred Prickleback (Figs. 29, 30; Tables 28, 29)

Literature. Hart (1973), Eschmeyer et al. (1983), Matarese et al. (1989), Watson (1996), Mecklenburg and Sheiko (2004).

Material examined. 17 specimens (7.0–49.0 mm) from the coast of Oregon (see Appendix for details).

Distribution and life history. *Plectobranchus evides* is found over mud, gravel, or sand bottoms 84–368 m deep (Eschmeyer et al., 1983; Mecklenberg and Sheiko, 2004) from central British Columbia to southern California. Adults can grow to 132 mm TL (Hart, 1973). Little is known of the early life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Fig. 29). Larvae of Bluebarred Prickleback have not been collected during AFSC ichthyoplankton surveys. Larvae (4.7–49.0 mm) are collected off the northern and central coast of Oregon during March–May and July. Larvae are found in winter and spring, primarily in February–April, during CalCOFI surveys (Watson, 1996).

Morphology (Table 28). Notochord flexion in *P. evides* begins after 11.0 mm (only one flexion larva was available for examination) and is complete before 20.0 mm. Postflexion larvae are 20.0–50.0 mm. Transformation begins after 50.0 mm, and length at the beginning of the juvenile stage is unknown. Larvae are slender throughout development (mean body depth: 8.9% SL, 7.9% SL, 9.5% SL, in the preflexion–postflexion stages). Relative head length increases throughout larval development. Relative snout to anus length decreases slightly from the preflexion stage to the postflexion stage. Relative snout length and eye diameter decrease during larval development.

Pigmentation (Fig. 30). Larvae of *P. evides* are moderately pigmented. Among stichaeids, they have a unique pigment pattern composed of patches along the postanal body. The head is unpigmented through the early postflexion stage (<27 mm). In preflexion-stage larvae, three patches are present anterior to the anus: the first patch is on the lateral surface of the gut near the base of the pectoral fin, the second is above the dorsal margin of the gut midway between the pectoral fin and anus, and the third patch is composed of melanophores on the hindgut and above the dorsal margin of the hindgut. Postanal pigment consists of three patches: the anteriormost is ventrolateral, the next is a lateral bar at about 85% SL, and the posterior patch encircles the tail with melanophores above and below the notochord tip as well as in the caudal peduncle and finfold area.

During the flexion stage, the melanophores above the gut increase in size and develop internally. Along the postanal body, the middle patch becomes primarily mediolateral and the melanophores in the posteriormost patch become larger but fewer in number. Mediolateral spots later appear in the caudal peduncle area, in addition to melanophores around the notochord tip, along the hypural edge, and extending onto the developing caudal-fin rays.

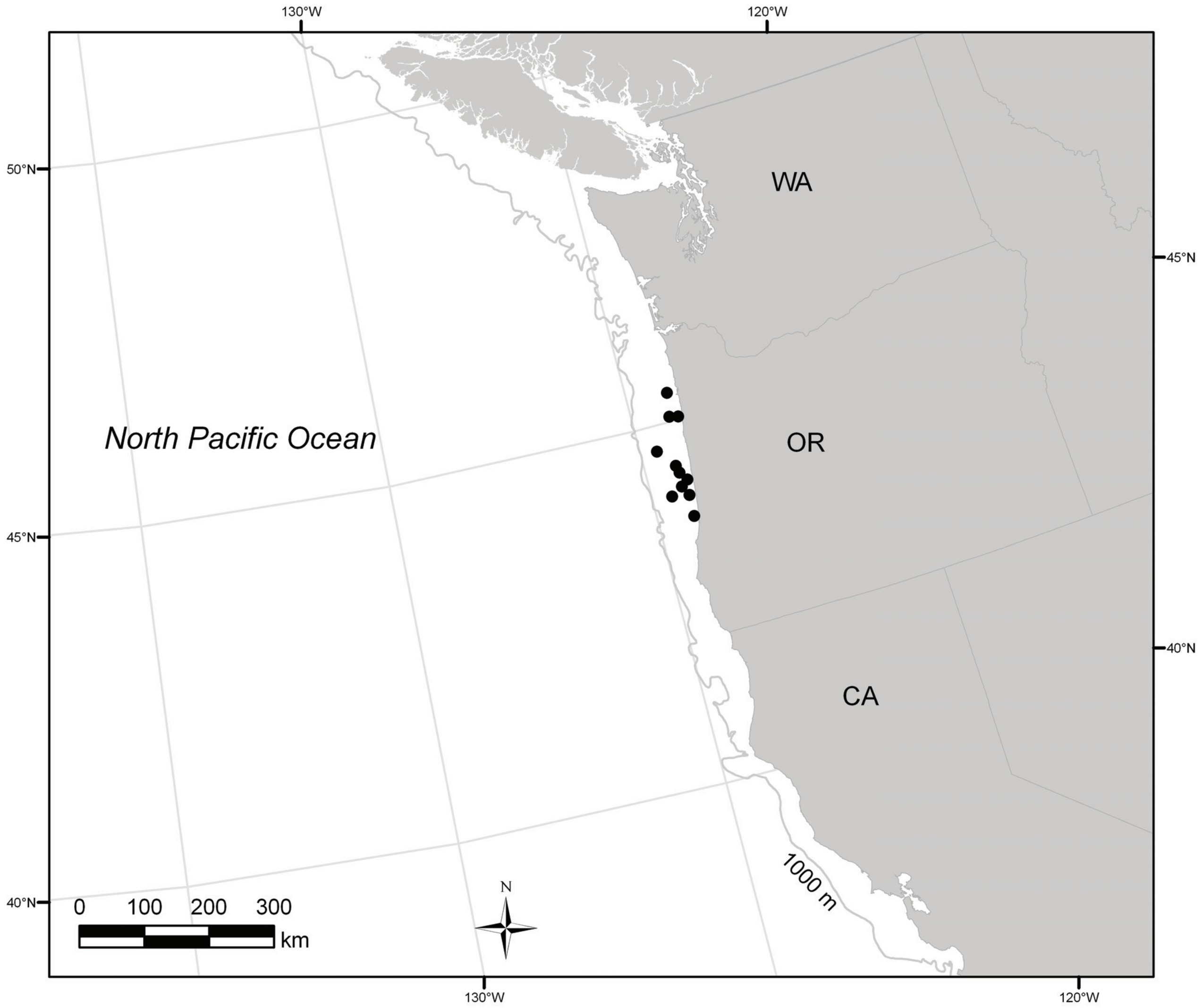

Figure 29

Distribution of larvae of Bluebarred Prickleback (*Plectobranchus evides*) collected in the North Pacific Ocean off the Oregon coast. Each symbol may indicate more than one occurrence. Isobath=1000 m.

By the early postflexion stage, some pigment develops externally on the snout, at the jaw angle, and posteriorly on the mid- and hindbrain. The pigment near the base of the pectoral fin is internal and may be difficult to see. Most of the melanophores in the remaining five pigment patches become primarily internal, but external pigment remains along the hindgut and in the three postanal patches. Mediolateral pigment in the caudal peduncle area increases anteriorly, and melanophores are present on the caudal-fin rays along the hypural edge.

Meristic features (Table 29). No flexion larvae were available for clearing and staining. All fin elements except pelvics are developed and ossified in postflexion larvae by 23.0 mm. The pectoral-fin and anal-fin rays, however, are only weakly ossified. The count of two inferior procurrent caudal-fin rays observed in the 23.0- and 39.5-mm specimens is lower than the count previously reported for this species (3–4; Watson, 1996). Vertebral centra and neural and haemal spines also are developed and ossified by 23.0 mm. The counts of 21 precaudal centra and 61 total vertebral centra observed in the 34.0-mm specimen are greater than the counts previously reported for this species (20+39–40=59–60; Watson, 1996). Pelvic-fin elements are present by 23.0 mm and developed and ossified by 39.5 mm, perhaps earlier. Ranges of adult meristic counts are given in Table 2.

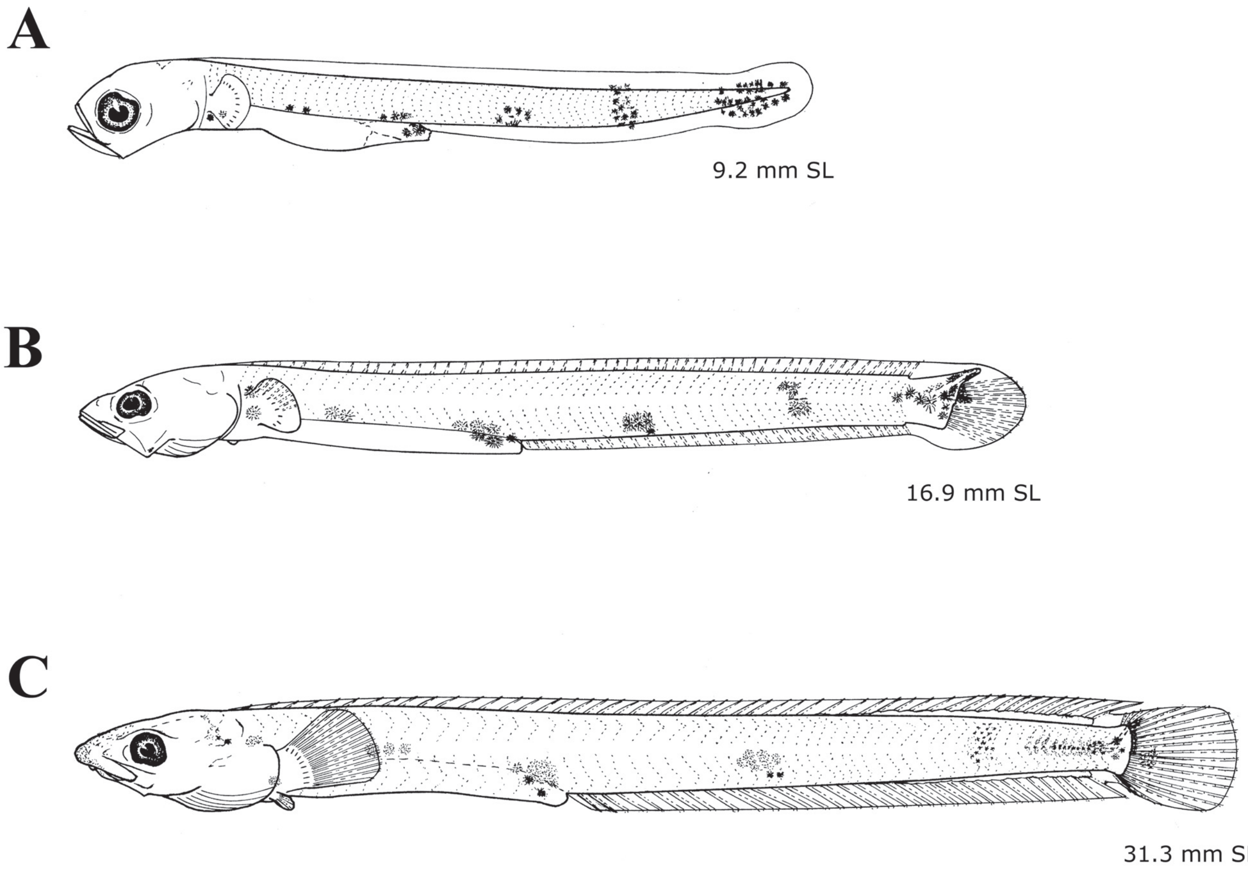

Figure 30

Larvae of Bluebarred Prickleback (*Plectobranchus evides*): (**A**) preflexion stage, 9.2 mm standard length (SL); (**B**) flexion stage, 16.9 mm SL; and (**C**) postflexion stage, 31.3 mm SL. Illustrations from Matarese et al. (1989).

Table 28

Body proportions of Bluebarred Prickleback (*Plectobranchus evides*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion	Postflexion	
Sample size	3		1	8	
Standard length (mm)	9.5±1.7	(7.8–11.1)	15.1[1]	34.0±10.8	(20.0–50.0)
Head length/SL	13.7±1.9	(11.6–15.3)	20.5	22.1±4.8	(17.8–28.1)
Snout length/HL	32.9±4.9	(29.4–36.4)[2]	25.8	24.9±5.7	(17.6–32.4)
Eye diameter/HL	29.1±6.6	(23.5–36.4)	19.4	19.0±3.5	(14.4–25.8)
Snout to anus length/SL	47.4±1.2	(46.2–48.4)	49.7	47.1±2.6	(43.2–50.9)
Body depth/SL	8.9±0.7	(8.1–9.5)	7.9	9.5±1.7	(7.5–12.2)

[1] Original length 16.9 mm; 15.1 mm after preservative changed to ethanol.

[2] *n*=2

Table 29

Meristic counts of cleared and stained Bluebarred Prickleback (*Plectobranchus evides*) larvae. Counts are of ossified elements only. Specimen above dashed line (-----) was in the preflexion stage, and the specimens below were in the postflexion stage.

	Spines, rays					Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
9.5													
23.0	LV	II,36	15		5	20	39	59	39	20	40	60	4,7+7,2
34.0[1]						21	39	60	39	21	40	61	
39.5	LV	II,35	15	I,3	5	20	39	59	39	20	40	60	4,7+7,2
50.0	LIV	II,35	15	I,3	5	20	39	59	39	20	40	60	4,7+7,3

[1] Two specimens, neither had stained fin elements; they likely were initally preserved improperly.

Species comparisons. Larvae of *P. evides* are unusual among stichaeids because they have five lateral melanophore patches that are almost evenly spaced and extend from midgut to the caudal region. The posteriormost patch extends anteriorly onto the caudle peduncle in postflexion larvae. *Plectobranchus evides* is the only species in the study area that lacks PVM during larval stages.

Subfamily Xiphisterinae

Alectridium aurantiacum, Lesser Prickleback

See "Other material" section of this guide.

Alectrias spp. (Fig. 31; Tables 30, 31)

Literature. Tokuya and Amaoka (1980), Shiogaki (1985, 1987), Coleman (1999), Hatooka (2002), Mecklenburg et al. (2002), Mecklenburg and Sheiko (2004).

Material examined. 19 specimens (10.7–16.6 mm) from the Sea of Japan (see Appendix for details).

Distribution and life history. Stone Cockscomb (*Alectrias alectrolophus*) is found to depths of 100 m, usually at depths <50 m, commonly intertidally, and often in bays with bottoms of pebble-rock debris (Mecklenberg et al., 2002; Mecklenberg and Sheiko, 2004) in the northern Sea of Japan; Sea of Okhotsk; Norton Sound, Alaska; the Bering Sea; off southeastern Kamchatka; and the Commander Islands. A reported occurrence off Amchitka Island in the western Aleutian Island Archipelago is unconfirmed (Mecklenberg et al., 2002). Adults can grow to 128 mm TL. Adhesive eggs are laid in a mass guarded by the female parent (Coleman, 1999); larvae are pelagic.

The only larvae available for examination for this study were from Japan, where several *Alectrias* species are found (*A. alectrolophus*, *A. benjamini, A. mutsuensis*). Six of the larvae, specifically those with 19–20 precaudal myomeres, were *A. alectrolophus*, according to information published by Hatooka (2002), but because there were no discernable differences in pigment among the larvae examined, this section is a description of the genus only.

Larval distribution. Larvae of the genus *Alectrias* have not been collected in our study area. Nineteen larvae (10.7–16.6 mm) collected in May and June from two locations off Muroran and Usujiri, southwest Hokkaido, Japan, were available for examination (see Appendix).

Morphology (Table 30). Notochord flexion in species of *Alectrias* begins before 10.7 mm and is complete as early as 12.1 mm. Postflexion larvae are 12.1–16.6 mm. Lengths at which transformation and the juvenile stage begin are unknown. Body depth is moderate in the flexion stage (11.5% SL) and decreases slightly (10.7% SL) in the postflexion stage. Relative head length, snout to anus length, and eye diameter all decrease from the flexion stage to the postflexion stage, while relative snout length increases (an observation made on the basis of measurements from only one flexion specimen).

Pigmentation (Fig. 31). A total of 2 flexion and 17 postflexion larvae were available for examination. Flexion and postflexion larvae are lightly pigmented. There usually are one to several spots over the brain and a large internal spot at the nape. A single line of internal pigment occurs at the cleithral symphysis in the shape of a "V". There are about four internal stellate melanophores dorsally along the gut and several external melanophores on the dorsal surface of the hindgut. A ventral midline series of melanophores on the gut begins anterior to the cleithral pigment and extends to just anterior to the anus. A PVM series (33–39), consisting

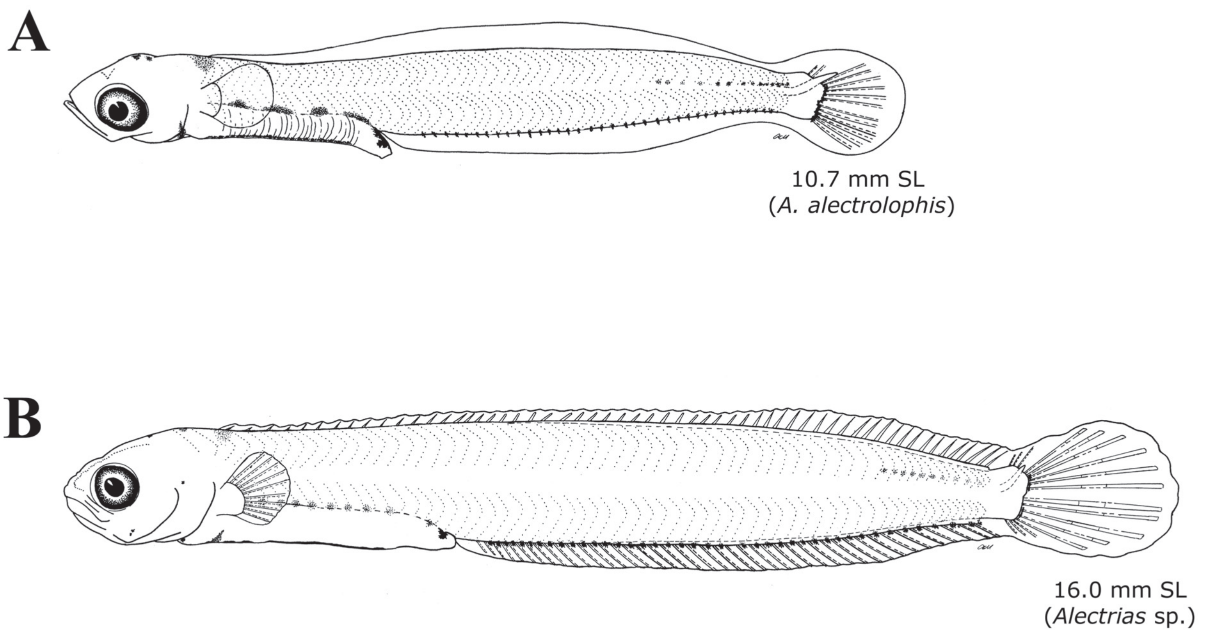

Figure 31

Larvae of *Alectrias* spp: (**A**) Stone Cockscomb (*Alectrias alectrolophus*): flexion stage, 10.7 mm standard length (SL), Hokkaido University Museum of Zoology (HUMZ-L) 02756; and (**B**) *Alectrias* sp.: postflexion stage, 16.0 mm SL, HUMZ-L 03915. Illustrations by A. Overdick.

of a melanophore each at most myosepta, extends from postanal myomere 4–5 to the caudal peduncle. Internal melanophores are present dorsally above the notochord in the peduncle area. Pigment occurs along the edge of the hypural bones.

Few changes occur in postflexion larvae. The dorsal spots on the head decrease in size, becoming less prominent. Several spots are added on the lower jaw and opercular area. Pigment is added in the isthmus area. The number of melanophores on the dorsal surface of the gut increases to about eight, and all are smaller than they were during the flexion stage. Although less prominent, pigment remains visible along the edges of the hypural bones.

Meristic features (Table 31). Principal caudal-fin rays are developed by 11.7 mm and ossified by 14.0 mm. Procurrent caudal-fin rays begin ossifying by 14.0 mm before all elements are developed, and they are developed and ossified by 15.8 mm. Dorsal-fin and anal-fin elements are present by 11.7 mm. Anal-fin rays are ossified by 14.0 mm, and anal-fin spines are ossified by 15.8 mm. Dorsal-fin spines begin to ossify by 14.0 mm before all are developed; dorsal-fin spines are developed and ossified by 15.8 mm. Pectoral-fin rays are present by 11.7 mm and ossified by 14.0 mm. This genus lacks pelvic fins. Vertebral centra and neural and haemal spines are developed by 11.7 mm; neural and haemal spines are weakly ossified. By 14.0 mm, all vertebral centra are ossified. Both cleared and stained postflexion specimens had <19 precaudal vertebrae, and they were most likely *A. benjamini* or *A. mutsuensis*. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larval Xiphisterinae are most similar to larvae in the subfamilies Chirolophinae and Lumpeninae. Larval Xiphisterinae have longer guts than do most Chirolophinae larvae (snout to anus length: 41–51% SL vs. 32–37% SL) and lack dorsal midline pigment and pelvic fins. Xiphisterines can be distinguished from lumpenine larvae by their deeper bodies (body depth: 9.0–11.0% SL vs. 6.6–8.5% SL), typically shorter guts (snout to anus length: 41–43% SL vs. 43–50% SL), and ventral pigment on the gut (vs. absent).

Based on limited material, larvae of *Alectrias* species are similar to most species of Xiphisterinae, particularly species of *Anoplarchus*. Larvae of *Alectrias* species cannot be readily distinguished from *Anoplarchus insignis* because of overlapping meristic counts and the presence of head pigment and internal pigment above the notochord in the caudal peduncle. However, species of *Alectrias* can be distinguished from *Anoplarchus*

Table 30

Body proportions of *Alectrias* spp. larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion	Flexion	Postflexion
Sample size		1	17
Standard length (mm)		10.7	15.0±1.2 (12.1–16.6)
Head length/SL		16.6	15.3±1.0 (13.4–17.0)
Snout length/HL		26.4	29.9±4.0 (22.9–36.4)
Eye diameter/HL		29.6	28.3±3.0 (23.4–34.9)
Snout to anus length/SL		45.9	41.2±1.0 (38.8–42.5)
Body depth/SL		11.5	10.7±0.8 (9.3–11.8)

Table 31

Meristic counts of cleared and stained *Alectrias* spp. larvae[1]. Counts are of ossified elements only. Specimen between dashed lines (-----) was undergoing notochord flexion. This genus lacks pelvic fins.

	Spines, rays			Branchi-ostegal	Neural spines			Haemal	Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	rays	Abdominal	Caudal	Total	spines	Abdominal	Caudal	Total	Caudal-fin rays
11.7					16	46	62	46				
14.0	LIX	41	10	5	17	45	62	45	17	46	63	3,6+6,2
15.8	LVIII	I,41	9	5	16	45	61	45	16	46	62	4,6+6,2

[1] Counts of 14.0- and 15.8-mm larvae match *A. benjamini* and *A. mutsuensis*.

purpurescens by the presence of pigment on the head in the flexion and postflexion stages (absent in *A. purpurescens*), presence of internal pigment above the notochord on the caudal peduncle (also absent in *A. purpurescens*), usually more caudal myomeres (44–50 vs. 40–46), and usually more dorsal-fin spines and anal-fin rays in postflexion larvae (LV–LXVI; I,39–45 vs. LIV–LX; I–II,35–42). Larvae of *Alectrias* species are slightly deeper bodied than are larvae of both *Anoplarchus* species (mean body depth: 11.5–10.7% SL vs. 8.9–9.9% SL) during the flexion and postflexion stages.

Anoplarchus insignis, Slender Cockscomb (Figs. 32, 33; Tables 32, 33)

Literature. Eschmeyer et al. (1983), Watson (1996), Mecklenburg and Sheiko (2004).

Material examined. 178 specimens (5.2–36.5 mm) from the Bering Sea, Gulf of Alaska, coast of Washington, and Puget Sound, Washington (see Appendix for details).

Distribution and life history. *Anoplarchus insignis* is found among rocks and algae from intertidal areas to a depth of 30 m, most frequently in subtidal areas (Mecklenberg and Sheiko, 2004), in the southeastern Bering Sea, and throughout the Aleutian Islands to northern California in the North Pacific Ocean. Adults grow to 118 mm TL (Eschmeyer et al., 1983). Little is known of its life history. Eggs are probably demersal and spawned in an adhesive mass; larvae are pelagic.

Larval distribution (Fig. 32). The third most abundant stichaeid in our study area, larvae of Slender Cockscomb (5.2–31.1 mm) are found in April–June (most frequently in May) in the Bering Sea, west of and around Unimak Pass, into the Gulf of Alaska in nearshore and shelf areas, around Kodiak Island to the mouth of Cook Inlet, off the northern coast of Washington, and in Puget Sound, Washington.

Morphology (Table 32). Notochord flexion in *A. insignis* begins at 8.9 mm and is complete by 14.0 mm.

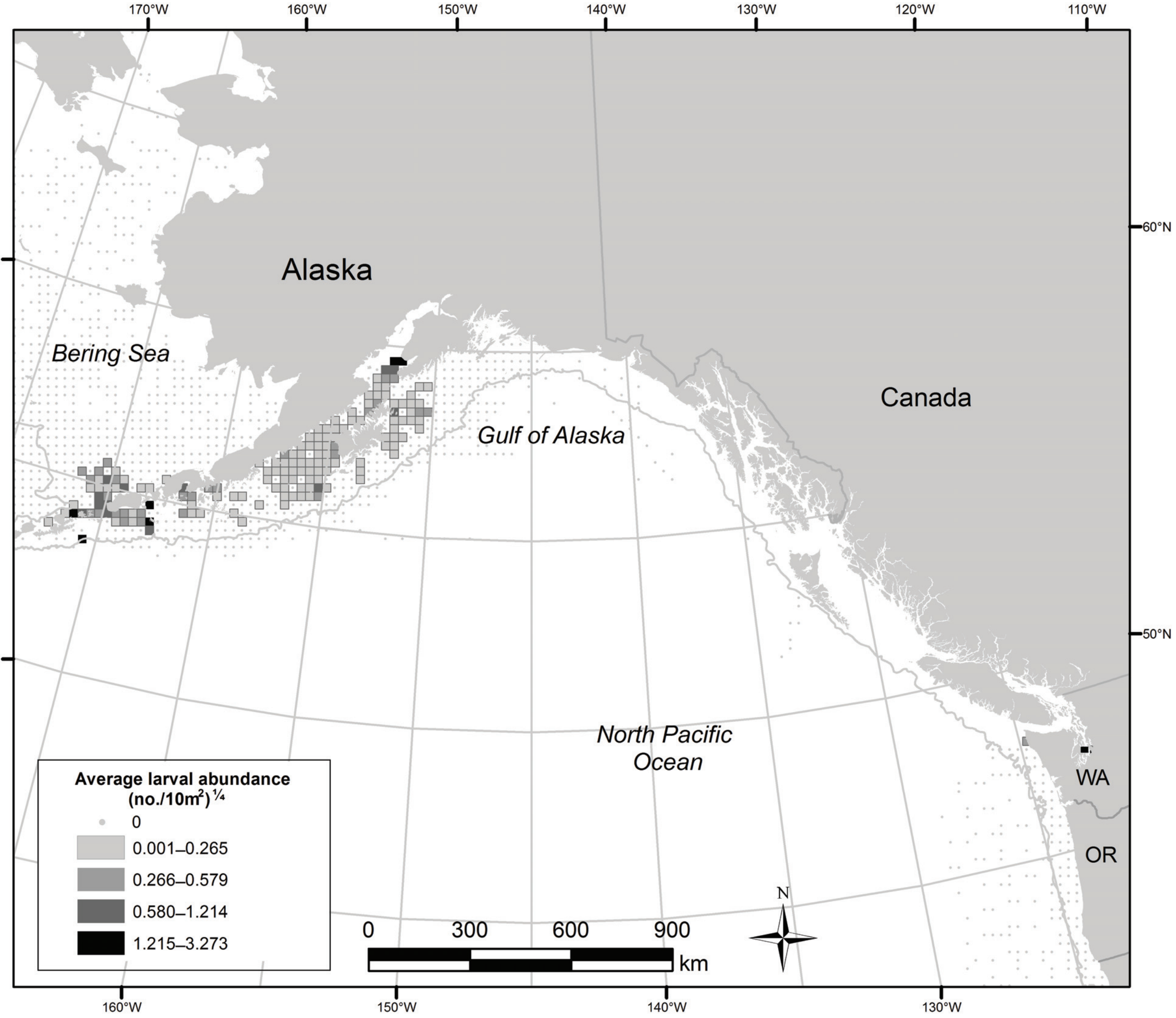

Figure 32

Distribution and abundance of larvae of Slender Cockscomb (*Anoplarchus insignis*) collected by bongo net in the Bering Sea, Gulf of Alaska, and Puget Sound, Washington. A fourth-root transformation was computed for the data to normalize the abundance. Isobath=1000 m.

Postflexion larvae are 14.0–20.6 mm. Transformation can begin between 17.0 (note 17.0-mm specimen in Fig. 33) and 25.0 mm, and the juvenile stage begins before 35.0 mm. Larvae are slender-bodied with a mean body depth of 9.2% SL in the preflexion stage that slightly decreases to 9.0% SL in later stages. Relative head and snout lengths increase and relative eye diameter decreases from the preflexion stage to the postflexion stage. Snout to anus length remains constant throughout development.

Pigmentation (Fig. 33). Larvae of *A. insignis* are moderately pigmented. Preflexion larvae as small as 6.5 mm may have a melanophore on the hindbrain or nape area. A small melanophore at the base of the cleithrum persists throughout development. Five or more melanophores are present dorsally on the gut in addition to several that cover the hindgut. A ventral midline row of pigment extends three-fourths of the length of the gut. Preflexion larvae have about 45–55 small, closely spaced PVM. Several melanophores are present in the ventral caudal finfold.

During the flexion stage, several changes in pigmentation occur. By early flexion, the prominent spot on the nape becomes embedded and pigment is present on the

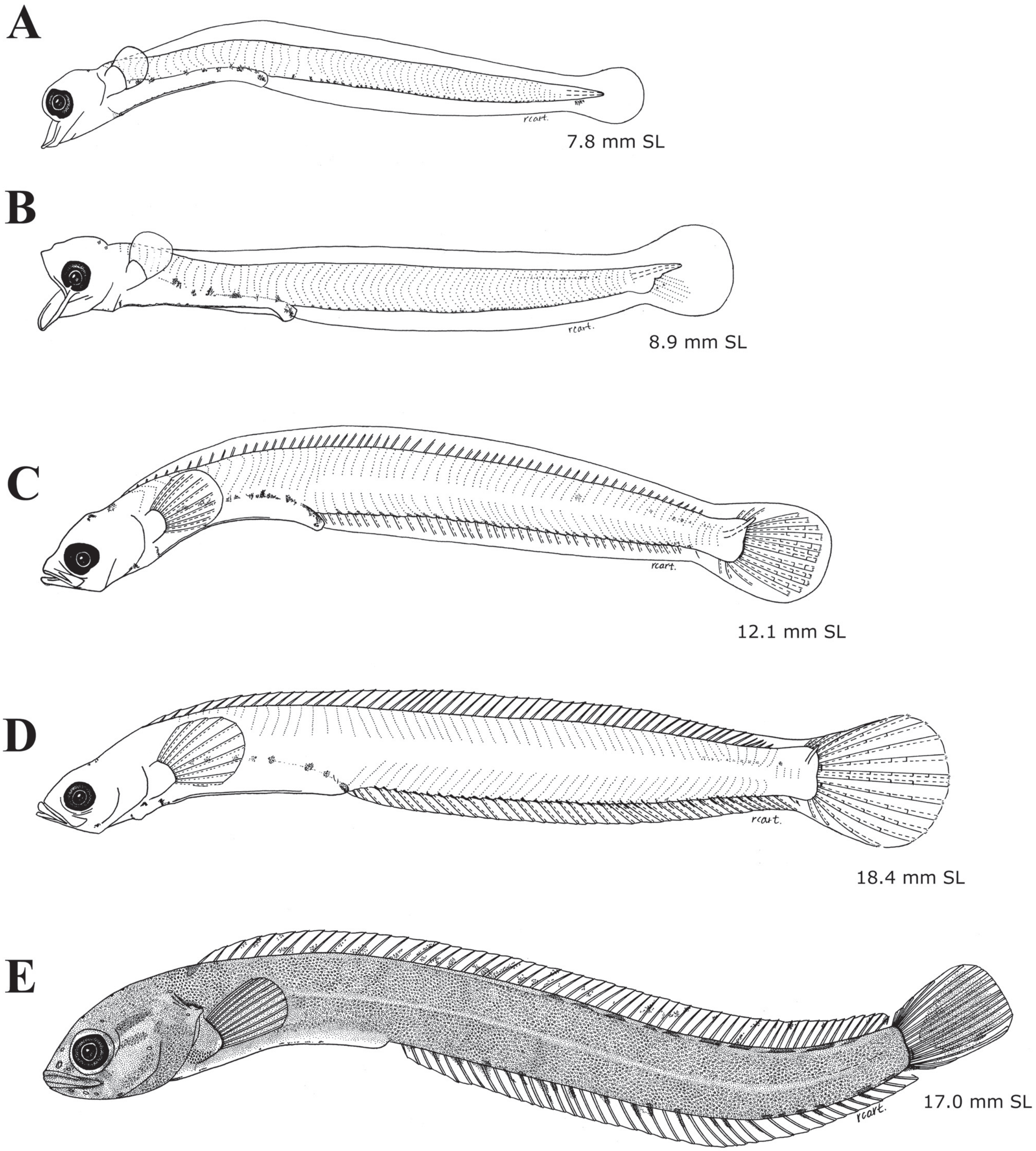

Figure 33

Larvae of Slender Cockscomb (*Anoplarchus insignis*): (**A**) preflexion stage, 7.8 mm standard length (SL), composite of 7.3- and 7.8-mm SL specimens, University of Washington (UW) 145894 and UW 141551; (**B**) flexion stage, 8.9 mm SL, UW 141567; (**C**) late flexion stage, 12.1 mm SL, UW 143894; (**D**) postflexion stage, 18.4 mm SL, UW 140942; and (**E**) transformation stage, 17.0 mm SL, UW 40411. Illustrations by R. Cartwright.

Table 32

Body proportions of Slender Cockscomb (*Anoplarchus insignis*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	70		71		27	
Standard length (mm)	6.8±0.8	(5.2–8.9)	11.3±1.7	(8.9–13.9)	16.1±2.0	(14.0–20.6)
Head length/SL	13.8±1.3	(10.6–16.8)	13.2±1.6	(9.8–17.8)[1]	14.6±1.0	(12.4–16.7)
Snout length/HL	18.8±5.6	(7.7–28.6)[2]	23.2±4.7	(11.6–34.9)[1]	25.1±3.0	(18.6–31.8)
Eye diameter/HL	40.7±5.6	(30.7–55.5)[3]	32.5±4.6	(23.6–41.6)[1]	27.3±3.7	(20.2–34.3)
Snout to anus length/SL	41.3±2.0	(36.9–46.2)	41.1±1.5	(38.2–44.3)	41.6±1.5	(37.7–44.6)
Body depth/SL	9.2±1.7	(6.0–13.3)[4]	9.0±0.7	(7.2–10.3)	9.0±0.7	(8.0–11.6)

[1] *n*=69
[2] *n*=53
[3] *n*=58
[4] *n*=67

Table 33

Meristic counts of cleared and stained Slender Cockscomb (*Anoplarchus insignis*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion. This species lacks pelvic fins.

Standard length (mm)	Spines, rays			Branchiostegal rays	Neural spines			Haemal spines	Centra			Caudal-fin rays
	Dorsal fin	Anal fin	Pectoral fin		Abdominal	Caudal	Total		Abdominal	Caudal	Total	
7.2												
7.5												
8.3												
9.0												
9.4												
10.1												
10.9												
11.5												
11.7												
12.0												
13.1					17	44	61	44				
13.5												
14.0												
14.3												
15.1												
15.6					17	45	62	45				
16.4				5	18	47	65	47	18	48	66	6+5
16.4				5	19	46	65	46	19	47	66	2,6+6,1
17.2				5	18	47	65	47	18	48	66	6+7,1
18.2				5	18	47	65	47	18	48	66	6+6
18.5	LX	I,44	10	5	17	47	64	47	17	48	65	4,6+6,2
19.2	LIX	I,42	10	5	17	46	63	46	17	47	64	5,6+7,2
20.0	LXI	I,44	10	5	18	46	64	46	18	47	65	5,6+7,2
36.5	LXI	I,42	10	5	18	46	64	46	18	47	65	4,6+7,2

isthmus. Pigment increases along the dorsal surface of the gut and hindgut. The PVM coalesce to about 38–39, one per pterygiophore, and become more slash-like in appearance. Five or more internal melanophores form dorsally on the notochord; initially light and undefined, these melanophores become associated with the posterior epaxial myomeres. Additional head pigment usually develops during the postflexion stage but is not present in every larva. The prominent nape spot becomes embedded but remains visible. The number of PVM decreases further to about 36, and the internal pigment on the notochord is not always easily visible.

During transformation and early juvenile stages, melanophores cover the entire head and body. Two dark streaks radiate outward posteriorly from the eye, with the dorsalmost streak appearing as a nearly horizontal bar through the eye. Another short, diagonally oriented vertical bar is present near the ventral margin of the eye. This bar appears loosely joined to another streak along the outer edge of the preopercle, and together they form a "V" shape. A prominent spot is present at the dorsal fin origin, and irregularly shaped clusters of melanophores are seen on the membrane along the entire length of the dorsal fin. Up to 10 prominent, dash-shaped spots are present posteriorly along the base of the dorsal fin. A similar pigmentation pattern forms along the entire length of the anal fin, although the clusters of melanophores are concentrated more along the fin rays rather than on the fin membrane. Dark pigment spots are present on the dorsal and ventral margins of the hypurals, and a large patch of small melanophores covers most of the caudal fin.

Meristic features (Table 33). Principal caudal-fin rays are present by 8.3 mm, developed by 12.0 mm, and ossified by 16.4 mm. Procurrent caudal-fin rays are present by 12.0 mm, and ossification begins at 16.4 mm before all are developed. All procurrent caudal-fin rays are ossified by 18.5 mm. The ranges of 1–5 superior and 1–4 inferior procurrent caudal-fin rays observed on radiographs are greater than the ranges previously reported for this species (3–4, 2–3; Watson, 1996). Anal-fin elements are present by 13.1 mm, and dorsal-fin spines are present between 14.0 and 15.1 mm. All elements in both fins are ossified by 18.5 mm. The count of 38 anal-fin rays observed on radiographs is lower than the count previously reported for this species (40–46; Watson, 1996). Pectoral-fin rays are present by 10.9 mm, developed by 14.3 mm, and ossified by 18.5 mm. Pelvic fins are absent. Vertebral centra are present by 9.0 mm, developed by 10.9 mm, and all of them are ossified by 16.4 mm. The count of 42 caudal centra observed on radiographs is lower than the count previously reported for this species (44–49; Watson, 1996). Neural and haemal spines are ossified by 15.6 mm (ossification occurred at 13.1 mm in one specimen), before vertebral centra are ossified. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larvae of *A. insignis* are most likely to be confused with other Xiphisterinae, particularly their congener *A. purpurescens*, but they also may be confused with species of *Alectrias* and the opisthocentrine *Opisthocentrus ocellatus*. *Anoplarchus insignis* is generally more pigmented than is *A. purpurescens* throughout development. A small melanophore present on the nape early in development, along with additional head pigment in later stages, is absent in *A. purpurescens*. Larvae of *A. insignis* typically have more PVM (>45) during the preflexion stage than do larvae of *A. purpurescens* (≤40), and they also have a row of melanophores above the notochord in the caudal peduncle; this row is absent in *A. purpurescens*. Larvae of *A. insignis* cannot be readily distinguished from species of *Alectrias* because of overlapping counts of meristic features and the presence of head pigment and internal pigment above the notochord in the caudal peduncle in both taxa. Larvae of *A. insignis* can be distinguished from larvae of *O. ocellatus* by a line or row of small, punctate, ventral melanophores that extends along the anterior three-fourths of the length of the gut rather than an evenly spaced row of large stellate melanophores along its entire length. In addition, *A. insignis* has a shorter snout to anus length (mean: 41.1–41.6% SL vs. 48.2–53.2% SL) and fewer precaudal vertebrae (17–19) than does *O. ocellatus* (21–23).

***Anoplarchus purpurescens*, High Cockscomb (Figs. 34, 35; Tables 34, 35)**

Literature. Schultz and DeLacy (1932), Peppar (1965), Hart (1973), Marliave (1975a), Wang (1986), Matarese et al. (1989), Watson (1996).

Material examined. 204 specimens (4.7–37.0 mm) from the Bering Sea; Gulf of Alaska; Puget Sound, Washington; and the coasts of British Columbia, Canada, and Oregon (see Appendix for details).

Distribution and life history. *Anoplarchus purpurescens* is found from the Bering Sea near the Pribilof Islands, throughout the Aleutian Islands, and in nearshore areas in the Gulf of Alaska and North Pacific Ocean to southern California, mostly in intertidal areas to depths of 30 m among rocks and algae. Maximum length of adults is 200 mm TL (Hart, 1973); age at maturity is 2–3 years (Peppar, 1965). In southern British Columbia, Washington, and California, spawning occurs in January–March (Marliave, 1975a; Schultz and DeLacy, 1932; Wang, 1986). Eggs 1.3–1.5 mm in diameter, with one large (0.33–0.41 mm in diameter) and one smaller oil globule, are laid in pedestal-shaped masses of 2000–3000

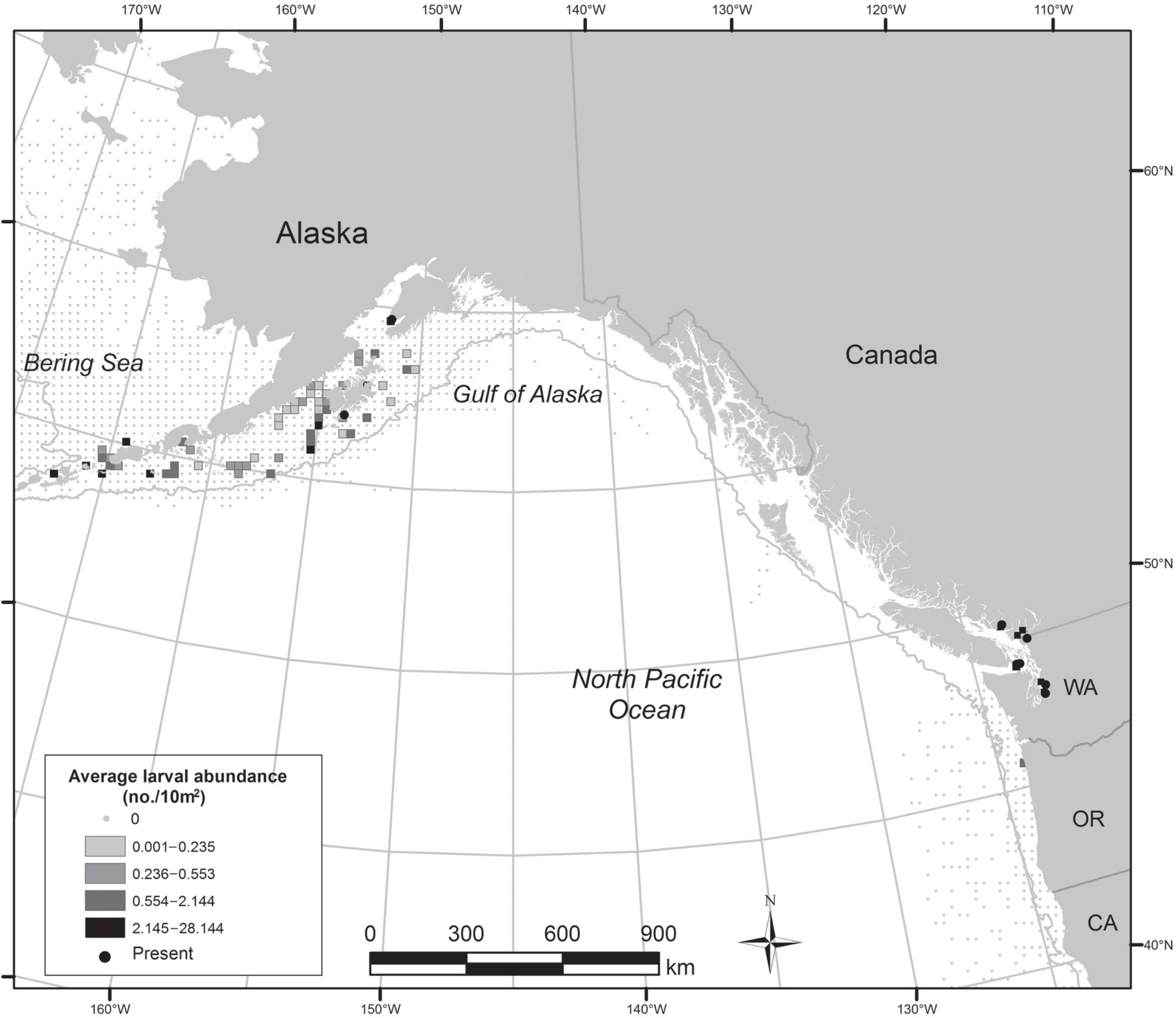

Figure 34

Distribution and abundance of larvae of High Cockscomb (*Anoplarchus purpurescens*) collected in the Bering Sea; Gulf of Alaska; Straits of Georgia, British Columbia, Canada; Puget Sound, Washington; and North Pacific Ocean off the coast of Oregon. Squares indicate collections made by bongo net; black circles indicate additional nonquantitative collections (presence only) and may represent more than one occurrence. Isobath=1000 m.

eggs under or between rocks or shells and guarded by the female during a 3-week incubation period (Schultz and DeLacy, 1932; Peppar, 1965; Marliave, 1975a; Matarese et al., 1989). Larvae hatch at 7.5 mm TL (Peppar, 1965).

Larval distribution (Fig. 34). Larvae of High Cockscomb are found in the Bering Sea north of Unimak Island; near Amchitka Island in the western Aleutian Island Archipelago; west of and around Unimak Pass; into the Gulf of Alaska on the shelf and around Kodiak Island; Straits of Georgia, Canada; Puget Sound, Washington; and the coast of northern Oregon. In Alaskan waters, larvae (5.8–20.0 mm) are collected in April–June with maximum occurrence observed in May; the larva off Oregon (20.0 mm) was collected in April. It is likely that spawning occurs earlier in the year at the lower latitudes.

Morphology (Tables 34, 35). Notochord flexion in *A. purpurescens* begins at 9.4 mm and is complete at 12.0–13.0 mm. Postflexion larvae are 12.1–20.0 mm. Transformation can begin by 12.0 mm, and it was complete soon after flexion in reared specimens; our 20.0-mm field-collected specimen had no characteristics that indicated that transformation had begun. The

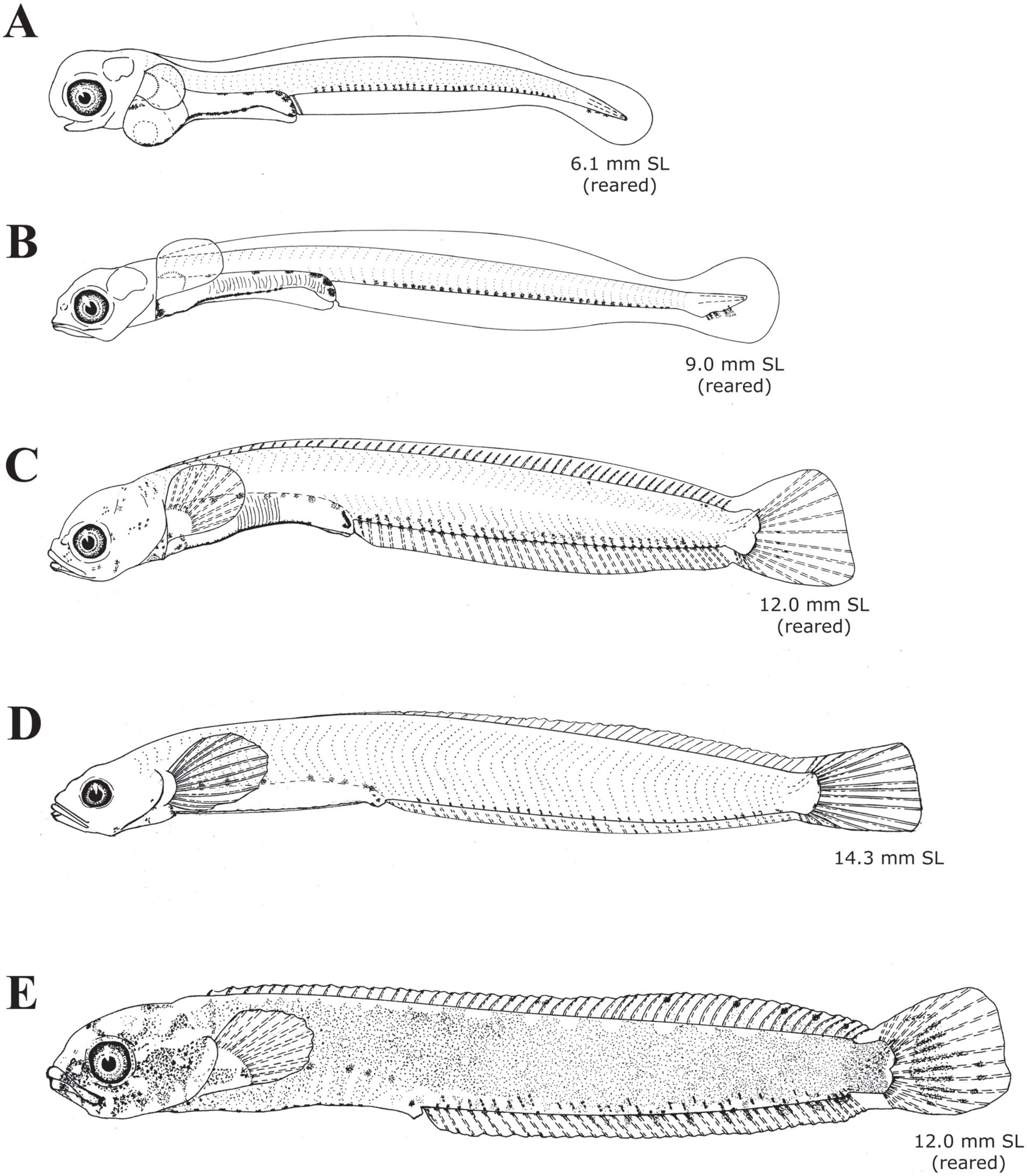

Figure 35

Larvae of High Cockscomb (*Anoplarchus purpurescens*): (**A**) preflexion stage, 6.1 mm standard length (SL); (**B**) flexion stage, 9.0 mm SL; (**C**) late flexion stage, 12.0 mm SL; (**D**) postflexion stage, 14.3 mm SL, composite of 13.2- and 14.3-mm SL specimens, University of Washington (UW) 145895 and UW 145872; and (**E**) transformation stage, 12.0 mm SL. Illustrations (A–C, E) from Matarese et al. (1989, reared) and (D) by B. Vinter.

Table 34

Body proportions of High Cockscomb (*Anoplarchus purpurescens*) larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	152		27		8	
Standard length (mm)	7.3±1.1	(5.2–9.3)	10.3±0.8	(9.4–12.9)	15.2±2.2	(13.1–20.0)
Head length/SL	13.8±1.3	(10.5–18.1)	13.7±1.2	(11.5–16.4)	14.8±1.8	(12.4–17.3)
Snout length/HL	23.1±6.7	(10.5–39.3)[1]	24.9±4.3	(17.2–32.1)[2]	26.7±4.9	(20.8–33.9)
Eye diameter/HL	39.8±5.8	(26.5–57.1)[3]	32.6±3.3	(27.5–42.4)	27.2±3.2	(22.9–32.8)
Snout to anus length/SL	42.0±2.4	(37.0–49.3)[4]	41.8±1.8	(38.3–45.2)	43.2±1.6	(41.0–45.4)
Body depth/SL	9.0±1.2	(4.7–11.9)	8.9±0.7	(7.7–10.0)	9.9±0.3	(9.5–10.4)[5]

[1] *n*=138
[2] *n*=26
[3] *n*=145
[4] *n*=151
[5] *n*=7

Table 35

Meristic counts of cleared and stained High Cockscomb (*Anoplarchus purpurescens*) larvae and juveniles. Counts are of ossified elements only. Specimens between dashed lines (-----) were undergoing notochord flexion. This species lacks pelvic fins.

	Spines, rays				Neural spines				Centra			
Standard length (mm)	Dorsal fin	Anal fin	Pectoral fin	Branchiostegal rays	Abdominal	Caudal	Total	Haemal spines	Abdominal	Caudal	Total	Caudal-fin rays
5.8												
7.3												
8.9												
9.4					3	44		44				
10.1												
11.4					17	45	62	45				
12.1	LVI	I,40		5	17	43	60	43	17	44	61	4,6+6,2
13.2[1]					18	41	59	41				4,6+6,3
14.5	XXXVII[2]	I,38	10	5	18	40	58	40	18	41	59	2,6+6,1
17.1	LVII	I,40	10	5	18	43	61	43	18	44	62	4,6+7,2
28.0	LVII	I,40	10	5	19	43	62	43	19	44	63	4,6+6,3
37.0	LVII	I,39	10	5	19	42	61	42	19	43	62	4,6+6,3

[1] Dorsal-fin and anal-fin pterygiophores were stained, but fin elements were not.
[2] Anteriormost XVI dorsal-fin spines weakly formed and unossified.

28.0- and 37.0-mm cleared and stained specimens were juveniles, indicating that this stage begins at <28.0 mm. Larvae are slender-bodied (mean body depth 9.0% SL, initially), increasing in size slightly (mean body depth 9.9% SL) in the postflexion stage. Relative snout length increases, and head length and snout to anus length increase slightly, from the preflexion stage to the postflexion stage. Relative eye diameter decreases from the preflexion stage to the postflexion stage.

Pigmentation (Fig. 35). Larvae of *A. purpurescens* are lightly pigmented throughout larval development. There is no dorsal head pigment until after the postflexion stage. A small melanophore persists at the base of the cleithrum through all stages. In preflexion larvae, three or more dorsal pigment spots are present on the gut, and several spots cover the hindgut. A line of pigment extends three-fourths of the way along the ventral midline of the gut and persists through the transformation stage.

Preflexion larvae have a series of about 34–45 (usually <40) moderately spaced PVM. Melanophores (usually two) are present along the ventral margin of the notochord tip where the hypurals will form.

Few pigmentation changes occur during the early flexion stage. Up to four dorsal spots appear on the gut. The melanophores in the hypural area become prominent. Late flexion larvae undergo several changes in pigment. Pigment appears laterally on the head. More pigment is visible in the area of the isthmus, with a short series of spots forming a ventral line. Up to eight dorsal spots are present on the gut, and the hindgut also has several spots. The PVM appear slash-like with melanophores that extend along the pterygiophores and hypaxial musculature. A few melanophores are on the dorsal midline at 75% and 90% SL and also on the caudal-fin rays. Pigment on the dorsal surface of the gut is more difficult to see in postflexion-stage larvae as the melanophores become embedded.

Beginning early in the transformation stage, the typical adult facial pigment pattern develops as settlement approaches. Although our 12.0-mm reared specimen (Fig. 35E) had juvenile pigmentation, we have not observed this pigment pattern in field-caught specimens up to 20.0 mm. During transformation and early juvenile stages, melanophores cover nearly the entire head and body. Irregularly shaped patches and streaks of larger melanophores give the head a mottled appearance. The dorsal and ventral melanophores on the gut are retained from late larval stages during the early transformation stage. A row of regularly spaced unpigmented semicircular spots along the base of the dorsal fin are more closely spaced anteriorly. Several large melanophores are present posteriorly near the distal margin of the dorsal fin. Irregularly spaced PVM are present, some of which have an adjacent cluster of melanophores that extends onto the anal fin. Slash-like PVM are present on the hypaxial myosepta just dorsally of the ventral midline. Pigment is also present on the dorsal and ventral margins of the hypural edge, and a large patch of small melanophores covers the central portion of the caudal fin. Our 28- and 37-mm specimens displayed juvenile pigmentation before they were cleared and stained.

Meristic features (Table 35). Principal caudal-fin rays are present by 9.4 mm and ossified by 12.1 mm. Procurrent caudal-fin rays are present and begin to ossify by 12.1 mm before all are developed; all of these rays are ossified by 13.2 mm. The counts of one superior and one inferior procurrent caudal-fin rays observed on radiographs are lower than the counts previously reported for this species (3–4, 3–4; Watson, 1996). Anal-fin elements and dorsal-fin spines can be developed and ossified by 12.1–17.1 mm. Pectoral-fin rays are present by 11.5 mm, developed by 13.2 mm, and ossified by 14.5 mm. Pelvic fins are absent. Vertebral centra are present by 9.5 mm and ossified by 12.1–14.5 mm. The count of 16 precaudal centra observed on radiographs is lower than the count previously reported for this species (17–19; Watson, 1996). Neural and haemal spines are ossified before vertebral centra, by 11.4 mm, although, in one specimen, they were partially ossified by 9.4 mm. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Larvae of *A. purpurescens* are similar to not only other Xiphisterinae, particularly their congener *A. insignis*, but also species of *Alectrias* and the opisthocentrine *Opisthocentrus ocellatus*. *Anoplarchus purpurescens* is generally more lightly pigmented than is *A. insignis* throughout development. Unlike *A. insignis*, pigmentation on the head and nape is absent in *A. purpurescens* until near the end of the postflexion stage, and melanophores posteriorly above the notochord are absent in *A. purpurescens*. *Anoplarchus purpurescens* typically has fewer PVM (34–45, usually £40) during the preflexion stage than does *A. insignis* (45–55). *Anoplarchus purpurescens* can be distinguished from species of *Alectrias* by the absence of pigment on the head in the flexion and postflexion stages (present in *Alectrias* spp.), absence of internal pigment above the notochord on the caudal peduncle (present in *Alectrias* spp.), usually fewer caudal myomeres (40–46 vs. 44–50), and usually fewer dorsal-fin spines and anal-fin rays (LIV–LX; I–II,35–42 vs. LV–LXVI; I,39–45). Larvae of *Anoplarchus purpurescens* are more slender-bodied than are larvae of *Alectrias* species (mean body depth: 8.9–9.9% SL vs. 11.5–10.7% SL) during the flexion and postflexion stages. Larvae of *A. purpurescens* can be distinguished from *O. ocellatus* by a line or row of small, punctate, ventral melanophores that extends along the anterior three-fourths of the length of the gut rather than an evenly spaced row of large, stellate melanophores ventrally along the entire length of the gut. In addition, *A. purpurescens* has a shorter snout to anus length (mean: 41.8–43.2% SL vs. 48.2–53.2% SL) and fewer precaudal vertebrae (17–19) than has *O. ocellatus* (21–23).

Cebidichthys violaceus, Monkeyface Prickleback (Figs. 36, 37; Table 36)

Literature. Fitch and Lavenburg (1971), Burge and Schultz[2], Eschmeyer et al. (1983), Wang (1986), Marshall and Wyllie-Echeverria (1992), Lea and Reilly (2001), PG&E[3].

---

[2] Burge, R. T., and S. A. Schultz. 1973. The marine environment in the vicinity of Diablo Cove with special reference to abalones and bony fishes. Mar. Res. Tech. Rep. No. 19, 433 p. Calif. Dep. Fish Game, Long Beach, CA.

[3] PG&E (Pacific Gas & Electric Co.). Diablo Canyon Power Plant 316(b) Demonstration Project. Document No. E9-055.0. Prepared for Pacific Gas & Electric Co. by Tenera Environmental Services. March 2000.

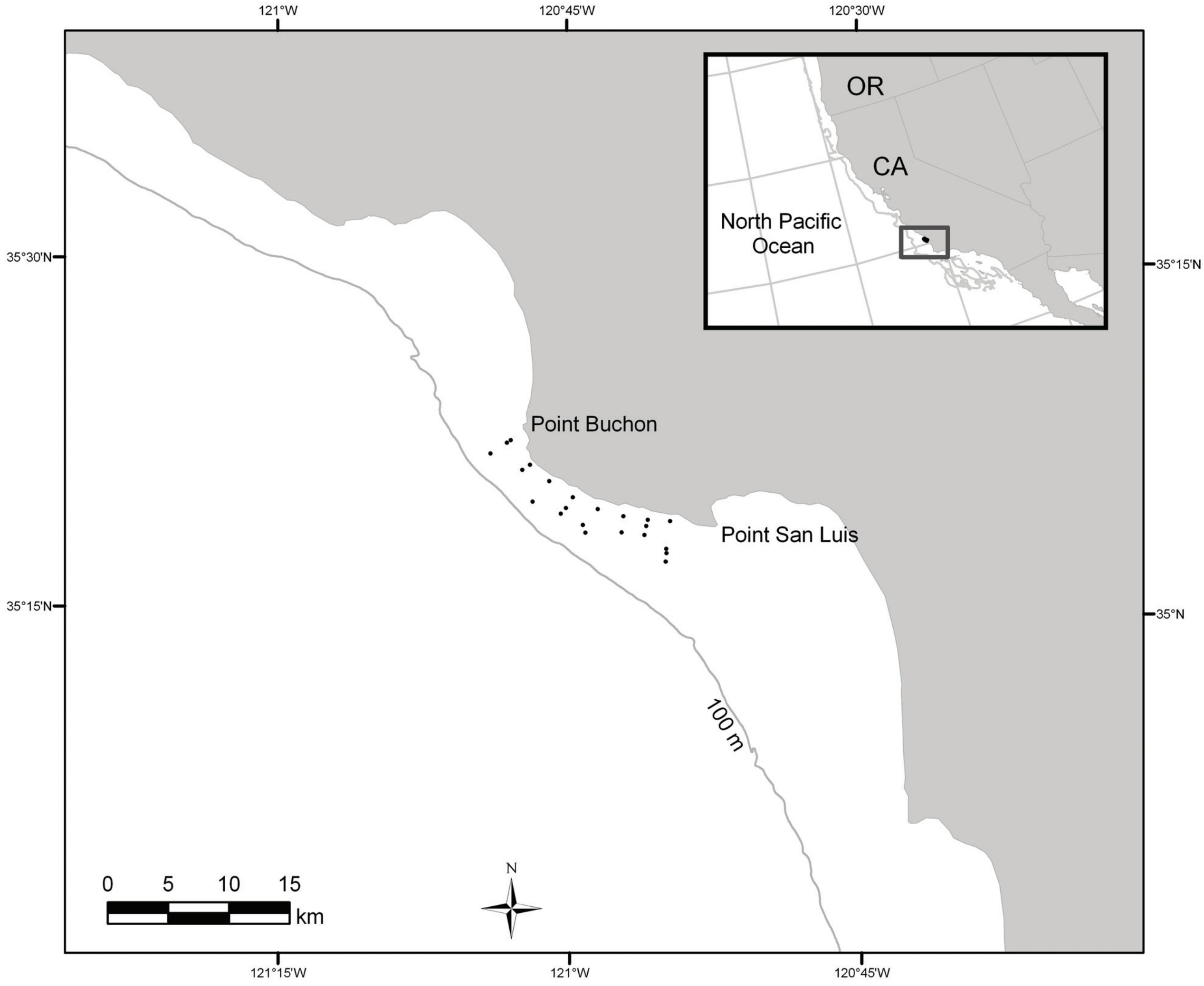

Figure 36

Distribution of larvae of Monkeyface Prickleback (*Cebidichthys violaceus*) collected in the North Pacific Ocean off the California coast. Each symbol may indicate more than one occurrence. Isobath=100 m. Inset shows location of area expanded in the main map.

Material examined. 10 specimens (6.2–14.4 mm) from the coast of California (see Appendix for details).

Distribution and life history. *Cebidichthys violaceus* is common in tidepools and rocky intertidal and subtidal habitats to depths of 24 m (Burge and Schultz[2]; Eschmeyer et al., 1983) from southern Oregon to northern Baja California, Mexico. This species is the only stichaeid for which there is a small, specialized recreational fishery (Lea and Reilly, 2001). Adults grow to 760 mm TL and may live to 18 years (Eschmeyer et al., 1983; Marshall and Wyllie-Echeverria, 1992). Males and females reach 50% maturity at five years and 100% maturity at eight years. Fecundity ranges from 17,500 to 46,000 eggs, which are deposited on subtidal rocky surfaces from January to May, with a peak in February–April (Marshall and Wyllie-Echeverria, 1992); eggs (about 2 mm diameter) are laid in the form of a ball with 6000–8000 eggs in a cluster (Fitch and Lavenburg, 1971). Nests are guarded by one or both parents (Lea and Reilly, 2001). Hatch size is about 4.8 mm; larvae are pelagic (PG&E[3]).

Larval distribution (Fig. 36). Larvae of Monkeyface Prickleback have not been collected during AFSC ichthyoplankton surveys. Larvae at lengths of 4.8–24.6 mm

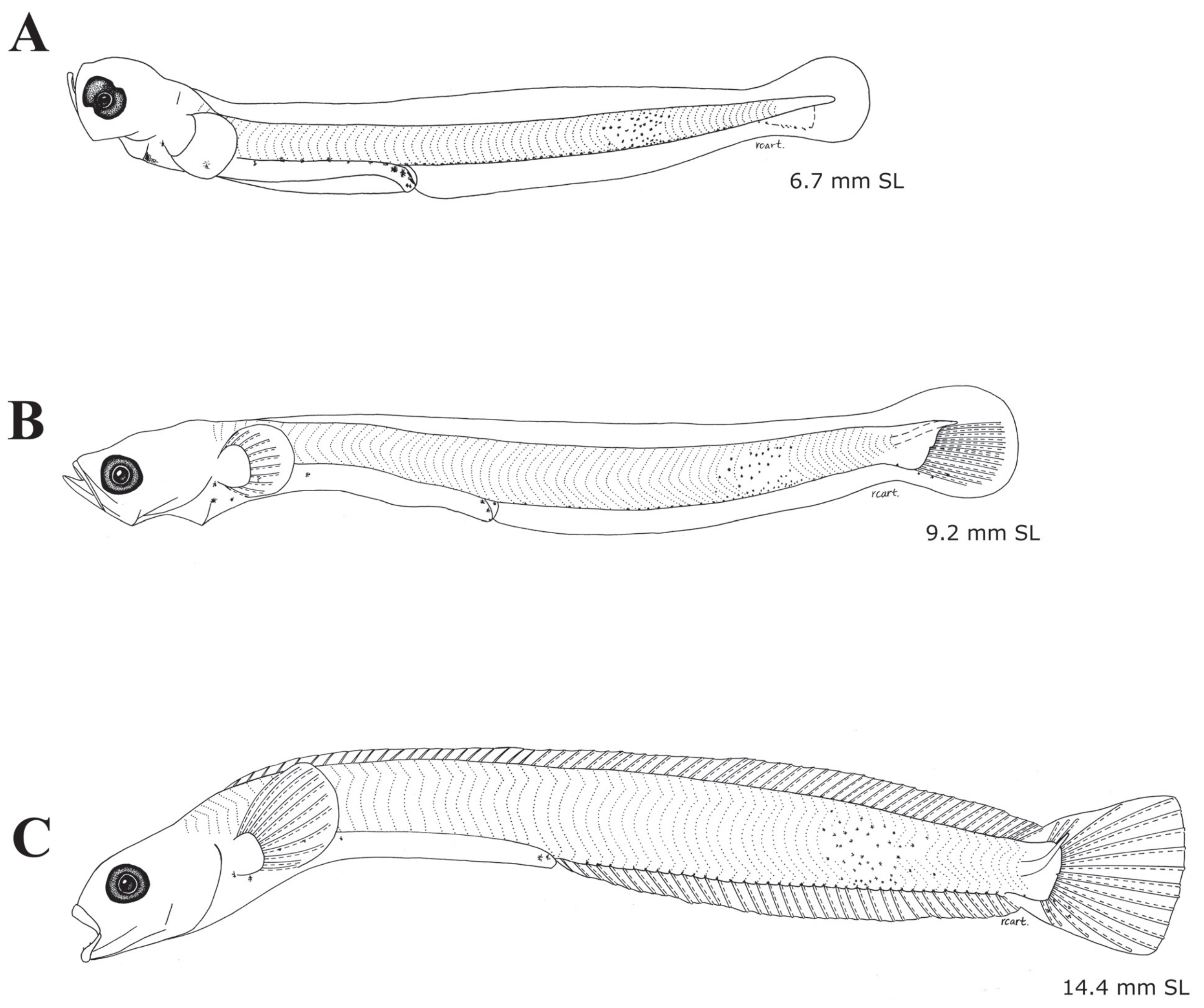

Figure 37

Larvae of Monkeyface Prickleback (*Cebidichthys violaceus*): (**A**) preflexion stage, 6.7 mm standard length (SL), University of Washington (UW) 144863; (**B**) flexion stage, 9.2 mm SL, UW 144865; and (**C**) postflexion stage, 14.4 mm SL, UW 144869. Illustrations by R. Cartwright.

(most specimens were 6.6–7.6 mm) have been collected off central California between Point Buchon and Point San Luis in January–July; greatest abundances occur in April–May (PG&E^3). Larvae also have been collected in San Francisco Bay, California (Wang, 1986).

Morphology (Table 36). Notochord flexion in *C. violaceus* begins by 8.6 mm and is complete by 13.6 mm. The two postflexion larvae examined were 13.6–14.4 mm; longer postflexion larvae would probably be found in the field. Lengths at which transformation and the juvenile stage begin are unknown. Larvae are slender-bodied with a mean body depth of 8.2% SL in the preflexion stage (*n*=2), increasing to 8.6% SL and 9.6% SL in the flexion and postflexion stages. Relative head length and snout to anus length increase slightly through development, and relative snout length and eye diameter decrease.

Pigmentation (Fig. 37). Larvae are moderately pigmented. Among stichaeids, only larvae of *C. violaceus* have lateral pigment in a single bar on the postanal body. The head is unpigmented through at least the early postflexion stage. In preflexion larvae, ventral pigment is present below the pectoral-fin base anteriorly on the gut. A series of about 8–10 melanophores occurs dorsally along the gut with 3–4 additional spots on the hindgut. Anteriorly,

Table 36

Body proportions of Monkeyface Prickleback *(Cebidichthys violaceus)* larvae. Except for standard length (SL), values given for each body proportion are expressed as percentage of SL or head length (HL): mean, ± standard deviation, and range (in parentheses).

	Preflexion		Flexion		Postflexion	
Sample size	2		4		2	
Standard length (mm)	6.4±0.3	(6.2–6.6)	9.7±1.1	(8.6–10.7)	14.0±0.6	(13.6–14.4)
Head length/SL	15.1±1.0	(14.4–15.8)	16.5±2.1	(13.8–18.8)	16.7±2.5	(14.9–18.5)
Snout length/HL	29.9±3.3	(27.6–32.2)	24.7±4.4	(21.3–31.1)	20.8±6.2	(16.4–25.2)
Eye diameter/HL	32.2±1.1	(31.5–33.0)	27.5±3.4	(23.5–31.8)	22.2±3.3	(20.0–24.7)
Snout to anus length/SL	48.6±1.4	(47.6–49.5)	49.6±1.7	(47.5–51.2)	50.6±0.3	(50.3–50.8)
Body depth/SL	8.2±0.6	(7.8–8.6)	8.6±0.6	(8.1–9.4)	9.6±1.2	(8.8–10.4)

a few melanophores are present laterally on the gut near the base of the pectoral fin. Postanal pigment consists of one large bar and a series of PVM. The bar is composed of small melanophores between postanal myomeres 24 and 33.

During the flexion stage, the dorsal melanophores on the gut become internal, but anterior and hindgut melanophores remain external. The postanal pigment bar melanophores and PVM are small and numerous. A single melanophore is present on the ventral margin of the caudal peduncle. Spots appear along the hypural edge and extend onto the developing caudal-fin rays. By the early postflexion stage, a few spots are present externally around the base of the pectoral fin, but pigmentation otherwise changes little. Light external pigment along the lateral surface of the gut and hindgut is still visible. The postanal body pigment bar remains approximately between myomeres 24 and 33. Pigment is relatively unchanged on the caudal peduncle and on the caudal-fin rays along the hypural edge.

Meristic features. No specimens of *C. violaceus* were available to clear and stain. Development of principal caudal-fin and pectoral-fin rays was evident by 9.2 mm in unstained specimens of mid-flexion larvae. All median and paired fin elements appear developed in postflexion larvae by 14.4 mm. The posterior two-thirds of the dorsal fin is composed of soft rays. Pelvic fins are absent. Ranges of adult meristic counts are given in Table 2.

Species comparisons. Adults and larvae of *C. violaceus* are notably different in appearance from all other Stichaeidae in our study area. Most notably, the posterior two-thirds of the dorsal fin is composed of soft rays. Although somewhat similar in general morphology to species of *Anoplarchus*, larval *C. violaceus* have a longer mean snout to anus length (48.6–50.6% SL vs. 41.1–43.2% SL) and no ventral pigment on the gut; in contrast, species of *Anoplarchus* have a row or line of pigment on the gut. The most noticeable difference between *C. violaceus* and other xiphisterine larvae is the presence of a bar of small melanophores that cover an area of the postanal body at about 75–85% SL, just anterior of the caudal peduncle. Larvae of *C. violaceus* also have more preanal myomeres (vertebrae) than do larvae of both *A. insignis* and *A. purpurescens* (23–25 vs. 16–19) and more total vertebrae than has *A. purpurescens* (65–71 vs. 58–64).

Phytichthys chirus, Ribbon Prickleback

See “Other material” below.

Xiphister atropurpureus, Black Prickleback

See “Other material” below.

Xiphister mucosus, Rock Prickleback

See “Other material” below.

Other material

This section provides brief accounts and descriptions of larval stages of eight stichaeid taxa represented by very limited material from our collections. On the basis of general morphology, pigmentation, and counts of meristic features, these specimens, except *Acantholumpenus mackayi* (Tokuya and Amaoka, 1980), were tentatively identified. All individuals shared the following characters: bodies generally slender, guts short (snout to anus length of about 50% SL or less), PVM typically present, myomeres 50–83, and other meristic features that overlap with at least one known stichaeid species.

A single preflexion larva, 10.6 mm (Fig. 38A), collected in the Beaufort Sea, bore a strong resemblance to *Stichaeus punctatus* (subfamily Stichaeinae, Fig. 3) and was very likely *Eumesogrammus praecisus*. This larva had a short gut (37.5% SL) with pigment along its ventral surface, melanophores on the dorsal midline, internal pigment above the notochord, PVM, and, most notably, slash-like hypaxial pigment along the myosepta. In addition, this larva had 50 myomeres, which is within the vertebral range (50–53) for *E. praecisus*; the count of 53 total vertebral centra observed on radiographs is greater than the count previously published for this species (50–52; Mecklenburg et al., 2002). This larva differed from preflexion *S. punctatus* by having a more slender body (body depth: about 5.0% SL vs. 7.9–11.2% SL), a continuous line of ventral pigment along the entire length of the gut (vs. restricted to the anterior one-half of the gut), and larger size during the preflexion stage (10.6 mm SL vs. 6.4–9.0 mm SL). Adult *E. praecisus* occur in the northern Bering, Chukchi, and Beaufort seas, Canadian Arctic Ocean, off the coast of Greenland, and in the North Atlantic Ocean. Larvae are likely unknown because few ichthyoplankton collections have been made within this species' range. With the increasing interest in Arctic ecosystems, it is likely that more of these larvae will be collected in the future.

Grigor'ev (1992a) described and illustrated two postflexion larvae that he identified as *Chirolophis snyderi* (28.0 and 33.0 mm TL) collected near Kamchatka, Russia. However, because of the poor quality of these illustrations, it is unclear how larval *C. snyderi* are distinguished from *C. decoratus* and *C. nugator* other than that the collection locality reported for *C. snyderi* by Grigor'ev (1992a) excludes *C. decoratus* and *C. nugator*.

We examined 12 larvae of *Chirolophis* cf. *snyderi* that were clearly not *C. decoratus* or *C. nugator*. These larvae were collected with bongo and neuston nets and Tucker trawls; 11 larvae were caught in the Gulf of Alaska and 1 was collected in the Bering Sea. Of these specimens, two were illustrated (Fig. 38B–C) and four were cleared and stained. Flexion larvae of *C.* cf. *snyderi* are most likely to be confused with *C. decoratus* and *C. nugator*, but they can be distinguished by a row of evenly spaced, internal melanophores above the urostyle that extends anteriorly only to the caudal peduncle. In *C. decoratus* and *C. nugator*, urostyle pigment is absent, but the internal notochord pigment extends anteriorly from the caudal peduncle to midbody or farther. Larvae of *C.* cf. *snyderi* lack dorsal melanophores on the gut, unlike *C. decoratus* and *C. nugator*. However, the illustrated 18.5-mm *C.* cf. *snyderi* specimen had two deeply embedded melanophores that were just above the dorsal surface of the gut at about 75% gut length and not visible from a lateral view. Mean body depth is greater in postflexion *C.* cf. *snyderi* than in *C. decoratus* or *C. nugator* (14% SL vs. 8.9% SL and 9.9% SL). Although there is minimal overlap, meristic counts of *C. snyderi*, particularly vertebrae, typically are intermediate between *C. decoratus* and *C. nugator* (61–65 vs. 65–69 and 55–61). Another species, Matcheek Warbonnet (*Chirolophis tarsodes*; Jordan and Snyder, 1902), has meristic counts similar to *C. snyderi* (Table 2), but it is unlikely that these examined larvae were *C. tarsodes* because this species is known from very few adult specimens (Mecklenburg et al., 2002). Until we obtain and identify additional specimens, we cannot be certain of this larval identification.

A single late-postflexion larva of *Acantholumpenus mackayi* (36.5 mm) was collected in Norton Sound, Alaska (subfamily Lumpeninae, Fig. 38D; see Tokuya and Amaoka, 1980: fig. 11). This larva was similar to other larval Lumpeninae, particularly *Lumpenella longirostris*, in having a slender body (body depth 8.5% SL), a long snout, a long gut (snout to anus length 47% SL) with melanophores on its lateral surface, and what appeared to be a very faint row of embedded PVM that were visible only in ventral view. As with the other members of the subfamily Lumpeninae, the presence of mediolateral pigment indicates that an *A. mackayi* larva will soon enter the transformation stage. Postflexion larvae of *A. mackayi* are distinguished from *L. longirostris* and *Lumpenus sagitta* by the presence of mediolateral pigment by about 35 mm (vs. absence before 40 mm). In addition, *A. mackayi* has more precaudal (27–30 vs. 22–25) and total (76–80 vs. 70–75) vertebrae than does *L. longirostris*. Meristic counts of *A. mackayi* and *L. sagitta* generally overlap, but *A. mackayi* may have fewer caudal vertebrae (47–50 vs. 46–55). Fin-ray counts for the examined larva (D:LXVIII; A:II,41; P_1:14; P_2:I,3) were consistent with *A. mackayi* (Table 2). This specimen appeared to have >75 myomeres, a number that is within the known vertebral range for this species (76–80).

Two preflexion larvae with lenths of 10.3 and 10.8 mm were collected near Vancouver Island, British Columbia, Canada (Fig. 39A) and another larva (length unknown[4]) was sampled from southeast Alaska. These three larvae were very likely *Lumpenopsis hypochroma* (Hastings and Walker, 2003; Mecklenburg and Sheiko, 2004). These specimens were somewhat similar to *Opisthocentrus ocellatus* (subfamily Opisthocentrinae) in having a relatively long gut (about 47% SL) with a row of large melanophores along its ventral surface. These larvae had an unusual feature: 11–15 internal anterior PVM separated by an unpigmented space of 3–4 myomeres from 4 external PVM. Two mediolateral melanophores were directly above the posterior PVM. From their general appearance, and considering species for which there is no larval description, the most likely identity of these larvae was *L. hypochroma*. Hastings and Walker (2003) reported 54–55 vertebrae for this species (counts based on three specimens), and our larvae had 54–55 myomeres. Because they had similar vertebral counts, our larvae were very possibly *L. hypochroma*; however, until more adults are available from which to obtain additional

---

[4] Specimen was examined by M. S. Busby, but it is now lost.

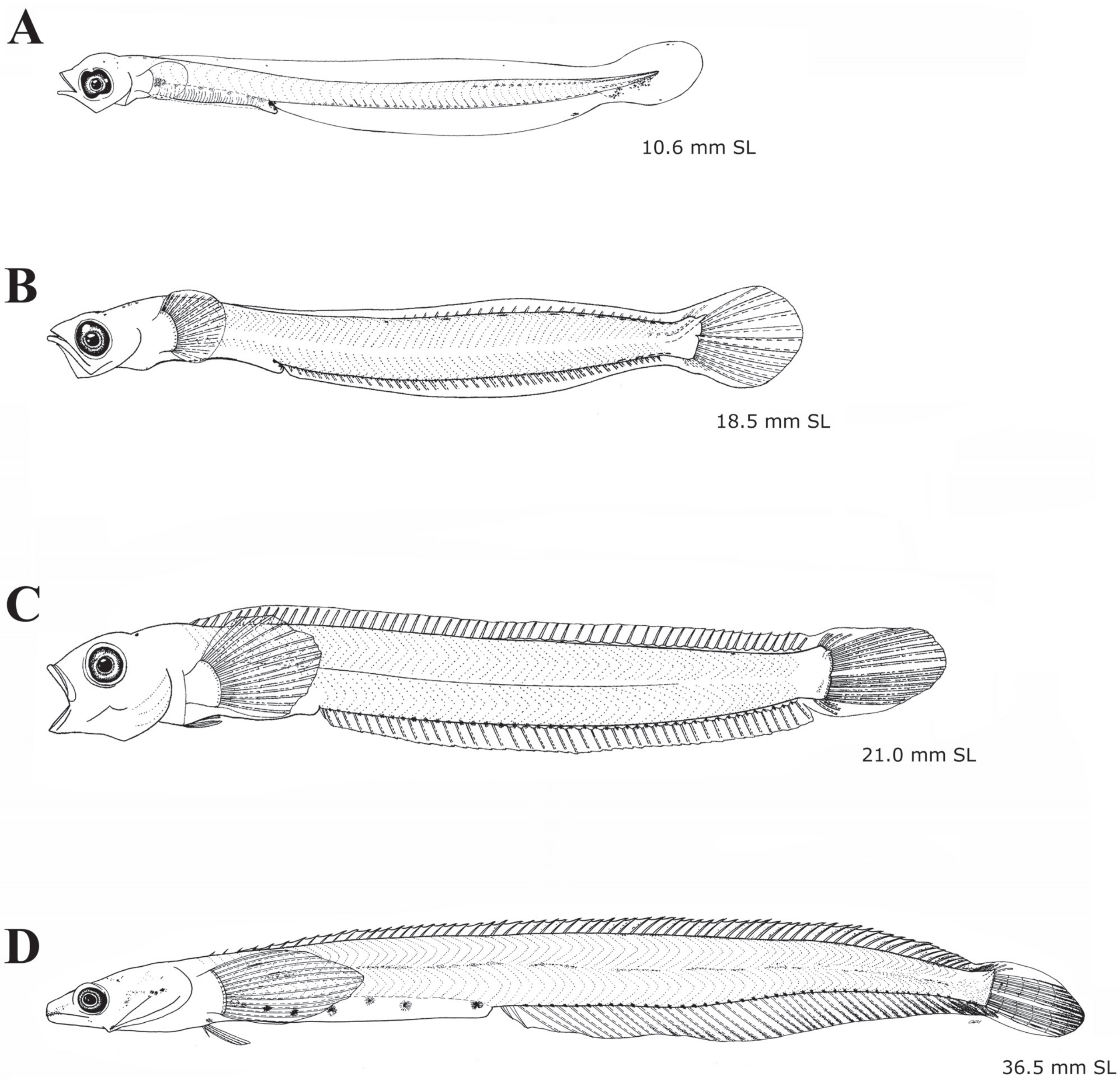

Figure 38

Larvae from other material: (**A**) Fourline Snakeblenny (*Eumesogrammus praecisus*), preflexion stage, 10.6 mm standard length (SL), University of Washington (UW) 145179; (**B**) *Chirolophis* cf. *snyderi*, flexion stage, 18.5 mm SL, UW 145178; (**C**) *Chirolophis* cf. *snyderi*, postflexion stage, 21.0 mm SL, UW 144864; and (**D**) Blackline Prickleback (*Acantholumpenus mackayi*), late-postflexion stage, 36.5 mm SL, UW 145177. Illustrations by A. Overdick.

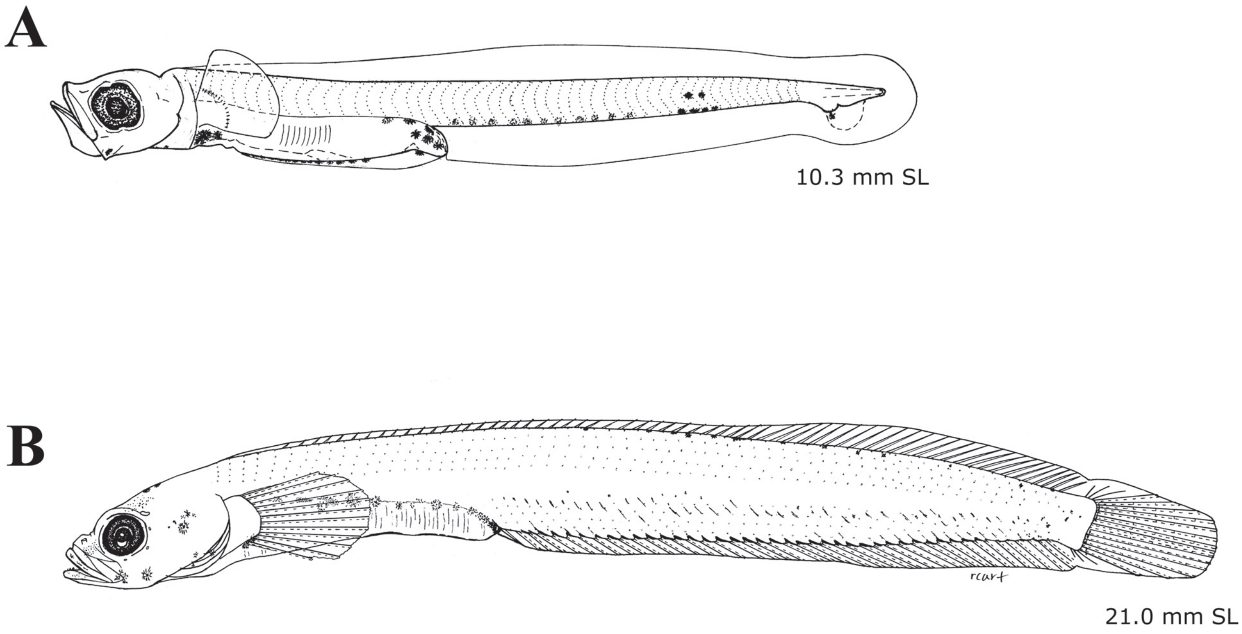

Figure 39

Larvae from other material: (**A**) Y-prickleback (*Lumpenopsis hypochroma*), preflexion stage, 10.3 mm standard length (SL), University of Washington (UW) 145180; and (**B**) Lesser Prickleback (*Alectridium aurantiacum*), postflexion stage, 21.0 mm SL, UW 145871 (original specimen lost). Illustrations by A. Overdick.

counts and we locate additional larval specimens, we cannot be absolutely certain of the identification.

Two postflexion larvae with lengths of 20.0 and 21.0 mm (Fig. 39B) collected during a 1997 cruise in the southeastern Bering Sea resembled *Stichaeus punctatus* (subfamily Stichaeinae, Fig. 3) and were tentatively identified as *Eumesogrammus praecisus* (Fig. 38A). These larvae had a short gut (about 40% SL) with a line of ventral pigment, melanophores on the dorsal midline, internal pigment above the notochord, PVM, and slash-like hypaxial pigment along the myosepta. However, the best match for the specimens' meristic counts (D: LIII, LXIII; A: I,40 or 41, I,43 or 44; P_1: 12; P_2: absent; vertebrae: 63 [20+43], 67 [21+46]) is *Alectridium aurantiacum* (subfamily Xiphisterinae), among stichaeid species reported from the study area. All Xiphisterinae and their larvae lack pelvic fins, but pelvic fins are present in Stichaeinae.

Matarese et al. (1989) provided species accounts for *Phytichthys chirus*, *Xiphister atropurpureus*, and *X. mucosus* larvae on the basis of material collected in Barkley Sound, British Columbia, Canada, by Marliave (1975a, 1975b; as presented in Matarese et al., 1989). Wang (1986) reported information on early life history of *Xiphister* species from the Sacramento-San Joaquin estuary. After reexamination of the material from Marliave (1975a, 1975b, as presented in Matarese et al., 1989) and examination of new material, it became apparent that the use of pigmentation to distinguish preflexion- and flexion-stage larvae of these three taxa is problematic. Yolk-sac larvae (Fig. 40A) of *X. atropurpureus* from known parents hatch at about 6.3 mm with an amber-colored yolk sac and a short gut (about 38% SL). Larvae have six evenly spaced dorsal melanophores on the gut with a single spot on the hindgut, about 38 PVM with the posteriormost 5–6 appearing dash-like, and about 5–6 small, widely spaced melanophores on the dorsal midline that begin at about midbody and extend to the caudal peduncle. Notochord flexion in *X. atropurpureus* occurs between 12.0 and 16.0 mm. In our limited material, individuals at lengths of about 12.0 mm showed early hypural development but no flexion of the notochord, and individuals at lengths of 15.8 and 16.0 mm were clearly in the postflexion stage (Fig. 40B).

We have three wild-caught postflexion specimens of *Phytichthys chirus* from Puget Sound, Washington (Fig. 40C). *Phytichthys chirus* and species of *Xiphister* can usually be identified with counts of abdominal vertebrae (precaudal myomeres) (Table 2). We measured, cleared, and stained larvae of each prospective taxon and, after verifying our identifications, determined that larvae of *P. chirus* are generally similar to species of *Xiphister*. However, *P. chirus* is deeper bodied during the postflexion

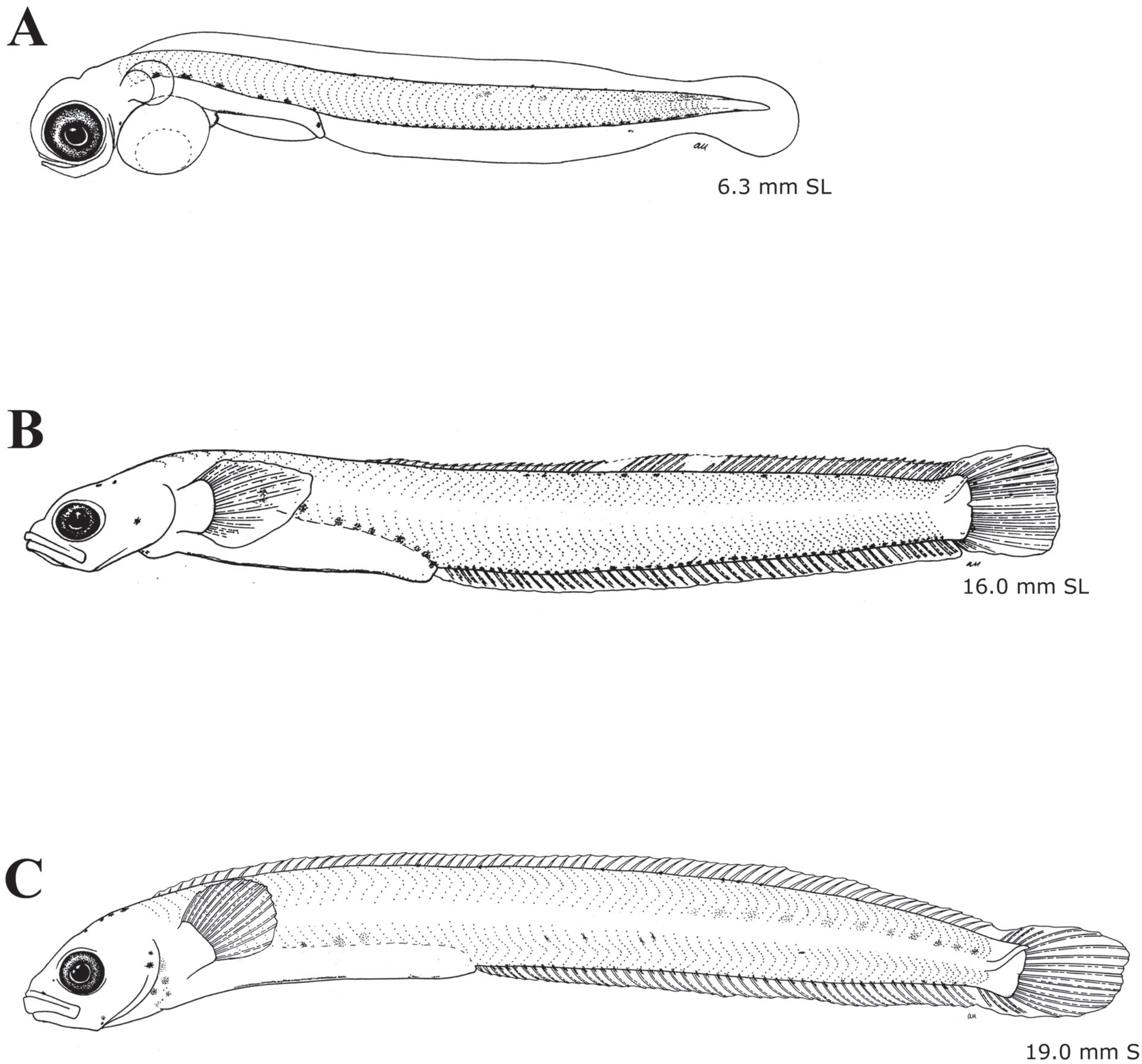

Figure 40

Larvae from other material: (**A**) Black Prickleback (*Xiphister atropurpureus*), yolk-sac stage, 6.3 mm standard length (SL), University of Washington (UW) 144848; (**B**) *X. atropurpureus*, postflexion stage, 16.0 mm SL, UW 145176; and (**C**) Ribbon Prickleback (*Phytichthys chirus*), postflexion stage, 19.0 mm SL, UW 145181. Illustrations by A. Overdick.

stage (13.5% SL) compared to both *Xiphister* species (10.5–12.0% SL), and this species has a longer gut (snout to anus length 47% SL) than does *X. atropurpureus* (43% SL). *Phytichthys chirus* typically has more precaudal vertebrae (24–25) than does *X. atropurpureus* (22–24) and fewer than does *X. mucosus* (29–31). Lastly, postflexion *P. chirus* has a double row of irregularly spaced melanophores along the dorsal midline. Similar pigmentation is present in *X. atropurpureus*, but it is less pronounced and does not extend as far anteriorly. From the limited material examined, dorsal midline pigment was apparently absent in *X. mucosus* (specimens not suitable for illustration). However, it is presently unclear how useful pigment characters are in distinguishing among these three species because very few specimens were available for study. Additional larvae of all three taxa could likely be collected by intertidal and nearshore ichthyoplankton surveys.

Discussion

With this study, at least one early life history stage is now known for most of the 27 stichaeid species reported from the NEP and Bering Sea; exceptions are *Eumesogrammus praecisus*, *Lumpenopsis hypochroma*, and *Alectridium aurantiacum*, all tentatively identified and illustrated herein. Illustrations of complete developmental series (preflexion, flexion, and postflexion; some previously published) are collectively presented in this guide for 14 species, and there are at least 2 developmental stages presented for an additional 6 species. New, original illustrations of 16 preflexion, 17 flexion, 22 postflexion, and 6 transformation stages are presented for 25 species. This guide represents a comprehensive source of original morphological, meristic, and pigmentation characters that will ensure accurate identification of the early life history stages of this family of cryptic nearshore fishes. Additional work on stichaeids, such as molecular studies on phylogenetic relationships and effects of ecosystem changes on species assemblages, will benefit from the completion of this guide. However, there are still gaps in our knowledge, especially of egg and juvenile stages (Table 37). Additional collections, particularly from intertidal and nearshore habitats, are needed to fill some of these gaps. Eggs could be obtained from adults spawning in captivity, from extensive intertidal surveys, or by divers in subtidal areas. Larvae and juveniles might also be collected by similar methods in these habitats. It is likely that juveniles of some species are already represented in regional fish collections, but location and examination of them was beyond the scope of this study. Species of *Phytichthys* and *Xiphister* are likely collected as larvae in intertidal and nearshore surveys. Ichthyoplankton surveys in the more northern reaches of the Bering Sea and Arctic Basin likely will provide additional specimens and undescribed early life history stages of *Acantholumpenus mackayi* and *E. praecisus*. Additional material might also help clarify some of the difficulties in identification of larvae of the Arctic species of *Lumpenus*, particularly *L. fabricii* and *L. medius*.

Meristic, morphological, and pigmentation characters are all useful for species-level identification of larval and early juvenile pricklebacks (Table 38). Although many of the character states and meristic values reported here are new, some are updated from previous studies. Examples include myomere counts for *Stichaeus punctatus* that Faber (1976) reported as <50, but we (and others) found 51–55, and PVM for *Lumpenus maculatus* that had been usually 30–40 (also from Faber, 1976), but we report 34–41. We also found length at transformation of *S. punctatus* begins at about 28 mm and is complete by 35 mm, lengths that are greater than Faber's (1976) value of about 25 mm. Grigor'ev (1992b) reported 14 precaudal myomeres for *L. medius* and 40–42 PVM for *L. fabricii*, but we found 21–25 precaudal myomeres for *L. medius* and 33–45 PVM (preflexion–postflexion) for *L. fabricii*.

Counts of precaudal, caudal, and total vertebrae (myomeres) and anal-fin elements are the most helpful meristic characters for generic and species-level identifications. Body depth and gut length (snout to anus length) are the most important morphological characters. Number of PVM can sometimes be a distinguishing pigmentation characteristic or at least can help to narrow the possible choices (e.g., Chirolophinae and Xiphisterinae). Although some stichaeid taxa have very distinct pigmentation patterns (e.g., *S. punctatus*, *Plectobranchus evides*, and *Cebidichthys violaceus*), others have more subtle differences within their respective subfamilies (e.g., Chirolophinae: *Bryozoichthys* and *Chirolophis*; Lumpeninae: *Lumpenella, Lumpenus*, and *Poroclinus*) or genera (e.g., *Anoplarchus* and *Xiphister*). In the genus *Lumpenus,* however, pigmentation alone is not useful to distinguish species.

Another useful character to aid identification is the length at stage of development, particularly the size at onset of transformation. It is worth noting, however, that we observed variation within taxa in length at transformation, particularly between reared and wild-caught individuals. Laboratory-reared larvae may transform early as a result of the proximity of suitable substrate for settlement in the aquaria. Larval Xiphisterinae transform at ≤35 mm, but Lumpeninae are generally >35 mm at transformation (Table 38). We observed a wide range of lengths at transformation for wild-caught individuals in these subfamilies, including species of *Lumpenus* and *Anoplarchus*. It has been suggested that larvae of some intertidal fishes are locally retained by physical forces and are, therefore, genetically isolated populations distinctly adapted to their environments (Marliave, 1986). Adaptation to physical forces could influence length at transformation because it has been suggested that larvae of some species may be able to delay transformation until they encounter suitable juvenile habitat (Moser, 1981; McCormick, 1999). Larval behavior might also be involved, especially for these species that sometimes demonstrate prolonged larval stages (e.g., *Lumpenus*). Most of the specimens we examined were collected in the field, but some were reared in the laboratory. Transformation of reared specimens at smaller sizes, compared to wild-caught specimens, is evident in our developmental series of *Anoplarchus purpurescens* (Fig. 35D wild-caught; A–C, E reared).

Our observations that ossification does not occur until postflexion in some species, even when the larvae appear well developed and in good condition, indicate that there may be problems with some of the specimens that were cleared and stained. In some instances, smaller specimens showed indications of ossification, but larger specimens did not (e.g., *Chirolophis nugator*, *Lumpenus maculatus*, *L. sagitta*, *Anoplarchus insignis*, *A. purpurescens*).

Table 37

Summary of knowledge of early life history stages of the family Stichaeidae in the northeastern Pacific Ocean and Bering Sea based on this study.

	Life history stage				
Taxon	Egg	Preflexion	Flexion	Postflexion	Juvenile
STICHAEINAE					
Eumesogrammus praecisus		X^{1}			
Stichaeus punctatus	X	X	X	X	X
CHIROLOPHINAE					
Bryozoichthys lysimus		X	X	X	X
Bryozoichthys marjorius		X	X	X	X
Chirolophis decoratus		X	X	X	X
Chirolophis nugator	X	X	X	X	
Chirolophis snyderi				X^{1}	
Gymnoclinus cristulatus				X	
LUMPENINAE					
Acantholumpenus mackayi				X	
Lumpenella longirostris		X	X	X	X
Lumpenus fabricii		X	X	X	X
Lumpenus maculatus		X	X	X	X
Lumpenus medius		X	X	X	X
Lumpenus sagitta		X	X	X	
Poroclinus rothrocki		X	X	X	X
OPISTHOCENTRINAE					
Lumpenopsis hypochroma		X^{1}			
Opisthocentrus ocellatus	X	X	X		X
Plectobranchus evides		X		X	
XIPHISTERINAE					
Alectrias spp.	X		X	X	
Alectridium aurantiacum				X^{1}	
Anoplarchus insignis		X	X	X	X
Anoplarchus purpurescens	X	X	X	X	X
Cebidichthys violaceus	X	X	X	X	
Phytichthys chirus	X	X^{1}	X^{1}	X	
Xiphister atropurpureus	X	X^{1}	X^{1}	X	
Xiphister mucosus	X	X^{1}	X^{1}	X^{1}	

[1] Identification is tentative.

There were also instances when results differed between two cleared and stained specimens of the same length (e.g., *L. maculatus*, *L. sagitta)*. In these cases, it is possible that preservation in acidic formaldehyde could have decalcified bones in early ossification. It should also be noted that the typical alcian blue solution used to stain cartilage contains acetic acid, which may also decalcify skeletal elements just beginning to ossify. Acquisition of additional specimens of larvae and early juveniles of these species would permit more clearing and staining and would provide additional osteological examinations. A general observation made during this study was that specimens initially preserved in marble chip buffered formalin cleared more slowly and stained with less consistent results than did specimens preserved in sodium borate buffered formalin. The difference in preservation technique is likely the cause of the variability of results observed in cleared and stained specimens.

Larval characters: relationships within family Stichaeidae

The phylogeny of stichaeid fishes is poorly understood, and relationships of the subfamilies have not been investigated. Stoddard (1985), Yatsu (1986), Kartavtsev et al. (2009), and Radchenko et al. (2009) have suggested that the current classifications (subfamilies of Makushok (1958) are not monophyletic groups. We have followed the subfamily classification of Mecklenburg and Sheiko (2004), which differs from Makushok (1958) only in that species from Makushok's Alectriinae are included in Xiphisteriinae. A phylogeny of the family might be resolved through the use of modern cladistic analysis with multiple character sets and inclusion of all known taxa. In addition to adult morphological characters, some early life history features noted here will be a valuable addition to the systematic data set (Table 38) and might help resolve relationships within the family, particularly among the subfamilies. To include early life history characters into a proposed phylogeny of the family Stichaeidae and establish relationships within and among the subfamilies, it will be necessary to establish primitive (ancestral) larval character states through selection of multiple outgroup taxa, both within and outside Zoarcoidei.

Traditionally, the ronquils (family Bathymasteridae), have been considered the basal zoarcoid family, closely related to stichaeids, and would be an appropriate outgroup family (Anderson, 1994). Larvae of the bathymasterid *Ronquilus jordani* have been described (Stevenson and Matarese, 2008: fig. 1) and share several general morphological and pigment characters with *Stichaeus punctatus* (Fig. 3). Both of these species have deep bodies in postflexion (≥12.5% SL) (more so for *R. jordani*) and short guts (<40% SL) with ventral pigment, rows of melanophores along the dorsal midline, internal pigment both above and below the notochord in the area of the caudal peduncle, and slash-like hypaxial melanophores along the myosepta. These attributes would be considered primitive larval characters, because they are shared with *R. jordani*, supporting the Stichaeinae as the basal stichaeid subfamily. The larva we identified tentatively as *Eumesogrammus praecisus* also shares these characters, although postflexion body depth was unknown (Fig. 38A). In addition, Stichaeinae have the lowest counts of vertebrae in the family, and Anderson (1994) considered low vertebral counts a primitive character state among zoarcoid fishes. With the exception of a deep body (9% SL vs. >12% SL), the slash-like hypaxial melanophores, and low vertebral counts, the genus *Chirolophis*, in the subfamily Chirolophinae, shares short gut and general pigmentation characters with the genus *Stichaeus*.

Shared larval characters within other subfamilies support their close relationships. The Lumpeninae generally share the characters of sparse pigmentation with a row of PVM, melanophores present dorsally or laterally on gut, and slender bodies with relatively long guts (snout to anus lengths). Xiphisterine larvae are also very similar to one another with PVM, relatively short guts, medium body depth, and a lack of pelvic fins (Table 38). It should be noted, however, that counts of PVM are variable among taxa within the subfamilies and probably not phylogenetically informative. Although only notable in postflexion larvae and adults, absence (loss) of pelvic fins might be a derived character.

Within other subfamilies, however, some species have marked differences in some of their larval characters. For example, within the Chirolophinae, postflexion-stage *Gymnoclinus cristulatus* is deeper bodied (16% SL vs. 6.3–10% SL) and more heavily pigmented than are other members of the subfamily (the genera *Bryozoichthys* and *Chirolophis*), which are all similar with short guts, PVM, internal pigment above the notochord, and pigment on the dorsal midline in varying degrees. In Opisthocentrinae, *Opisthocentrus ocellatus* larvae possess features more similar to some members of Xiphisterinae, including a long gut (snout to anus length 40–50% SL) with a row of melanophores on its ventral surface, PVM, and the absence of pelvic fins. Other Opisthocentrinae, such as the genera *Kasatkia* (Mecklenburg and Sheiko, 2004) and *Pholidapus* (Hatooka, 2002), lack pelvic fins, but their larvae are unknown.

One unusual observation is that our larvae tentatively identified as *Alectridium aurantiacum* (Fig. 39B) shared pigment characters of the Stichaeinae, but it was placed in Xiphisterinae primarily because it lacked pelvic fins. The absence of pelvic fins in Xiphisterinae (and some Opisthocentrinae) is an important character that distinguishes this subfamily from Stichaeinae. On the basis of meristic features, it is possible this larva was an undescribed species of Stichaeinae that has not yet developed pelvic fins. The striking similarities in pigmentation characters between postflexion *A. aurantiacum* and *S. punctatus*, however, indicate a possible relationship that warrants further investigation. These similarities are pigment along the ventral midline of the gut and dorsal midline, PVM, and slash-like hypaxial pigment along the myosepta.

Larval characters: relationships within suborder Zoarcoidei

The phylogenetic relationships of the family Stichaeidae within the suborder Zoarcoidei (Bathymasteridae, Zoarcidae, Ptilichthyidae, Zaproridae, Anarhichadidae, Cryptacanthodidae, Pholidae, and Scytalinidae) are not well understood and need further study. Larvae of scytalinids are unknown, and zoarcids lack a larval stage. In addition to adult morphological characters, some early life history features are noted on the basis of unpublished sources (Ichthyoplankton Information System, http://access.afsc.noaa.gov/ichthyo/index.cfm), our observations during the course of this study, and ongoing research on bathymasterid and cryptacanthodid larvae. Bathymasterids, stichaeids, and pholids have similar pigment patterns with PVMs; zaprorids and cryptacanthodids share similar heavy pigment patterns and

Table 38

Summary of some important characters useful for identification of larval and early juvenile stichaeids. Morphological measurements are mean percentages of standard length for larvae in the postflexion stage, except for Ocellated Blenny (*Opisthocentrus ocellatus*), which was in the flexion stage; postanal ventral melanophore (PVM) counts are for postflexion stage. Lengths at developmental stage are standard length in millimeters unless otherwise noted. BD=body depth; SNA=snout to anus length; Post=postflexion; Trans=transformation; abs=absent.

	Vertebrae			Fins		Pigment	Morphology[1]		Length at developmental stage			
Taxon	Precaudal	Caudal	Total	Pelvic	Anal	PVM	BD	SNA	Hatch	Flexion	Post	Trans
STICHAEINAE												
Eumesogrammus praecisus	15–17	35–37	50–53	I,3	I–II,29–32,II–III	40						
Stichaeus punctatus	14–16	36–40	51–55	I,4	I–II,32–37	32–35	12.5	40.0	<6.4	9.0–16.4	16.4–28.2	>28.0,<35.0
CHIROLOPHINAE												
Bryozoichthys lysimus	16–17	53–58	69–75	I,3	I,47–53	46–48	8.5	34.0	<6.9	12.0–22.0	21.6–35.6	>36.0
Bryozoichthys marjorius	15–17	55–59	71–76	I,3	I,51–59	53–54	6.5	32.0	<7.7	11.0–24.0	21.4–40.0	>40.0,<55.0
Chirolophis decoratus	16–17	50–53	65–69	I,3–4	I–II,44–49	>40	9.0	35.0	<8.7	13.0–19.5	19.5–31.6	>32.0
Chirolophis nugator	14–16	42–46	55–61	I,3–4	I–II,37–42	35–37	10.0	37.0	<8.7	12.3–17.0	17.0–25.0	>25.0
Chirolophis snyderi	16–17	44–48	63–65	I,4	I–II,43–47							
Chirolophis tarsodes	15	47–50	61–65	I,3–4	I,43–46							
Gymnoclinus crisulatus	18–19	46–47	65	I,2	40–43	Variable	16.0	47.0			18.8–26.8	>26.8
LUMPENINAE												
Acantholumpenus mackayi	27–30	47–50	76–80	I,3	II,41–48	40	8.5	47.0			?–35.0	>35.0
Lumpenella longirostris	22–25	47–49	70–75	I,2–3	II–V,36–42	42–44	6.5	43.0	<8.0	13.0–25.0	24.9–40.4	>40.0–50.0
Lumpenus fabricii	23–28	43–49	70–75	I,3	I,38–44	33–37	7.0	43.0	<11.9	13.0–21.0	20.0–46.0	45.0–50.0
Lumpenus maculatus	25–30	39–43	66–72	I,3–4	I–II,34–40	34–41	7.5	50.0	<8.0	13.0–25.0	20.0–66.2	>50.0
Lumpenus medius	21–25	42–50	65–70	I,3	I,37–42	29–38	8.0	44.0	<9.6	11.0–14.5	?–46.5	>35.0
Lumpenus sagitta	26–29	46–55	75–82	I,3	I–II,44–50	44–53	6.5	44.0	<5.0[2]	15.5–25.0	25.0–40.0	>40.0
Poroclinus rothrocki	18–20	45–48	64–68	I,3	III,40–44	40–41	8.5	44.0	<5.5	9.5–20.0	20.0–30.0	<28.0
OPISTHOCENTRINAE												
Lumpenopsis hypochroma	17–18	36–38	54–55	I,3	I,30–32	11–15+4[3]						
Opisthocentrus ocellatus	21–23	39–44	61–67	abs	I–II,32–39	40	12.0	53.0	9.0–10.0[4]	14.0–?		<22.0
Plectobranchus evides	20–21	39–40	59–61	I,3	II–III,34–36	abs	9.5	47.0	<4.7	11.0–20.0	20.0–49.0	>49.0
XIPHISTERINAE												
Alectrias alectrolophus	17–20	47–50	64–70	abs	I,41–45							
Alectrias spp.	15–20	44–50	60–70	abs	I,39–45	<40	11.0	41.0	<10.7	11.0	12.0–16.5	
Alectridium aurantiacum	20–21	47	60–68	abs	I,41–44	45					20.0–?	
Anoplarchus insignis	17–19	42–49	60–69	abs	I,38–46	36	9.0	42.0	<5.2	9.0–14.0	14.0–20.6	<35.0
Anoplarchus purpurescens	16–19	40–46	58–64	abs	I–II,35–42	<40	10.0	43.0	7.5 mm TL[5]; <4.7[6]	9.0–13.0	12.1–21.0	<28.0
Cebidichtys violaceus	23–25	40–47	65–71	abs	I–II,39–42	≥40	9.5	51.0	≤4.8[7]	8.6–13.6	13.6–14.4	
Phytichthys chirus	24–25	50–52	75–76	abs	II–III,40–45							
Xiphister atropurpureus	22–24	51–56	73–80	abs	0–I,49–55							
Xiphister mucosus	29–31	44–53	73–83	abs	0–I,46–50							

---

[1] Morphometric values rounded to the nearest 0.5 mm.

[2] Hart (1973).

[3] Internal anterior PVM separated by an unpigmented space of 3–4 myomeres from four external PVM.

[4] Shiogaki (1982).

[5] Peppar (1965).

[6] This study.

[7] PG&E (text footnote 3).

development milestones; and larvae of both anarhichadids and ptilichthyids are unique in terms of morphology and pigment. However, there are some notable morphological and pigmentation similarities between larval stichaeids and other zoarcoids, particularly Bathymasteridae and Pholidae.

For example, as previously noted, postflexion *Stichaeus punctatus* (Fig. 3C) shares several general morphological and pigment characters with *Ronquilus jordani* (Stevenson and Matarese, 2008: fig. 1). Both of these species have deep bodies (≥12.5% SL) (*R. jordani* more so) and short guts (<40% SL) with ventral pigment, rows of melanophores along the dorsal midline, internal pigment both above and below the notochord in the area of the caudal peduncle, and slash-like hypaxial melanophores along the myosepta. All of these characters, except the slash-like hypaxial melanophores, also are shared with species of *Bathymaster* (Stevenson and Matarese, 2008: fig. 9). *Chirolophis* (present study) also is similar in appearance to *S. punctatus* and *R. jordani* but lacks the slash-like hypaxial myomeres and is more slender-bodied. Many stichaeid larvae also resemble pholids with a long, slender body with a row of PVM; in most cases, however, pholids have a longer gut (>50% SL) and more vertebrae (>80).

Systematics of the Stichaeidae requires further study as monophyly of the group has not been demonstrated. Since Makushok (1958), there have been few additional studies and attempts at classification (Makushok, 1961; Gosline, 1968; Anderson, 1984; Stoddard, 1985; Yatsu, 1986; Anderson, 1994). In each of these studies, the taxonomic scope was limited, specimens of some species were not examined, or early life history characters were not considered.

Yabe and Uyeno (1996) reported similarities between zoarcoids and some cottoids. More recent molecular and morphological studies have provided interesting insight into the relationships of other zoarcoids (Zoarcidae, Pholidae) to gasterosteiforms (e.g., Aulorhynchidae, Gasterosteidae) and the cottoid lineage of the scorpaeniform (e.g., Cyclopteridae, Cottidae, Anoplopomatidae, Hexagrammidae) fishes (Imamura and Yabe, 2002; Chen et al., 2003; Miya et al., 2003; Smith and Wheeler, 2004; Kartavtsev et al., 2009; Radchenko et al., 2009). Wiley and Johnson (2010) have formally recognized zoarcoids within the order Cottiformes, but a detailed study of the morphology and systematics of the Zoarcoidei is still needed. A more robust reconstruction of stichaeid phylogenetic relationships will require additional specimens with a more complete character set. New morphological data from adults and larvae will contribute to the overall understanding of the phylogenetic relationships of the Stichaeidae.

With the completion of this guide, many early life history characters are now available to be used in studies of systematics in conjunction with molecular data (see Roje, 2010). Larval fishes possess unique characters and adaptations for planktonic life that are often very different from those of adults and are useful in studies of taxonomy and systematics (Moser and Ahlstrom, 1974). Early life history characters of stichaeid fishes show promise for use in phylogenetic analyses and, along with molecular data, should be considered in future systematic studies of this very interesting family of fishes.

Acknowledgments

Larval fish taxonomists at the Alaska Fisheries Science Center have been examining stichaeid larvae for more than 30 years. J. Dunn, B. Vinter, and K. Waldron initiated work in the 1970s by separating larvae into groups. B. Vinter compiled, measured, and illustrated many of the larvae that formed the basis of this study.

A joint project in the late 1970s and early 1980s with the University of Washington (UW) comparing inshore and offshore larval fishes enabled further taxonomic studies that led to the identification of unknown stichaeids. More species were identified as part of zoarcoid research in the mid-1980s for the Ahlstrom Symposium. Studies were resumed in the late 1990s when UW student E. MacDonald began her thesis research on larvae of the genus *Lumpenus*.

We thank the following for providing hard-to-obtain specimens: K. Garrison and E. MacDonald (formerly UW); J. Marliave (Vancouver Public Aquarium); W. Watson (NOAA Southwest Fisheries Science Center); G. McGowen (Los Angeles County Museum); H. Imamura (Hokkaido University Museum of Zoology); D. Markle (Oregon State University); N. Laman (AFSC); C. Ehrler (Tenera Environmental Services); T. Pietsch, K. Maslenikov, and D. Roje (UW); C. Mecklenberg (California Academy of Sciences); and J. Paulic (Canada Department of Fisheries and Oceans).

Many scientists and interns at AFSC assisted throughout this study: B. Vinter (compiling and measuring specimens; illustrations while at first employed by and later under contract to AFSC); K. Mier (statistics); S. Picquelle, formerly of AFSC, and J. Benson (GIS mapping); A. Fleischer and R. Takamine (interns; data collection and radiographs); A. Overdick (data collection, radiographs, and illustrations); L. De Forest (clearing and staining, preliminary review of manuscript); S. Remple, formerly of AFSC (clearing and staining and compiling data for materials examined); R. Cartwright, formerly of AFSC (data compilation and illustrations); and N. Laman, J. Orr, and D. Stevenson (of the "Tuesday Fish Lunch Group" for helpful discussions). Some original illustrations drawn by B. Vinter and R. Cartwright were later revised by A. Overdick.

We thank L. De Forest and D. Stevenson also for their review of the draft manuscript. W. Watson greatly improved the accuracy and quality of the draft manuscript by providing a detailed review and sharing his vast reserve of knowledge of larval fish taxonomy. The final draft benefited from thoughtful reviews by D. Markle, E. Hilton, and an anonymous reviewer.

Literature cited

Amaoka, K., K. Nakaya, H. Araya, and T. Yasui (eds).
1983. Fishes from the north-eastern Sea of Japan and the Okhotsk Sea off Hokkaido.The intensive research of unexploited fishery resources on continental slopes, 371 p. Japan Fisheries Resource Conservation Assoc., Tokyo.

Anderson, M. E.
1984. On the anatomy and phylogeny of Zoarcidae (Teleostei: Perciformes). Ph.D. diss., 253 p. College of William and Mary, Williamsburg, VA.
1994. Systematics and osteology of the Zoarcidae (Teleostei: Perciformes). Ichthyol. Bull. 60:1–120.

Blackburn, J. E.
1973. A survey of the abundance, distribution, and factors affecting distribution of ichthyoplankton in Skagit Bay. M.S. thesis, 136 p. Univ. Washington, Seattle.

Blaxter, J. H. S.
1976. Reared and wild fish—how do they compare? *In* Proceedings of the 10th European symposium on marine biology, vol. 1; Ostend, Belgium, 17–23 September 1975 (G. Persoone and E. Jaspers, eds.), p. 11–26. Institute for Marine Scientific Research, Bredene, Belgium.

Blood, D. M., and A. C. Matarese.
2010. Larval development and identification of the genus *Triglops* (Scorpaeniformes: Cottidae). NOAA Prof. Paper NMFS 10, 49 p.

Busby, M. S.
1998. Guide to the identification of larval and early juvenile poachers (Scorpaeniformes: Agonidae) from the northeastern Pacific Ocean. NOAA Tech. Rep. NMFS 137, 88 p.

Chen, W. J., C. Bonillo, and G. Lecointre.
2003. Repeatability of clades as a criterion of reliability: a case study for molecular phylogeny of Acanthomorpha (Teleostei) with larger number of taxa. Mol. Phylogen. Evol. 26:262–288.

Coleman, R. M.
1999. Parental care in intertidal fishes. *In* Intertidal fishes: life in two worlds (M. H. Horn, K. L. Martin, and M. A. Chotkowski, eds.), p. 165–180. Academic Press, San Diego.

Eisner, L., N. Hillgruber, E. Martinson, and J. Maselko.
2012. Pelagic fish and zooplankton species assemblages in relation to water mass characteristics in the northern Bering and southeast Chukchi seas. Polar Biol. 36:87–113.

Eschmeyer, W. N., E. S. Herald, and H. Hammann.
1983. A field guide to Pacific coast fishes of North America, 336 p. Houghton Mifflin Co., Boston.

Faber, D. J.
1976. Identification of four northern blennioid fish larvae in the Canadian Atlantic Ocean (Stichaeidae, Lumpeninae). J. Fish. Res. Board Can. 33:1798–1802.

Fahay, M. P.
1983. Guide to the early stages of marine fishes occurring in the western North Atlantic Ocean, Cape Hatteras, to the southern Scotian Shelf. J. Northwest Atl. Fish. Sci. 4:1–423.
2007. Early stages of fishes in the western North Atlantic Ocean (Davis Strait, Southern Greenland and Flemish Cap to Cape Hatteras). Volume two: Scorpaeniformes through Tetraodontiformes, 764 p. Northwest Atlantic Fisheries Organization, Dartmouth, Nova Scotia.

Farwell, M. K., J. M. Green, and V. A. Pepper.
1976. Distribution and known life history of *Stichaeus punctatus* in the Northwest Atlantic. Copeia 1976:598–602.

Fitch, J. E., and R. J. Lavenburg.
1971. California marine food and game fishes, 179 p. Univ. Calif. Press, Berkeley.

Fujita, S., and K. Uchida.
1959. Breeding habits and rearing of larvae of a blennioid fish, *Ernogrammus hexagrammus* (Temminck et Schlegel). Sci. Bull. Fac. Agric. Kyushu Univ. 17:283–289. [In Japanese.]

Golet, G. H., K. J. Kuletz, D. D. Roby, and D. B. Irons.
2000. Adult prey choice affects chick growth and reproductive success in pigeon guillemots. The Auk 117(1):82–91.

Gosline, W. A.
1968. The suborders of perciform fishes. Proc. U. S. Natl. Mus.124:1–78.

Grigor'ev, S. S.
1992a. Larvae of Snyder's prickleback, *Chirolophis snyderi* (Stichaeidae). J. Ichthyol. 32(4):145–149.
1992b. Larvae of three lumpenid species (*Anisarchus medius*, *Lumpenus fabricii*, *Leptoclinus maculatus*) from near Kamchatka waters. J. Ichthyol. 32(6):131–137.

Hart, J. L.
1973. Pacific fishes of Canada. Bull. Fish. Res. Board Can. 180, 740 p.

Haryu, T., T. Nishiyama, T. Tsujita, H. Ogi, and S. Mishima.
1985. Kinds and distribution of fish larvae in the surface layer of the Bering Sea in summer. Mem. Kushiro City Mus. 10:6–18.

Hastings, P. A., and H. J. Walker, Jr.
2003. *Lumpenopsis clitella*: a new species of prickleback (Teleostei: Stichaeidae) from southern California, with comments on *Lumpenopsis* Soldatov. Copeia 2003:803–809.

Hatooka, K.
2002. Stichaeidae. *In* Fishes of Japan with pictorial keys to the species, English edition II (T. Nakabo, ed.), p. 1046–1054. Tokai Univ. Press, Tokyo.

Hunter, J. R.
1984. Synopsis of culture methods for marine fish larvae. *In* Ontogeny and systematics of fishes, Spec. Publ. No. 1 (H. G. Moser, W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall Jr., and S. L. Richardson, eds.), p. 24–27. Am. Soc. Ichthyol. Herpetol. Allen Press, Lawrence, KS.

Imamura, H., and M. Yabe.
2002. Demise of the Scorpaeniformes (Actinopterygii: Percomorpha): an alternative phylogenetic hypothesis. Bull. Fish. Sci. Hokkaido Univ. 53:107–128.

Kartavtsev, Y. P., S. N. Sharina, T. Goto, O. A. Rutenko, V. V. Zemnukhov, A. A. Semenchenko, D. L. Pitruk, and N. Hanzawa.

2009. Molecular phylogenetics of pricklebacks and other percoid fishes from the Sea of Japan. Aquat. Biol. 8:95–103.

Keats, D. W., D. H. Steele, J. M. Green, and G. M. Martel.

1993. Diet and population size structure of the Arctic shanny, *Stichaeus punctatus* (Pisces: Stichaeidae), at sites in eastern Newfoundland and the eastern Arctic. Environ. Biol. Fishes 37:173–180.

Kendall, A. W., Jr., C. D. Jennings, T. M. Beasley, R. Carpenter, and B. L. Somayajulu.

1983. Discovery of a cluster of unhatched fish eggs of a zoarcid buried 10 to 12 cm deep in continental slope sediments off Washington State, USA. Mar. Biol. 75:193–199.

Kendall, A. W., Jr., E. H. Ahlstrom, and H. G. Moser.

1984. Early life history stages of fishes and their characters. *In* Ontogeny and systematics of fishes, Spec. Publ. No. 1 (H. G. Moser, W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall Jr., and S. L. Richardson, eds.), p. 11–22. Am. Soc. Ichthyol. Herpetol. Allen Press, Lawrence, KS.

Lea, R. N., and P. N. Reilly.

2001. Monkeyface Prickleback. *In* California's living marine resources: a status report (W. S. Leet, C. M. Dewees, R. Klingbeil, and E. J. Larson, eds.), p. 181–182. Cal. Dept. Fish Game Publ. SG01-11, Univ. Calif., Agriculture and Natural Resources, Richmond.

MacDonald, E. L.

2001. Ontogeny of *Lumpenus maculatus* (Perciformes: Stichaeidae) based on external morphology and osteology, with comparisons to congeneric larvae. M.S. thesis, 82 p. Univ. Washington, Seattle.

Makushok, V. M.

1958. The morphology and classification of the northern blennioid fishes (Stichaeidae, Blennioidei, Pisces). Tr. ZIN/Proc. Zool. Instit. RAN. 25:3–129.

1961. Group Neozoarsinae [sic] and its place in system (Zoarcidae, Blennioidei, Pisces). Tr. IORAN/Trans. Inst. Oceanol. RAN 63:198–224.

1986. Lumpeninae (subfamily of Stichaeidae). *In* Fishes of the northeastern Atlantic and the Mediterranean, vol. III (P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, eds.), p. 1126–1129. UNESCO, Paris.

Marliave, J. B.

1975a. The behavioral transformation from the planktonic larval stage of some marine fishes reared in the laboratory. Ph.D. diss., 231 p. Univ. British Columbia, Vancouver, Canada.

1975b. Seasonal shifts in the spawning site of a Northeast Pacific intertidal fish. J. Fish. Res. Board Can. 32:1687–1691.

1986. Lack of planktonic dispersal of rocky intertidal fish larvae. Trans. Am. Fish. Soc. 115:149–154.

Marliave, J. B., and E. E. DeMartini.

1977. Parental behavior of intertidal fishes of the stichaeid genus *Xiphister.* Can. J. Zool. 55:60–63.

Marshall, W. H., and T. Wyllie-Echeverria.

1992. Age, length, weight, reproductive cycle and fecundity of the monkeyface prickleback (*Cebidichthys violaceus*). Calif. Fish Game 73(1):37–44.

Matarese, A. C., A. W. Kendall, Jr., D. M. Blood, and B. M. Vinter.

1989. Laboratory guide to early life history stages of Northeast Pacific fishes. NOAA Tech. Rep. NMFS 80, 652 p.

Matarese, A. C., D. M. Blood, S. J. Picquelle, and J. L. Benson.

2003. Atlas of abundance and distribution patterns of ichthyoplankton from the Northeast Pacific Ocean and Bering Sea ecosystems based on research conducted by the Alaska Fisheries Science Center (1972–1996). NOAA Prof. Paper NMFS 1, 281 p.

McCormick, M. I.

1999. Delayed metamorphosis of a tropical reef fish (*Acanthurus triostegus*): a field experiment. Mar. Ecol. Prog. Ser. 176:25–38.

Mecklenburg, C. W., and B. A. Sheiko.

2004. Family Stichaeidae Gill 1864—pricklebacks. Calif. Acad. Sci. Annotated Checklists of Fishes No. 35, 36 p.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson.

2002. Fishes of Alaska, 1037 p. American Fisheries Society, Bethesda, MD.

Methot, R. D.

1986. Frame trawl for sampling juvenile fish. CalCOFI Rep. 27:267–278.

Miller, D. J., and R. N. Lea.

1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish Game Bulletin No. 157, 249 p.

Miya, M., H. Takeshima, H. Endo, N. B. Ishiguro, J. G. Inoue, T. Mukai, T. P. Satoh, M. Yamaguchi, A. Kawaguchi, K. Mabuchi, S. M. Shirai, and M. Nishida.

2003. Major patterns of higher teleostean phylogenies: a new perspective based on 100 complete mitochondrial DNA sequences. Mol. Phylogen. Evol. 26:121–138.

Moser, H. G.

1981. Morphological and functional aspects of marine fish larvae. *In* Marine fish larvae: morphology, ecology, and relation to fisheries (R. Lasker, ed.), p. 89–131. Wash. Sea Grant Prog., Univ. Wash. Press, Seattle.

Moser, H. G. (ed.).

1996. The early life stages of fishes in the California Current Region. CalCOFI Atlas No. 33, 1505 p.

Moser, H. G., and E. H. Ahlstrom.

1974. Role of larval stages in systematic investigations of marine teleosts: the Myctophidae, a case study. Fish. Bull. 72:391–413.

Nelson, J. S.

1984. Fishes of the world, 523 p. John Wiley & Sons, New York.

2006. Fishes of the world, 601 p. John Wiley & Sons, Hoboken, NJ.

Nelson, J. S., E. J. Crossman, H. Espinosa-Pérez, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams.

2004. Common and scientific names of fishes from the United States, Canada, and Mexico, 6th edition. Spec. Publ. 29, Am. Fish. Soc., Bethesda, MD, 386 p.

Novikov, N. P., A. S. Sokolovsky, T. G. Sokolovskaya, and Y. M. Yakovlev.

2002. The fishes of Primorye. Far Eastern State Tech. Fish. Univ., Vladivostok, Russia, 552 p.

Peppar, J. L.
1965. Some features of the life history of the cockscomb prickleback, *Anoplarchus purpurescens* Gill. M.S. thesis, 165 p. Univ. British Columbia, Vancouver, Canada.

Posgay, J. A., and R. R. Marak.
1980. MARMAP bongo zooplankton samplers. J. Northwest Atl. Fish. Sci. 1:91–99.

Potthoff, T.
1984. Clearing and staining techniques. *In* Ontogeny and systematics of fishes, Spec. Publ. No. 1 (H. G. Moser, W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall Jr., and S. L. Richardson, eds.), p. 35–37. Am. Soc. Ichthyol. Herpetol. Allen Press, Lawrence, KS.

Powles, H., and D. F. Markle.
1984. Identification of larvae. *In* Ontogeny and systematics of fishes, Spec. Publ. No. 1 (H. G. Moser, W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall Jr., and S. L. Richardson, eds.), p. 31–33. Am. Soc. Ichthyol. Herpetol. Allen Press, Lawrence, KS.

Radchenko, O. A., I. A. Chereshnev, A. V. Petrovskaya, and A. A. Balanov.
2009. Molecular systematics and phylogeny of the suborder Zoarcoidei. Vestn. DVO. 3:40–47. [In Russian.]

Roje, D. M.
2010. Incorporating molecular phylogenetics with larval morphology while mitigating the effects of substitution saturation on phylogeny estimation: A new hypothesis of relationships for the flatfish family Pleuronectidae (Percomorpha: Pleuronectiformes). Mol. Phylogen. Evol. 56:586–600.

Sameoto, D. D., and L. O. Jaroszyinski.
1969. Otter surface sampler: a new neuston net. J. Fish. Res. Board Can. 26:2240–2244.

Schultz, L. P., and A. C. DeLacy.
1932. The eggs and nesting habits of the crested blenny, *Anoplarchus*. Copeia 1932:143–147.

Shiogaki, M.
1981. Notes on the life history of the stichaeid fish *Opisthocentrus tenuis*. Jap. J. Ichthyol. 28:319–328.
1982. Life history of the stichaeid fish *Opisthocentrus ocellatus*. Jap. J. Ichthyol. 29:77–85.
1983. On the life history of the stichaeid fish *Chirolophis japonicus*. Jap. J. Ichthyol. 29:446–455.
1985. Life history of the stichaeid fish *Alectrias mutsuensis* in Mutsu Bay, northern Japan. Sci. Rep. Aquaculture Cen. Aomori Pref. 4:11–20.
1987. Life history of the stichaeid fish *Alectrias benjamini*. Sci. Rep. Aquaculture Cen. Aomori Pref. 5:9–20.
1988. *Gymnoclinus cristulatus*. *In* An atlas of early stage fishes in Japan (M. Okiyama, ed.), p. 755–756. Tokai Univ. Press, Tokyo. [In Japanese.]

Shiogaki, M., and Y. Dotsu.
1972. Life history of the blennioid fish *Dictyosoma burgeri*. Bull. Fac. Fish. Nagasaki Univ. 33:21–38.

Shiogaki, M., and T. Haryu.
1988. *Bryozoichthys lysimus*. *In* An atlas of the early stage fishes in Japan (M. Okiyama, ed.), p. 753–754. Tokai Univ. Press, Tokyo. [In Japanese.]

Shiogaki, M., and T. Sasaki.
1988. Lumpeninae. *In* An atlas of the early stage fishes in Japan (M. Okiyama, ed.), p. 756–757. Tokai Univ. Press, Tokyo. [In Japanese.]

Smith, P. E., and S. L. Richardson.
1977. Standard techniques for pelagic fish egg and larva surveys. FAO Fish. Tech. Pap. 175, 100 p.

Smith, W. L., and W. C. Wheeler.
2004. Polyphyly of the mail-cheeked fishes (Teleostei: Scorpaeniformes): evidence from mitochrondrial and nuclear sequence data. Mol. Phylogen. Evol. 32:627–646.

Stevenson, D. E., and A. C. Matarese.
2008. The ronquils: a review of the North Pacific fish family Bathymasteridae (Actinopterygii: Perciformes: Zoarcoidei). Proc. Biol. Soc. Wash. 118:367–406.

Stoddard, K. M.
1985. A phylogenetic analysis of some prickleback fishes (Teleostei, Stichaeidae, Xiphisterinae) from the North Pacific Ocean, with a discussion of their biogeography. M.A. thesis, 88 p., California State Univ., Fullerton.

Tokranov, A. M., and A. M. Orlov.
2004. Biology of Longfin Prickleback *Bryozoichthys lysimus* (Stichaeidae) from Pacific waters of northern Kuril Islands. J. Ichthyol. 44:365–369.

Tokuya, K., and K. Amaoka.
1980. Studies on larval and juvenile blennies in the coastal waters of the southern Hokkaido. Bull. Fac. Fish. Hokkaido Univ. 31:16–49.

Tucker, G. H.
1951. Relation of fishes and other organisms to the scattering of underwater sound. J. Mar. Res. 10:215–238.

Wang, J. C. S.
1986. Fishes of the Sacramento–San Joaquin estuary and adjacent waters, California: a guide to the early life histories. Interagency Ecological Study Program for the Sacramento–San Joaquin Estuary. Tech. Rep. 9, 602 p. [Available from Ecological Analysts, Inc., 2150 John Glenn Drive, Concord, CA 94520.]

Watson, W.
1982. Development of eggs and larvae of the white croaker, *Genyonemus lineatus* Ayres (Pisces: Sciaenidae), off the southern California coast. Fish. Bull. 80:403–417.
1996. Stichaeidae: Pricklebacks. *In* The early stages of fishes in the California Current region (H. G. Moser, ed.), p. 1116–1120. CalCOFI Atlas 33.

Wiebe, P. H., K. H. Burt, S. H. Boyd, and A. W. Morton.
1976. The multiple opening/closing net and environmental sensing system for sampling zooplankton. J. Mar. Res. 34:313–326.

Wiley, E. O., and G. D. Johnson.
2010. A teleost classification based on monophyletic groups. *In* Origin and phylogenetic interrelationships of teleosts: honoring Gloria Arratia: proceedings of the international symposium at the ASIH Annual Meeting in St. Louis, Missouri, 2007. (J. S. Nelson, H.-P. Schultze, and M. V. H. Wilson, eds.), p. 123–182. Verlag Dr. Friedrich Pfiel, Munich.

Wourms, J. P., and D. Evans.
1974a. The annual reproductive cycle of the black prickleback, *Xiphister atropurpureus*, a Pacific Coast blennioid fish. Can. J. Zool. 52:795–802.
1974b. The embryonic development of the black prickleback, *Xiphister atropurpureus*, a Pacific Coast blennioid fish. Can. J. Zool. 52:879–887.

Yabe, M., and T. Uyeno.

1996. Anatomical description of *Normanichthys crockeri* (Scorpaeniformes, *Incertae sedis:* Family Normanichthyidae). Bull. Mar. Sci. 58:494–510.

Yatsu, A.

1986. Phylogeny and zoogeography of the subfamilies Xiphisterinae and Cebidichthyinae (Blennioidei, Stichaeidae). *In* Indo-Pacific Fish Biology (T. Uyeno, R. Arai, T. Taniuchi, and K. Matsuura, eds.), p. 663–678. Proceedings of the Second International Conference on Indo-Pacific Fishes; Tokyo, Tokyo National Museum, Ueno Park, 29 July–3 August 1985. Ichthyological Society of Japan, Tokyo.

Appendix

This appendix provides details, such as number and length of specimens and location, depth, sampling gear, and date of collection, on the materials examined for identification of larval and early juvenile pricklebacks and on other material for other illustrated species. UW=University of Washington, HUMZ-L=Hokkaido University Museum of Zoology (larvae), OS=Oregon State University, MOCNESS=Multiple Opening/Closing Net and Environmental Sensing System.

Material examined

Stichaeus punctatus. 80 specimens (6.4–35.0 mm) examined. Chukchi Sea: UW 140709, 1 (19.4 mm), 68°31.5′ N, 171°27.2′ W, 0–45 m depth, bongo net (net 1), 15 August 2004; UW 140854, 1 (19.0 mm), 68°31.5′ N, 171°27.2′ W, 0–45 m depth, bongo net (net 2), 15 August 2004. Bering Sea: UW 144841, 1 (8.9 mm), 54°6.0′ N, 166°14.1′ W, 0–76 m depth, bongo net (haul 5), 28 April 1994; UW 144842, 1 (8.9 mm), 54°6.0′ N, 166°14.1′ W, 0–76 m depth, bongo net (haul 6), 28 April 1994; UW 144859, 1 (23.5 mm), 62°21.6′ N, 179°36.0′ W, 0 m depth, neuston net, 19 August 1994; UW 144860, 1 (9.9 mm), 55°15.1′ N, 165°13.9′ W, 0–105 m depth, bongo net, 16 May 1995; UW 140705, 1 (25.2 mm), 57°59.7′ N, 167°1.1′ W, 0–55 m depth, Methot net, 22 July 1995; UW 140706, 5 (23.1–24.4 mm), 58°30.5′ N, 166°0.1′ W, 0–35 m depth, Methot net, 23 July 1995; UW 144845, 1 (12.1 mm), 57°20.9′ N, 170°8.3′ W, 0–53 m depth, bongo net, 5 July 1997; UW 144846, 1 (22.3 mm), 57°18.5′ N, 170°9.5′ W, 0–42 m depth, bongo net, 5 July 1997; UW 144847, 2 (15.0–22.0 mm), 57°3.0′ N, 170°16.9′ W, 0–45 m depth, bongo net, 6 July 1997; UW 144844, 1 (20.2 mm), 56°37.8′ N, 169°34.4′ W, 0–40 m depth, Methot net, 10 July 1997; UW 144843, 1 (21.0 mm), 56°42.6′ N, 169°35.9′ W, 25–64 m depth, Tucker trawl, 10 July 1997. Gulf of Alaska: UW 144817, 1 (24.2 mm), 56°47.5′ N, 153°40.1′ W, 0 m depth, neuston net, 24 June 1978; UW 144818, 1 (23.0 mm), 56°33.3′ N, 154°51.2′ W, 0–18 m depth, bongo net, 25 June 1978; UW 144819, 1 (28.8 mm), 57°16.6′ N, 151°17.8′ W, 0 m depth, neuston net, 26 June 1978; UW 140857, 2 (24.4–25.4 mm), 56°42.1′ N, 153°33.6′ W, 0 m depth, neuston net, 29 June 1978; UW 140827, 1 (25.0 mm), 56°42.2′ N, 153°33.1′ W, 0 m depth, neuston net, 29 June 1978; UW 144816, 1 (26.0 mm), 56°25.4′ N, 152°37.4′ W, 0 m depth, neuston net, 1 July 1978; UW 144820, 1 (9.0 mm), 57°43.3′ N, 154°47.0′ W, 0–103 m depth, bongo net, 10 May 1985; UW 144836, 1 (18.5 mm), 56°18.1′ N, 156°16.7′ W, 0–102 m depth, Tucker trawl, 4 June 1988; UW 67888, 1 (9.3 mm), 56°46.7′ N, 154°28.1′ W, 0–63 m depth, bongo net, 11 May 1989; UW 49815, 1 (35.0 mm), 60°39.4′ N, 147°23.2′ W, 0–30 m depth, beam trawl, 21 September 1989; UW 62383, 1 (10.4 mm), 57°28.6′ N, 154°42.4′ W, 0–59 m depth, bongo net, 9 May 1990; UW 62705, 1 (10.1 mm), 59°2.2′ N, 152°18.1′ W, 0–100 m depth, bongo net, 15 May 1990; UW 72426, 1 (18.0 mm), 57°31.9′ N, 155°28.5′ W, 0–105 m depth, 4 June 1990; UW 144830, 1 (9.0 mm), 57°16.8′ N, 155°55.5′ W, 0–100 m depth, bongo net, 8 May 1991; UW 144837, 1 (10.0 mm), 56°16.4′ N, 158°4.9′ W, 0–64 m depth, bongo net, 22 May 1991; UW 144838, 1 (12.9 mm), 55°46.7′ N, 156°17.0′ W, 0–101 m depth, bongo net, 23 May 1991; UW 144831, 1 (7.9 mm), 57°9.2′ N, 156°9.1′ W, 0–77 m depth, bongo net, 8 May 1992; UW 144832, 1 (8.4 mm), 56°49.3′ N, 154°56.1′ W, 0–55 m depth, bongo net, 8 May 1992; UW 144833, 1 (8.1 mm), 56°56.0′ N, 157°3.9′ W, 40–58 m depth, MOCNESS, 12 May 1992; UW 144834, 1 (11.4 mm), 57°1.2′ N, 156°14.6′ W, 0–100 m depth, bongo net, 14 May 1992; UW 144839, 1 (13.6 mm), 56°55.3′ N, 155°25.2′ W, 0–99 m depth, bongo net, 26 May 1992; UW 144840, 2 (9.7–9.8 mm), 57°26.8′ N, 154°47.6′ W, 0–101 m depth, bongo net, 11 May 1993; UW 144850, 1 (7.7 mm), 57°8.4′ N, 156°5.7′ W, 0–30 m depth, Tucker trawl, 9 May 1994; UW 144849, 1 (10.3 mm), 57°8.7′ N, 156°0.6′ W, 0–57 m depth, Tucker trawl, 10 May 1994; UW 144861, 1 (13.5 mm), 57°16.7′ N, 155°55.2′ W, 0–101 m depth, bongo net, 28 May 1995; UW 144857, 1 (9.6 mm), 58°2.9′ N, 153°43.2′ W, 0–190 m depth, bongo net, 3 May 1996; UW 144856, 1 (8.6 mm), 56°34.7′ N, 156°54.8′ W, 0–120 m depth, 9 May 1996; UW 144858, 1 (12.4 mm), 55°31.7′ N, 160°4.7′ W, 0–101 m depth, bongo net, 31 May 1996; UW 144862, 1 (17.0 mm), 57°21.7′ N, 155°40.1′ W, 0–101 m depth, bongo net, 29 May 1997; UW 144823, 4 (6.4–7.6 mm), 55°33.7′ N, 161°31.4′ W, 0–29 m depth, bongo net, 24 May 1999; UW 144822, 1 (6.5 mm), 55°21.8′ N, 161°26.4′ W, 0–49 m depth, bongo net, 24 May 1999; UW 144827, 2 (7.2–8.2 mm), 55°21.8′ N, 161°26.4′ W, 0–40 m depth, bongo net, 24 May 1999; UW 144851, 1 (10.5 mm), 56°10.1′ N, 156°28.2′ W, 0–101 m depth, bongo net, 28 May 1999; UW 144824, 1 (9.7 mm), 56°38.8′ N, 156°4.2′ W, 0–100 m depth, bongo net, 30 May 1999; UW 144825, 1 (10.6 mm), 57°3.1′ N, 156°24.5′ W, 0–101 m depth, bongo net, 31 May 1999; UW 144852, 1 (11.5 mm), 57°24.0′ N, 156°17.2′ W, 0–21 m depth, bongo net, 31 May 1999; UW 144853, 4 (10.2–12.0 mm), 57°23.3′ N, 156°20.4′ W, 0–35 m depth, bongo net, 31 May 1999; UW 144826, 1 (15.4 mm), 57°32.2′ N, 152°2.2′ W, 0–65 m depth, bongo net, 2 June 1999; UW 144828, 7 (14.8–18.0 mm), 57°43.0′ N, 152°20.2′ W, 0–102 m depth, bongo net, 5 June 1999; UW 144854, 1 (19.5 mm), 57°24.1′ N, 156°14.1′ W, 0–30 m depth, bongo net, 1 June 2000; UW 144855, 1 (21.5 mm), 57°43.5′ N, 152°19.0′ W, 0–100 m depth, bongo net, 4 June 2000; UW 140831, 1 (12.0 mm), 59°31.0′ N, 149°48.8′ W, 0–194 m depth, bongo net, 15 May 2001; UW 144835, 1 (13.1 mm), 55°17.9′ N, 159°36.8′ W, 0–100 m depth, bongo net, 26 May 2002;

UW 140707, 1 (7.9 mm), 60°32.4′ N, 147°48.0′ W, 0–11 m depth, MOCNESS, 3 May 2003; UW 140708, 1 (10.7 mm), 60°32.1′ N, 147°48.2′ W, 10–20 m depth, MOCNESS, 2 June 2003. Location, depth, gear, and date of collection unknown for the following specimens: UW 145892, 1 (16.4 mm); UW 145893, 1 (18.9 mm).

Bryozoichthys lysimus. 82 specimens (6.9–49.0 mm) examined. Bering Sea: UW 144927, 3 (13.8–16.5 mm), 56°17.4′ N, 171°20.4′ W, depth unknown, bongo net, 6 May 1976; UW 144929, 1 (17.3 mm), 54°12.6′ N, 166°26.4′ W, 0–233 m depth, bongo net, 16 April 1977; UW 144932, 1 (20.5 mm), 55°4.2′ N, 165°9.0′ W, 0 m depth, neuston net, 18 April 1977; UW 145158, 1 (21.1 mm), 55°9.0′ N, 168°18.0′ W, 0–224 m depth, bongo net, 22 April 1977; UW 144933, 1 (21.4 mm), 56°31.8′ N, 166°18.0′ W, 0 m depth, neuston net, 23 April 1977; UW 144928, 1 (21.9 mm), 55°13.8′ N, 165°27.6′ W, 0–123 m depth, bongo net, 24 April 1977; UW 144931, 4 (20.6–24.7 mm), 55°22.2′ N, 166°9.0′ W, 0 m depth, neuston net, 24 April 1977; UW 144934, 6 (19.6–23.8 mm), 54°22.2′ N, 166°7.8′ W, 0 m depth, neuston net, 25 April 1977; UW 144930, 1 (22.5 mm), 54°7.8′ N, 166°8.4′ W, 0 m depth, neuston net, 26 April 1977; UW 144938, 5 (21.2–24.1 mm), 53°7.8′ N, 169°14.4′ W, 0 m depth, neuston net, 3 May 1977; UW 144937, 3 (20.5–24.5 mm), 54°31.2′ N, 166°25.8′ W, 0 m depth, neuston net, 5 May 1977; UW 144935, 1 (18.2 mm), 55°31.2′ N, 163°27.0′ W, 0–85 m depth, bongo net, 8 May 1977; UW 144936, 1 (29.0 mm original measurement when illustrated; remeasured at 26.8 mm for this study), 56°27.0′ N, 171°17.4′ W, 0 m depth, neuston net, 12 May 1977; UW 144939, 1 (13.2 mm), 54° N, 167°8.8′ W, 0 m depth, neuston net, 3 March 1978; UW 65424, 1 (21.6 mm), 54°49.8′ N, 168°5.6′ W, 0 m depth, neuston net, 1 June 1979; UW 144917, 1 (32.4 mm), 56°3.5′ N, 166°33.9′ W, 0 m depth, neuston net, 2 June 1979; UW 144911, 1 (20.3 mm), 54°4.9′ N, 171°26.2′ W, 0 m depth, neuston net, 7 June 1979; UW 144912, 3 (27.9–29.6 mm), 52°45.6′ N, 174°48.0′ W, 0 m depth, neuston net, 16 June 1979; UW 144913, 3 (32.6–35.6 mm), 54°45.8′ N, 168°51.6′ W, 0 m depth, neuston net, 17 June 1979; UW 144914, 1 (34.2 mm), 57°4.4′ N, 167°58.8′ W, 0 m depth, neuston net, 24 June 1979; UW 144915, 1 (31.9 mm), 56°23.0′ N, 170°22.0′ W, 0 m depth, neuston net, 26 June 1979; UW 144916, 2 (30.8–31.5 mm), 52°30.8′ N, 178°36.0′ W, 0 m depth, neuston net, 2 July 1979; UW 144918, 1 (12.0 mm), 54°11.0′ N, 166°56.8′ W, 0–399 m depth, bongo net, 15 April 1993; UW 144919, 1 (10.4 mm), 54°5.9′ N, 167°54.0′ W, 0–399 m depth, bongo net, 18 April 1993; UW 144922, 2 (19.0–21.5 mm), 54°47.5′ N, 167°30.0′ W, 0–400 m depth, bongo net, 22 April 1993; UW 144920, 3 (6.9–8.0 mm), 54°44.8′ N, 167°52.7′ W, 0–400 m depth, bongo net, 22 April 1993; UW 144923, 1 (17.0 mm), 54°46.0′ N, 168°1.6′ W, 0–400 m depth, bongo net, 27 April 1993; UW 144926, 1 (14.5 mm), 54°28.2′ N, 166°2.8′ W, 0–401 m depth, bongo net, 23 April 1995; UW 144940, 1 (49.0 mm), 51°56.2′ N, 176°50.3′ W, 0–87 m depth, gear unknown, 17 June 2001; UW 144909, 1 (25.0 mm), 54°27.1′ N, 166°59.9′ W, 0 m depth, neuston net, 16 May 2002. Gulf of Alaska: UW 69706, 1 (17.4 mm), 56°39.5′ N, 155°25.1′ W, 0 m depth, 12 April 1978; UW 69324, 4 (12.0–13.7 mm), 58°4.0′ N, 151°41.5′ W, 0–128 m depth, bongo net, 29 May 1978; UW 33190, 1 (10.2 mm), 58°10.0′ N, 152°14.0′ W, depth unknown, bongo net, 6–16 March 1979; UW 144902, 1 (12.9 mm), 57°3.0′ N, 155°53.0′ W, 0 m depth, neuston net, 19 March 1981; UW 60160, 1 (17.1 mm), 57°10.9′ N, 155°8.0′ W, 0–208 m depth, bongo net, 1 April 1981; UW 64990, 1 (22.3 mm), 56°41.0′ N, 156°26.0′ W, 0 m depth, neuston net, 21 April 1981; UW 145156, 1 (29.4 mm), 55°14.1′ N, 159°2.0′ W, 0 m depth, neuston net, 29 May 1982; UW 144904, 1 (27.1 mm), 54°54.1′ N, 158°39.0′ W, 0 m depth, neuston net, 29 May 1982; UW 144897, 1 (28.9 mm), 55°59.5′ N, 157°21.0′ W, 0 m depth, neuston net, 23 May 1983; UW 144903, 1 (23.4 mm), 57°11.5′ N, 154°44.0′ W, 0 m depth, neuston net, 20 April 1984; UW 55919, 3 (14.8–18.0 mm), 58°44.2′ N, 152°51.0′ W, 0 m depth, neuston net, 29 March 1985; UW 64569, 1 (29.3 mm), 54°8.0′ N, 164°14.0′ W, 0 m depth, neuston net, 6 June 1985; UW 64631, 5 (28.4–30.4 mm), 53°34.8′ N, 165°18.7′ W, 0 m depth, neuston net, 7 June 1985; UW 64723, 1 (25.3 mm), 53°0.5′ N, 167°59.0′ W, 0 m depth, 8 June 1985; UW 144898, 2 (15.4–16.2 mm), 53°59.3′ N, 162°10.0′ W, 0 m depth, neuston net, 18 April 1986; UW 39750, 1 (14.1 mm), 53°40.0′ N, 165°3.0′ W, 0–171 m depth, bongo net, 19 April 1986; UW 144900, 1 (30.4 mm), 56°24.0′ N, 153°23.4′ W, 0–60 m depth, Tucker trawl, 27 May 1986; UW 144925, 1 (32.0 mm), 55°46.6′ N, 156°16.7′ W, 0–100 m depth, bongo net, 28 May 1994.

Bryozoichthys marjorius. 90 specimens (7.7–53.0 mm) examined. Bering Sea: UW 144953, 2 (18.8–19.7 mm), 54°22.2′ N, 166°8.3′ W, 0 m depth, neuston net, 25 April 1977; UW 144983, 2 (31.0–31.6 mm), 54°7.8′ N, 166°9.3′ W, 0 m depth, neuston net, 26 April 1977; UW 144954, 3 (18.7–20.5 mm), 53°8.0′ N, 169°14.4′ W, 0 m depth, neuston net, 3 May 1977; UW 144969, 2 (23.3–25.8 mm), 54°22.2′ N, 166°8.4′ W, 0 m depth, neuston net, 5 May 1977; UW 144977, 1 (25.8 mm), 55°26.9′ N, 168°17.7′ W, 0 m depth, neuston net, 10 May 1977; UW 144959, 1 (20.6 mm), 55°26.6′ N, 171°18.8′ W, 0–219 m depth, bongo net, 13 May 1977; UW 144974, 3 (25.1–28.3 mm), 52°45.6′ N, 174°48.0′ W, 0 m depth, neuston net, 16 June 1979; UW 66115, 1 (31.9 mm), 58°16.6′ N, 172°48.6′ W, 0 m depth, neuston net, 17 June 1979; UW 144985, 2 (31.5–35.9 mm), 57°45.8′ N, 168°51.6′ W, 0 m depth, neuston net, 17 June 1979; UW 65595, 1 (32.9 mm), 55°38.9′ N, 167°3.6′ W, 0 m depth, neuston net, 18 June 1979; UW 65607, 1 (26.6 mm), 55°47.6′ N, 166°54.2′ W, 0 m depth, neuston net, 19 June 1979; UW 144981, 2 (30.3–35.8 mm), 55°28.8′ N, 167°46.2′ W, 0 m depth, neuston net, 20 June 1979; UW 144995, 1 (36.2 mm), 56°23.0′ N, 170°22.0′ W, 0 m depth, neuston net, 26 June 1979; UW 65874, 1 (38.0 mm), 56°29.8′ N, 171°55.7′ W, 0 m depth, neuston net, 28 June 1979; UW 65956, 2 (36.8–38.0 mm), 56°27.5′ N, 172°9.1′ W, 0 m depth, neuston net, 9 July 1979; UW 65974, 1 (36.0 mm), 56°59.6′ N, 173°33.9′ W, 0 m depth, neuston net, 9 July 1979; UW 66011, 1 (34.6 mm), 57°43.2′ N, 174°6.1′ W, 0 m depth, neuston net, 11 July 1979; UW 66153, 1 (34.9 mm), 59°19.6′ N, 174°11.0′ W, 0 m depth, neuston net, 19 July 1979; UW 66179, 1 (32.1 mm), 59°50.1′ N, 175°26.3′ W, 0 m depth, neuston net, 20 July 1979; UW 144964, 1 (22.5 mm), 54°59.4′ N, 168°12.6′ W, 0–202 m depth, bongo net, 21 April 1994; UW 144998, 1 (7.7 mm), 54°20.33′ N, 165°25.8′ W, 0–144 m depth, bongo net, 4 May 1995; UW 144963, 1 (22.5 mm), 54°28.1′ N, 166°2.2′ W, 0 m depth, neuston net, 13 May 2002; UW 144973, 1 (25.0 mm), 54°46.1′ N, 167°47.3′ W, 0 m depth, neuston net, 20 May 2002; UW 111242, 1 (53.0 mm), 52°12.8′ N, 174°56.4′ W, 206 m depth, benthic bag, 13 June 2002; UW 144943, 1 (13.7 mm), 56°32.3′ N, 151°46.1′ W, 0–602 m depth, bongo net, 15 February 2003. Gulf of Alaska: UW 144942, 1 (11.4 mm), 56°28.0′ N, 156°12.0′ W, 0–105 m depth, bongo net, 29 April 1972; UW 69029, 1 (22.8 mm), 56°15.5′ N, 153°21.2′ W, 0 m depth, neuston net, 14 April 1978; UW 60255, 1 (14.5 mm), 56°29.5′ N, 156°14.1′ W, 0–212 m depth, bongo net, 4 April 1981; UW 57125, 1 (15.8 mm), 55°27.2′ N, 159°18.0′ W, 0 m depth, neuston net, 23 May 1981; UW 36366, 2 (30.5–32.3 mm), 55°45.0′ N, 157°21.0′ W, 0 m depth, neuston net, 23 May 1983; UW 144991, 1 (34.4 mm), 55°15.3′ N, 157°49.7′ W, 0 m depth, neuston net, 26 May 1983; UW 57459, 1 (22.6 mm), 57°53.0′ N, 148°39.0′ W, 0 m depth, neuston net, 14 April 1984; UW 144967, 3 (22.7–23.6 mm), 57°11.5′ N, 154°44.0′ W, 0 m depth, neuston net, 20 April 1984; UW 83134, 1 (21.4 mm), 55°34.0′ N, 156°35.0′ W, 0 m depth, neuston net, 1 May 1984; UW 83138, 2 (21.9–22.8 mm), 55°28.0′ N, 158°58.0′ W, 0 m depth, neuston net, 5 May 1984; UW 55946, 2 (13.8–17.1 mm), 58°34.5′ N, 153°13.0′ W, 0 m depth, neuston net, 29 March 1985; UW 144947, 8 (15.9–18.2 mm), 58°44.2′ N, 152°51.0′ W, 0 m depth, neuston net, 29 March 1985; UW 144952, 1 (18.0 mm), 58°18.8′ N, 153°26.0′ W, 0 m depth, neuston net, 30 March 1985; UW 56216, 2 (18.0–21.6 mm), 57°12.2′ N, 155°26.0′ W, 0 m depth, neuston net, 4 April 1985; UW 56255, 1 (17.9 mm), 56°50.2′ N, 154°48.0′ W, 0–40 m depth, bongo net, 5 April 1985; UW 56581, 1 (19.8 mm), 57°38.5′ N, 150°32.0′ W, 0 m depth, neuston net, 17 April 1985; UW 63509, 5 (24.3–33.0 mm), 57°34.0′ N, 155°20.0′ W, 0 m depth, neuston net, 23 May 1985; UW 63908, 1 (34.0 mm), 57°18.4′ N, 155°50.9′ W, 0 m depth, neuston net, 27 May 1985; UW 63918, 1 (25.4 mm), 56°29.5′ N, 155°30.0′ W, 0 m depth, neuston net, 27 May 1985; UW 64168, 1 (29.6 mm), 55°35.5′ N, 157°15.2′ W, 0 m depth, neuston net, 30 May 1985; UW 64178, 1 (24.9 mm), 55°48.4′ N, 157°32.9′ W, 0 m depth, neuston net, 30 May 1985; UW 64277, 2 (19.7–27.3 mm), 55°39.4′ N, 158°35.7′ W, 0 m depth, neuston net, 1 June 1985; UW 144975, 1 (25.2 mm), 53°34.8′ N, 165°18.7′ W, 0 m depth, neuston net, 7 June 1985; UW 82725, 2 (19.3–20.5 mm), 57°20.0′ N, 150°56.2′ W, 0 m depth, neuston net, 10 April 1986; UW 60536, 1 (17.7 mm), 57°16.1′ N, 155°37.1′ W, 0–270 m depth, bongo net, 4 May 1986; UW 144945, 1 (14.9 mm), 57°18.7′ N, 155°16.8′ W, 0–238 m depth, bongo net, 7 April 1987; UW 35711, 1 (23.3 mm), 55°40.0′ N, 157° W, 0–66 m depth, bongo net, 23 April 1987; UW 52038, 1 (10.9 mm), 56°57.1′ N, 155°57.2′ W, 0–267 m depth, bongo net, 10 April 1988; UW 144961, 1 (22.0 mm), 56°44.7′ N, 156°46.0′ W, 0–104 m depth, Tucker trawl, 1 June 1989; UW 144958, 1 (20.4 mm), 56°1.8′ N, 156°49.4′ W, 0–54 m depth, Tucker trawl, 4 June 1989; UW 52670, 1 (16.7 mm), 57°32.8′ N, 154°49.9′ W, 0–226 m depth, bongo net, 10 April 1990; UW 144970, 1 (23.9 mm), 56°32.2′ N, 156°19.6′ W, 0–107 m depth, bongo net, 8 May 1991; UW 144984, 1 (31.5 mm), 57°40.7′ N, 154°46.5′ W, 0–100 m depth, bongo net, 11 May 1993; UW 144989, 1 (33.0 mm), 56°32.9′ N, 155°51.2′ W, 0–101 m depth, bongo net, 31 May 1993; UW 144979, 1 (28.0 mm), 57°43.1′ N, 155°15.9′ W, 0–145 m depth, bongo net, 28 May 1995. Location, depth, gear, and date of collection unknown for the following specimen: UW 145874, 1 (40.0 mm).

Chirolophis decoratus. 70 specimens (8.7–42.5 mm) examined. Bering Sea: UW 145014, 1 (22.5 mm), 55°38.7′ N, 163°9.5′ W, 0 m depth, neuston net, 15 May 2002; UW 145160, 1 (32.0 mm), 54°46.0′ N, 167°47.1′ W, 0 m depth, neuston net, 11 May 2006; UW 145161, 1 (22.0 mm), 54°35.1′ N, 165°39.1′ W, 0 m depth, neuston net, 13 May 2006. Gulf of Alaska: UW 110397, 1 (42.5 mm), 60°20.2′ N, 146°37.3′ W, 45 m depth, beam trawl, date unknown; UW 107634, 3 (11.1–14.9 mm), 56°44.8′ N, 154°17.9′ W, 0–14 m depth, Tucker trawl, 11 April 1978; UW 69705, 1 (21.8 mm), 56°39.5′ N, 155°25.1′ W, 0 m depth, neuston net, 12 April 1978; UW 145023, 1 (28.2 mm), 57°12.1′ N, 152°44.5′ W, 0 m depth, neuston net, 24 June 1978; UW 64891, 1 (27.0 mm), 55°57.8′ N, 153°31.0′ W, 0 m depth, neuston net, 19 April 1981; UW 37072, 1 (14.7 mm), 57°22.2′ N, 151°56.0′ W, 0–61 m depth, bongo net, 5 April 1982; UW 37157, 1 (17.4 mm), 57°30.5′ N, 155°31.0′ W, 0 m depth, neuston net, 8 April 1982; UW 37175, 1 (17.6 mm), 56°59.0′ N, 155°50.0′ W, 0 m depth, neuston net, 8 April 1982; UW 59889, 1 (23.0 mm), 54°52.2′ N, 157°32.0′ W, 0 m depth, neuston net, 28 May 1982; UW 145016, 1 (24.9 mm), 55°14.1′ N, 159°2.0′ W, 0 m depth, neuston net, 29 May 1982; UW 145018, 1 (26.6 mm), 54°54.1′ N, 158°39.0′ W, 0 m depth, neuston net, 29 May 1982;

UW 59978, 1 (31.6 mm), 55°4.2′ N, 158°51.0′ W, 0 m depth, neuston net, 29 May 1982; UW 60031, 1 (30.6 mm), 54°32.2′ N, 159°16.0′ W, 0 m depth, neuston net, 30 May 1982; UW 60023, 1 (30.8 mm), 54°32.2′ N, 159°16.0′ W, 0–82 m depth, bongo net, 30 May 1982; UW 36026, 1 (27.2 mm), 57°0.5′ N, 155°32.8′ W, 0 m depth, neuston net, 22 May 1983; UW 36198, 1 (31.1 mm), 56°14.8′ N, 156°26.6′ W, 0 m depth, neuston net, 24 May 1983; UW 145013, 1 (21.9 mm), 57°7.0′ N, 155°56.0′ W, 0 m depth, neuston net, 4 April 1985; UW 62916, 3 (29.5–31.2 mm), 59°2.9′ N, 148°30.0′ W, 0 m depth, neuston net, 18 May 1985; UW 145026, 1 (29.2 mm), 57°43.9′ N, 155°1.4′ W, 0 m depth, neuston net, 23 May 1985; UW 63937, 1 (15.9 mm), 56°52.0′ N, 155°28.0′ W, 0–202 m depth, bongo net, 27 May 1985; UW 63987, 1 (27.8 mm), 56°20.8′ N, 156°29.0′ W, 0 m depth, neuston net, 28 May 1985; UW 64156, 1 (28.6 mm), 55°24.5′ N, 156°55.1′ W, 0 m depth, neuston net, 30 May 1985; UW 64269, 1 (26.3 mm), 55°27.5′ N, 158°16.6′ W, 0 m depth, neuston net, 1 June 1985; UW 64343, 1 (30.3 mm), 54°12.0′ N, 158°29.0′ W, 0 m depth, neuston net, 2 June 1985; UW 60443, 1 (21.0 mm), 57°29.0′ N, 154°47.8′ W, 0–62 m depth, bongo net, 3 May 1986; UW 60667, 1 (11.9 mm), 56°47.1′ N, 155°54.6′ W, 0–294 m depth, bongo net, 7 May 1986; UW 145030, 1 (30.7 mm), 57°21.6′ N, 151°25.2′ W, 0–45 m depth, Tucker trawl, 26 May 1986; UW 145019, 1 (26.6 mm), 56°24.0′ N, 153°23.4′ W, 0–44 m depth, Tucker trawl, 27 May 1986; UW 37745, 1 (10.2 mm), 56°19.7′ N, 154°19.0′ W, 0–80 m depth, bongo net, 2 April 1988; UW 52204, 1 (21.5 mm), 57°35.0′ N, 155°21.0′ W, 0–307 m depth, bongo net, 7 April 1989; UW 52786, 1 (13.1 mm), 57°15.6′ N, 155°35.1′ W, 0–278 m depth, bongo net, 11 April 1990; UW 145009, 1 (19.5 mm), 57°21.4′ N, 155°27.1′ W, 0–259 m depth, bongo net, 9 April 1993; UW 145025, 1 (28.5 mm), 55°27.9′ N, 158°39.8′ W, 0–100 m depth, bongo net, 26 May 1994. British Columbia, Canada: UW 145169, 9 (8.7–9.7 mm), 49°21.6′ N, 123°29.3′ W, reared, 7 February 1979; UW 145170, 5 (10.9–11.5 mm), 49°21.6′ N, 123°29.3′ W, reared, 14 February 1979. Washington coast: UW 145168, 1 (21.5 mm), 48°16.4′ N, 123°33.6′ W, 0–50 m depth, bongo net, 24 February 1976; UW 145000, 1 (10.1 mm), 48°25.4′ N, 124°41.7′ W, depth unknown, bongo net, 12 January 1977; UW 51382, 1 (17.2 mm), 43°19.9′ N, 124°30.4′ W, 0–75 m depth, bongo net, 21 January 1987; UW 144999, 2 (10.0–10.5 mm), 41°59.1′ N, 124°22.3′ W, 0–56 m depth, bongo net, 23 January 1987. Location, depth, gear, and date of collection unknown for the following specimens: UW 145164, 1 (10.3 mm); UW 145166, 2 (10.2–11.6 mm); UW 145165, 1 (11.1 mm); UW 145162, 2 (21.0–21.9 mm); UW 145163, 1 (17.9 mm); UW 145875, 1 (13.6 mm); UW 145876, 1 (14.3 mm); UW 145877, 1 (14.8 mm); UW 145878, 1 (14.9 mm).

Chirolophis nugator. 76 specimens (8.7–25.0 mm) examined. Bering Sea: UW 145050, 1 (15.5 mm), 54°26.6′ N, 164°58.8′ W, 0–41 m depth, bongo net, 11 May 1997; UW 145048, 1 (18.5 mm), 56°27.4′ N, 169°28.4′ W, 0–96 m depth, Methot net, 12 July 1997. Gulf of Alaska: UW 32896, 2 (10.1–10.4 mm), 58°10.0′N, 152°14.0′ W, 0–10 m depth, Tucker trawl, 21 April 1978; UW 145045, 1 (20.1 mm), 57°12.1′ N, 152°44.5′ W, 0 m depth, neuston net, 24 June 1978; UW 50335, 1 (10.4 mm), 57°43.0′ N, 155°6.6′ W, 0–176 m depth, bongo net, 15 March 1981; UW 56975, 1 (19.3 mm), 56°30.0′ N, 155°14.0′ W, 0–23 m depth, bongo net, 18 March 1981; UW 145044, 2 (14.0–17.1 mm), 56°20.4′ N, 152°2.4′ W, 0–58 m depth, Tucker trawl, 27 May 1986; UW 35681, 1 (12.3 mm), 55°40.0′ N, 155°45.0′ W, 0–78 m depth, bongo net, 22 April 1987; UW 145038, 1 (10.4 mm), 56°24.3′ N, 154°7.9′ W, 0–40 m depth, bongo net, 20 April 1991; UW 145049, 1 (10.9 mm), 56°27.5′ N, 157°30.3′ W, 0–91 m depth, bongo net, 22 April 1991; UW 145036, 1 (9.6 mm), 57°16.8′ N, 155°55.5′ W, 0–100 m depth, bongo net, 8 May 1991; UW 145052, 1 (16.1 mm), 54°55.0′ N, 161°31.4′ W, 0–121 m depth, bongo net, 27 May 2000; UW 145051, 1 (19.0 mm), 55°49.6′ N, 155°49.0′ W, 0–49 m depth, bongo net, 30 May 2000; UW 145047, 1 (10.4 mm), 57°18.0′ N, 151°17.9′ W, 0 m depth, neuston net, 17 February 2003; UW 145046, 1 (25.0 mm), 56°2.6′ N, 157°6.3′ W, 0–100 m depth, bongo net, 29 May 2003. British Columbia, Canada: UW 145033, 2 (9.2–10.5 mm), 48°32.3′ N, 124°42.2′ W, 0–50 m depth, bongo net, 24 February 1976; UW 145062, 3 (8.7–9.7 mm), 49°21.6′ N, 123°29.3′ W, reared, 6 March 1984. Puget Sound, Washington: UW 145059, 1 (24.8 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 12 April 1988; UW 145060, 3 (20.1–20.8 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 19 April 1988; UW 145040, 2 (19.5–22.1 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 6 April 1989; UW 145061, 2 (20.8–22.3 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 11 April 1989; UW 145056, 2 (16.8–20.1 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 6 April 1990; UW 145057, 2 (18.0–23.1 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 4 May 1990; UW 145058, 8 (19.2–23.7 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 20 April 1991; UW 145053, 6 (10.6–22.5 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 26 February 1992; UW 145054, 13 (13.1–18.7 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 12 March 1992; UW 145055, 4 (14.0–20.3 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 28 March 1992; UW 145039, 1 (11.2 mm), 48°19.4′ N, 123° W, 0 m depth, dip net, 8 April 1993. Oregon coast: UW 55217, 1 (11.2 mm), 45°18.0′ N, 124°6.0′ W, 0–88 m depth, bongo net, 22 April 1987. California coast: UW 51287, 1 (9.2 mm), 44°41.2′ N, 124°10.4′ W, 0–60 m depth, bongo net, 19 January 1987; UW 145034, 2 (9.3–9.9 mm), 41°59.1′ N, 124°22.3′ W, 0–56 m depth, bongo net, 23 January 1987. Location, depth, gear, and date of collection unknown for the following specimens: UW 145170, 4 (9.8–12.9 mm); UW 145879, 1 (23.6 mm); UW 145880, 1 (24.1 mm).

Gymnoclinus cristulatus. 8 specimens (18.8–26.8 mm) examined (depths and gear unknown). Sea of Japan: HUMZ-L 02569, 3 (23.2–26.8 mm), 41°56.0′ N, 140°57.0′ E, 30 April 1983; HUMZ-L 03113, 5 (18.8–22.3 mm), 41°56.0′ N, 140°57.0′ E, 26 April 1984.

Lumpenella longirostris. 126 specimens (8.0–64.0 mm) examined. Bering Sea: UW 65743, 2 (26.2–32.5 mm), 56°45.3′ N, 167°29.6′ W, 0–82 m depth, neuston net, 23 June 1979. Gulf of Alaska: UW 27447, 1 (49.0 mm), 57°8.2′ N, 153°21.1′ W, 0–118 m depth, 1.5-m net, 4 March 1978; UW 32916, 3 (8.0–8.5 mm), 58°10.0′ N, 152°14.0′ W, 0–70 m depth, gear unknown, 3 May 1978; UW 145086, 1 (32.5 mm), 57°12.1′ N, 152°44.5′ W, 0–121 m depth, bongo net, 24 June 1978; UW 145093, 1 (40.0 mm), 56°42.7′ N, 153°33.4′ W, 28–71 m depth, Tucker trawl, 29 June 1978; UW 145081, 1 (32.0 mm), 56°37.4′ N, 153°26.8′ W, 0–56 m depth, bongo net, 30 June 1978; UW 145082, 1 (32.7 mm), 56°37.5′ N, 153°26.8′ W, 29–100 m depth, Tucker trawl, 30 June 1978; UW 145087, 1 (38.0 mm), 56°37.5′ N, 153°26.8′ W, 0–100 m depth, 30 June 1978; UW 66781, 1 (9.8 mm), 57°34.8′ N, 155°17.5′ W, 0–200 m depth, bongo net, 28 April 1981; UW 66786, 2 (9.8–12.2 mm), 57°31.3′ N, 155°27.5′ W, 0–216 m depth, bongo net, 28 April 1981; UW 66838, 4 (12.7–13.3 mm), 57°0.8′ N, 156°19.7′ W, 0–72 m depth, bongo net, 29 April 1981; UW 66879, 1 (14.8 mm), 56°49.9′ N, 155°57.1′ W, 0–218 m depth, bongo net, 29 April 1981; UW 66907, 3 (8.1–10.5 mm), 57°18.5′ N, 155°21.8′ W, 0–217 m depth, bongo net, 30 April 1981; UW 66916, 5 (10.8–12.2 mm), 57°24.2′ N, 154°56.0′ W, 0–202 m depth, bongo net, 30 April 1981; UW 66922, 3 (9.2–10.4 mm), 57°19.3′ N, 155°5.2′ W, 0–208 m depth, bongo net, 30 April 1981; UW 66929, 2 (11.7–14.2 mm), 57°14.4′ N, 155°15.1′ W, 0–208 m depth, 30 April 1981; UW 66971, 1 (15.8 mm), 56°56.3′ N, 155°32.4′ W, 0–209 m depth, bongo net, 1 May 1981; UW 66978, 1 (16.1 mm), 56°49.9′ N, 155°19.4′ W, 0–207 m depth, bongo net, 1 May 1981; UW 70563, 3 (11.7–17.3 mm), 58°9.0′ N, 153°24.3′ W, 0–208 m depth, bongo net, 20 May 1981; UW 70575, 1 (13.5 mm), 58°11.5′ N, 153°32.5′ W, 0–166 m depth, bongo net, 20 May 1981; UW 70586, 4 (13.1–16.0 mm), 58°14.5′ N, 153°39.4′ W, 0–166 m depth, bongo net, 20 May 1981; UW 70645, 5 (14.1–16.5 mm), 57°56.1′ N, 153°50.5′ W, 0–220 m depth, bongo net, 20 May 1981; UW 70652, 1 (14.8 mm), 57°59.5′ N, 153°58.0′ W, 0–163 m depth, bongo net, 20 May 1981; UW 70665, 1 (17.1 mm), 58°2.9′ N, 154°6.0′ W, 0–208 m depth, bongo net, 20 May 1981; UW 70704, 2 (15.4–15.8 mm), 57°48.4′ N, 154°31.5′ W, 0–208 m depth, bongo net, 21 May 1981; UW 70744, 1 (14.9 mm), 57°40.0′ N, 154°51.3′ W, 0–208 m depth, 21 May 1981; UW 70754, 4 (20.9–24.6 mm), 57°28.5′ N, 154°45.3′ W, 0–126 m depth, bongo net, 21 May 1981; UW 70875, 1 (18.8 mm), 57°18.7′ N, 155°22.7′ W, 0–208 m depth, bongo net, 21 May 1981; UW 70989, 1 (19.9 mm), 56°52.8′ N, 155°25.2′ W, 0–208 m depth, bongo net, 22 May 1981; UW 70995, 2 (19.8–24.9 mm), 56°56.3′ N, 155°25.2′ W, 0–208 m depth, bongo net, 22 May 1981; UW 68784, 2 (22.0–27.4 mm), 57°3.0′ N, 154°56.0′ W, 0–93 m depth, bongo net, 23 May 1981; UW 71018, 1 (24.5 mm), 57°4.5′ N, 155°47.6′ W, 0–208 m depth, bongo net, 23 May 1981; UW 71027, 1 (25.3 mm), 57°8.0′ N, 155°54.4′ W, 0–208 m depth, bongo net, 23 May 1981; UW 71072, 4 (21.3–23.5 mm), 57°6.9′ N, 156°18.4′ W, 0–75 m depth, bongo net, 23 May 1981; UW 71095, 3 (15.7–25.3 mm), 56°54.8′ N, 155°47.6′ W, 0–208 m depth, bongo net, 23 May 1981; UW 71145, 1 (23.2 mm), 56°34.0′ N, 155°45.5′ W, 0–208 m depth, bongo net, 23 May 1981; UW 68834, 1 (21.4 mm), 56°54.8′ N, 155°42.0′ W, 0–197 m depth, bongo net, 24 May 1981; UW 71164, 1 (23.8 mm), 56°45.0′ N, 156°6.2′ W, 0–208 m depth, bongo net, 24 May 1981; UW 71174, 1 (21.6 mm), 56°52.1′ N, 156°19.5′ W, 0–167 m depth, bongo net, 24 May 1981; UW 71224, 1 (22.2 mm), 56°28.2′ N, 155°53.2′ W, 0–208 m depth, bongo net, 24 May 1981; UW 68859, 1 (24.9 mm), 56°32.0′ N, 156°15.0′ W, 0–210 m depth, bongo net, 25 May 1981; UW 68867, 2 (25.1–27.2 mm), 56°23.2′ N, 156°6.0′ W, 0–22 m depth, bongo net, 25 May 1981; UW 36209, 1 (23.4 mm), 56°15.2′ N, 156°26.1′ W, 0–213 m depth, bongo net, 24 May 1983; UW 36257, 1 (17.3 mm), 56°43.5′ N, 156°53.2′ W, 0–62 m depth, bongo net, 24 May 1983; UW 36387, 1 (24.6 mm), 56° N, 157°21.0′ W, 0–94 m depth, bongo net, 25 May 1983; UW 36395, 1 (17.5 mm), 56°15.8′ N, 157°20.6′ W, 0–105 m depth, bongo net, 25 May 1983; UW 57781, 1 (9.9 mm), 56°51.5′ N, 156°8.0′ W, 0–216 m depth, bongo net, 24 April 1984; UW 63379, 1 (10.9 mm), 58°13.9′ N, 153°55.0′ W, 0–200 m depth, bongo net, 22 May 1985; UW 63420, 1 (10.8 mm), 58°4.1′ N, 153°53.0′ W, 0–185 m depth, bongo net, 22 May 1985; UW 60600, 1 (9.8 mm), 56°51.8′ N, 155°46.2′ W, 0–272 m depth, bongo net, 5 May 1986; UW 60755, 1 (11.0 mm), 56°22.2′ N, 156°26.5′ W, 0–218 m depth, bongo net, 13 May 1986; UW 67064, 2 (10.3–11.1 mm), 56°54.7′ N, 155°32.6′ W, 0–275 m depth, bongo net, 20 May 1987; UW 67070, 1 (12.8 mm), 56°43.0′ N, 155°24.3′ W, 0–198 m depth, bongo net, 21 May 1987; UW 67120, 4 (9.6–13.2 mm), 56°46.4′ N, 155°55.6′ W, 0–303 m depth, bongo net, 21 May 1987; UW 67138, 1 (10.5 mm), 56°37.0′ N, 155°33.2′ W, 0–190 m depth, bongo net, 21 May 1987; UW 82889, 1 (64.0 mm), 57°37.5′ N, 155°18.7′ W, 332 m depth, sled trawl, 15 April 1989; UW 94969, 1 (11.9 mm), 56°50.1′ N, 156°26.0′ W, 0–100 m depth, bongo net, 13 May 1992; UW 145094, 1 (19.0 mm), 56°7.8′ N, 157°27.8′ W, 0–101 m depth, bongo net, 22 May 1992; UW 145085, 1 (20.0 mm), 56°10.5′ N, 156°2.5′ W, 0–100 m depth, bongo net, 29 May 1996; UW 145084, 2 (25.5–26.5 mm), 57°7.2′ N, 156°5.4′ W, 0–79 m depth, bongo net, 29 May 1997; UW 145089, 1 (15.9 mm), 56°46.3′ N, 155°51.5′ W, 0–100 m depth, bongo net, 30 May 2001; UW 145088, 1 (22.5 mm), 57°22.1′ N, 155°14.2′ W, 0–100 m depth, bongo net, 31 May 2001; UW 145092, 1 (19.8 mm), 57°43.2′ N, 155°15.5′ W, 0–180 m depth, bongo net, 20 May 2002; UW 145091, 1 (17.6 mm), 56°24.3′ N, 156°29.4′ W, 0–56 m depth, bongo net, 29 May 2002; UW 145070, 1 (8.4 mm), 60°32.1′ N, 147°48.3′ W, 0–12 m depth, MOCNESS, 1 May 2003; UW 145071, 1 (8.9 mm), 60°32.1′ N, 147°48.3′ W, 21–41 m depth, MOCNESS, 1 May 2003; UW 145072, 4 (8.2–9.7 mm), 60°32.1′ N, 147°48.2′ W, 20–41 m depth, MOCNESS, 2 May 2003; UW 145076, 3 (9.0–10.1 mm), 60°32.1′ N, 147°48.2′ W, 0–14 m depth, MOCNESS, 2 May 2003; UW 145073, 1 (10.2 mm), 60°10.8′ N, 147°38.5′ W, 0–11 m depth, MOCNESS, 3 May 2003; UW 145077, 1 (12.0 mm), 60°32.4′ N, 147°48.0′ W, 20–40 m depth, MOCNESS, 3 May 2003; UW 145074, 1 (10.3 mm), 60°32.3′ N, 147°48.3′ W, 0–14 m depth, MOCNESS, 4 May 2003; UW 145075, 1 (10.2 mm), 60°32.3′ N, 147°48.3′ W, 21–41 m depth, MOCNESS, 4 May 2003; UW 145078, 1 (9.4 mm), 60°10.8′ N, 147°38.5′ W, 11–21 m depth, MOCNESS, 4 May 2003; UW 145079, 1 (9.0 mm), 60°10.8′ N, 147°38.5′ W, 0–11 m depth, MOCNESS, 4 May 2003; UW 145090, 2 (12.9–13.3 mm), 55°24.9′ N, 159°50.7′ W, 0–101 m depth, bongo net, 27 May 2003. Location, depth, gear, and date of collection unknown for the following specimens: UW 145882, 1 (35.6 mm); UW 145883, 1 (39.1 mm); UW 145884, 1 (40.4 mm).

Lumpenus fabricii. 22 specimens (12.1–57.0 mm) examined. Chukchi Sea: UW 145069, 2 (55.0–57.0 mm), 69°58.4′ N, 165°53.3′ W, 0 m depth, Cantrawl, 6 September 2007. Beaufort Sea: UW 145881, 1 (22.5 mm), geographic coordinates and depth unknown, bongo net, 10 August 1977; UW 145067, 1 (19.5 mm), 69°57.7′ N, 133°8.4′ W, 0–9 m depth, bongo net, 25 June 2003; UW 145068, 1 (35.0 mm), 69°45.0′ N, 133°21.7′ W, 0–12 m depth, bongo net, 25 June 2003. Bering Sea: UW 94975, 1 (46.0 mm), 57°56.0′ N, 163°30.0′ W, 0–90 m depth, Methot net, 6 September 1994; UW 94974, 1 (12.5 mm), 55°47.3′ N, 167°17.1′ W, 0–125 m depth, bongo net, 8 May 1995; UW 145063, 2 (20.5–30.0 mm), 67°25.0′ N, 173°37.5′ W, 0–22 m depth, bongo net, 16 August 2004; UW 145064, 1 (37.0 mm), 71°23.6′ N, 174°54.6′ W, 0–48 m depth, bongo net, 21 August 2004; UW 145065, 1 (22.5 mm), 71°54.5′ N, 175°29.3′ W, 0–44 m depth, bongo net, 21 August 2004; UW 145066, 1 (41.0 mm), 62° N, 171°0.2′ W, 0–40 m depth, bongo net, 20 September 2004. Gulf of Alaska: UW 94971, 2 (34.0–39.0 mm), 57°16.0′ N, 152°55.0′ W, 0–90 m depth, Tucker trawl, 20 June 1978; UW 94976, 1 (34.0 mm), 57°16.0′ N, 152°55.0′ W, depth unknown, bongo net, 20 June 1978; UW 94972, 1 (45.0 mm), 57°16.0′ N, 152°55.0′ W, depth unknown, bongo net, 26 July 1978; UW 94973, 1 (12.1 mm), 57°19.0′ N, 153°2.0′ W, depth, gear, and date unknown; UW 123507, 1 (length unknown), 57°37.6′ N, 152°25.3′ W, 0–50 m depth, bongo net, 18 May 1981; UW 123508, 1 (length unknown), 57°40.9′ N, 152°21.7′ W, 0–42 m depth, bongo net, 18 May 1981; UW 123509, 1 (length unknown), 57°38.7′ N, 152°23.6′ W, 0–79 m depth, bongo net, 27 May 1981; UW 94970, 1 (13.3 mm), 56°24.0′ N, 158°5.0′ W, 0–99 m depth, bongo net, 25 May 1994. Location, depth, and gear unknown for the following specimen: UW 145896, 1 (41.0 mm), 1978.

Lumpenus maculatus. 80 specimens (8.1–72.1 mm) examined. Bering Sea: UW 95047, 3 (27.5–33.0 mm), 60°6.0′ N, 174°39.6′ W, 0 m depth, neuston net, 3 August 1994; UW 95049, 1 (29.0 mm), 62°22.3′ N, 179°36.0′ W, 0–50 m depth, Methot net, 19 August 1994; UW 95032, 1 (10.4 mm), 55°58.0′ N, 163°58.5′ W, 0–77 m depth, bongo net, 24 April 1995; UW 95036, 1 (11.0 mm), 56°14.7′ N, 166°44.4′ W, 0–107 m depth, bongo net, 27 April 1995; UW 94977, 1 (28.0 mm), 56°29.5′ N, 166°59.4′ W, 0–98 m depth, Methot net, 21 July 1995; UW 94978, 1 (36.7 mm), 57°30.2′ N, 167°58.8′ W, 0–66 m depth, Methot net, 22 July 1995; UW 95044, 1 (61.0 mm), 57°2.6′ N, 170°37.7′ W, 0–73 m depth, Methot net, 21 September 1995; UW 94979, 1 (46.0 mm), 55°30.7′ N, 166°0.8′ W, 0–100 m depth, Methot net, 22 July 1996; UW 14506, 1 (42.0 mm), 56°29.6′ N, 168°57.6′ W, 0–90 m depth, Methot net, 22 July 1997; UW 94980, 3 (40.0–45.5 mm), 56°0.4′ N, 165°59.3′ W, 0–100 m depth, Methot net, 22 July 1997; UW 95045, 1 (57.5 mm), 56°27.4′ N, 169°28.4′ W, 0–92 m depth, Methot net, 11 September 1997; UW 14507, 1 (44.0 mm), 56°30.6′ N, 168°60.0′ W, 0–116 m depth, Methot net, 23 July 2001; UW 145102, 1 (52.8 mm), 56°29.9′ N, 168°58.7′ W, 0–95 m depth, Methot net, 8 August 2002. Gulf of Alaska: UW 14509, 1 (72.1 mm), 59°54.0′ N, 144°44.4′ W, 0–182 m depth, bongo net, 8 November 1978; UW 64838, 2 (8.1–8.2 mm), 56°33.8′ N, 153°6.0′ W, 0–90 m depth, bongo net, 18 April 1981; UW 57475, 1 (10.5 mm), 58°20.8′ N, 149°39.0′ W, 0–131 m depth, bongo net, 14 April 1984; UW 63531, 1 (17.0 mm), 57°32.8′ N, 154°44.5′ W, 0–185 m depth, bongo net, 23 May 1985; UW 61502, 1 (13.5 mm), 57°19.6′ N, 155°5.9′ W, 0–223 m depth, bongo net, 28 April 1988; UW 145103, 1 (22.4 mm), 56°40.1′ N, 155°12.5′ W, 0–62 m depth, Tucker trawl, 22 May 1988; UW 145105, 1 (31.1 mm), 55°58.8′ N, 157°2.1′ W, 0–76 m depth, Tucker trawl, 6 June 1988; UW 145100, 1 (19.4 mm), 56°9.0′ N, 157° W, 0–90 m depth, Tucker trawl, 4 June 1989; UW 62423, 1 (15.5 mm), 57°17.9′ N, 155°27.8′ W, 0–100 m depth, bongo net, 9 May 1990; UW 145095, 1 (11.8 mm), 57°18.0′ N, 155°42.9′ W, 0–258 m depth, bongo net, 27 April 1991; UW 94984, 5 (36.0–42.0 mm), 56°12.3′ N, 156°40.7′ W, 0–77 m depth, Methot net, 26 July 1991; UW 94985, 3 (50.0–53.0 mm), 56°11.6′ N, 157°21.7′ W, 0–129 m depth, Methot net, 27 July 1991; UW 94986, 3 (38.9–45.0 mm), 54°38.6′ N, 160°6.6′ W, 0–73 m depth, Methot net, 29 July 1991; UW 94987, 3 (47.0–56.5 mm), 54°47.3′ N, 162°33.8′ W, 0–37 m depth, Methot net, 30 July 1991; UW 94981, 1 (66.2 mm), 58°6.7′ N, 154°10.5′ W, 0–148 m depth, Tucker trawl, 30 March 1994; UW 94989, 6 (9.5–12.0 mm), 57°42.7′ N, 155°13.4′ W, 0–271 m depth, bongo net, 4 May 1994; UW 94990, 1 (10.9 mm), 56°25.5′ N, 155°37.1′ W, 0–69 m depth, bongo net, 6 May 1994; UW 94995, 3 (12.1–13.6 mm), 57°34.6′ N, 154°34.0′ W, 0–93 m depth, bongo net, 8 May 1994; UW 95002, 1 (16.0 mm), 57°6.5′ N, 155°59.5′ W, 0–30 m depth, Tucker trawl, 9 May 1994; UW 95010, 1 (16.2 mm), 57°8.0′ N, 155°56.1′ W, 29–64 m depth, Tucker trawl, 10 May 1994; UW 95012, 2 (13.1–14.2 mm), 57°3.7′ N, 155°53.1′ W, 56–101 m depth, Tucker trawl, 11 May 1994; UW 95013, 1 (12.0 mm), 57°3.7′ N, 155°53.1′ W, 0–56 m depth, Tucker trawl, 11 May 1994; UW 95015, 1 (15.0 mm), 56°58.6′ N, 155°52.7′ W, 0–52 m depth, Tucker trawl, 11 May 1994; UW 95016, 1 (14.0 mm), 56°58.6′ N, 155°52.7′ W, 52–108 m depth, Tucker trawl, 11 May 1994; UW 95018, 2 (13.0–14.1 mm), 56°55.6′ N, 155°53.4′ W, 0–294 m depth, bongo net, 11 May 1994; UW 95020, 1 (17.1 mm), 57°36.3′ N, 155°0.4′ W, 0–227 m depth, bongo net, 24 May 1994; UW 95022, 2 (18.8 mm), 57°1.8′ N, 156°21.1′ W, 0–89 m depth, bongo net, 25 May 1994; UW 95024, 2 (20.0–21.5 mm), 55°19.8′ N, 159°15.6′ W, 0–101 m depth, bongo net, 26 May 1994; UW 95025, 1 (24.0 mm), 55°22.6′ N, 156°56.4′ W, 0–86 m depth, bongo net, 27 May 1994; UW 95027, 1 (24.9 mm), 56°17.1′ N, 156°46.8′ W, 0–75 m depth, bongo net, 29 May 1994; UW 95028, 1 (23.9 mm), 56°31.4′ N, 156°47.1′ W, 0–100 m depth, bongo net, 30 May 1994; UW 95029, 2 (18.2–23.0 mm), 56°52.0′ N, 156°44.7′ W, 0–99 m depth, bongo net, 30 May 1994; UW 145099, 1 (17.1 mm), 55°31.7′ N, 160°4.9′ W, 0–100 m depth, bongo net, 27 May 2000; UW 145104, 1 (25.2 mm), 57°20.6′ N, 156°2.8′ W, 0–59 m depth, bongo net, 1 June 2000; UW 95046, 2 (57.0–62.0 mm), 55°27.8′ N, 158°32.6′ W, 0–134 m depth, shrimp trawl, 6 September 2000; UW 145096, 1 (12.0 mm), 58°50.2′ N, 151°20.8′ W, 0–116 m depth, bongo net, 29 April 2001; UW 145098, 1 (16.0 mm), 57°35.3′ N, 155°11.9′ W, 50–60 m depth, MOCNESS, 5 May 2001; UW 145101, 1 (20.8 mm), 54°55.4′ N, 161°4.9′ W, 0–88 m depth, bongo net, 26 May 2001; UW 145097, 1 (13.1 mm), 58°12.1′ N, 153°18.5′ W, 0–101 m depth, bongo net, 30 May 2006.

Lumpenus medius. 78 specimens (9.6–46.5 mm) examined. Arctic Ocean: UW 145110, 1 (40.0 mm), 73°20.0′ N, 165° W, 0–57 m depth, bongo net, 12 September 2003. Beaufort Sea: UW 145112, 1 (32.0 mm), 69°46.8′ N, 133°8.1′ W, 0–4 m depth, bongo net, 15 August 2002; UW 145111, 1 (35.0 mm), 69°57.7′ N, 133°8.4′ W, 0–9 m depth, bongo net, 16 August 2002. Gulf of Alaska: UW 33044, 10 (9.8–16.3 mm), 57°16.0′ N, 152°55.0′ W, 70 m depth, Tucker trawl, 5 April 1978; UW 33045, 2 (10.2–13.0 mm), 56°52.0′ N, 153°35.0′ W, 0–38 m depth, bongo net, 16 April 1978; UW 33049, 12 (31.0–41.5 mm), 57°16.0′ N, 152°55.0′ W, 0–90 m depth, Tucker trawl, 20 June 1978; UW 33050, 8 (33.0–38.0 mm), 57°16.0′ N, 152°55.0′ W, 70 m depth, Tucker trawl, 20 June 1978; UW 33051, 1 (36.0 mm), 57°16.0′ N, 152°55.0′ W, 90 m depth, Tucker trawl, 20 June 1978; UW 33052, 1 (39.0 mm), 57°50.0′ N, 152°19.0′ W, 103 m depth, sled trawl, 29 June 1978; UW 33053, 2 (41.0–44.5 mm), 57°16.0′ N, 152°55.0′ W, 87 m depth, sled trawl, 13 July 1978; UW 33064, 2 (40.0–42.5 mm), 57°50.0′ N, 152°19.0′ W, 130 m depth, sled trawl, 3 August 1978; UW 33065, 1 (46.0 mm), 57°1.0′ N, 153°29.0′ W, 116 m depth, sled trawl, 8 August 1978; UW 33074, 2 (11.5–12.3 mm), 57°19.0′ N, 153°2.0′ W, 0–81 m depth, bongo net, 15 March 1979; UW 33075, 1 (10.0 mm), 57°16.0′ N, 152°55.0′ W, 0–92 m depth, bongo net, 15 March 1979; UW 33076, 1 (14.4 mm), 57°16.0′ N, 152°37.0′ W, 0–47 m depth, bongo net, 15 March 1979; UW 33079, 6 (10.4–11.9 mm), 57°18.0′ N, 153°6.0′ W, 0–27 m depth, bongo net, 15 March 1979; UW 33080, 15 (9.6–12.2 mm), 57°20.0′ N, 152°55.0′ W, 0–33 m depth, bongo net, 15 March 1979; UW 33073, 2 (10.6–11.0 mm), 57°4.0′ N, 153°36.0′ W, 0–81 m depth, bongo net, 16 March 1979; UW 145885, 1 (31.0 mm), 54°17.2′ N, 164°16.1′ W, 0–65 m depth, bongo net, 25 May 2001. Location, depth, gear, and date of collection unknown for the following specimens: UW 33056, 1 (11.4 mm); UW 33057, 1 (45.0 mm); UW 33058, 2 (43.5–45.5 mm); UW 33059, 2 (39.5–43.0 mm); UW 33063, 1 (46.5 mm); UW 33069, 1 (11.4 mm).

Lumpenus sagitta. 92 specimens (5.8–53.0 mm) examined. Bering Sea: UW 142296, 1 (19.5 mm), 56°5.1′ N, 160°57.7′ W, 0–15 m depth, bongo net, 20 May 2003. Gulf of Alaska: UW 141556, 1 (13.8 mm), 56°32.0′ N, 155°44.0′ W, 0–152 m depth, bongo net, 29 April 1972; UW 141552, 1 (15.3 mm), 57°1.2′ N, 153°27.3′ W, 0–115 m depth, bongo net, 1 May 1972; UW 33120, 1 (31.2 mm), 57°16.0′ N, 152°55.0′ W, 0–70 m depth, Tucker trawl, 26 May 1978; UW 33125, 1 (51.0 mm), 57°16.0′ N, 152°55.0′ W, 0–10 m depth, Tucker trawl, 4 June 1978; UW 33126, 1 (49.5 mm), 57°16.0′ N, 152°55.0′ W, 0–50 m depth, Tucker trawl, 4 June 1978; UW 141253, 1 (15.7 mm), 57°7.3′ N, 155°34.5′ W, depth unknown, bongo net, 10 April 1980; UW 60222, 1 (15.4 mm), 56°22.8′ N, 155°26.1′ W, 0–30 m depth, bongo net, 3 April 1981; UW 66714, 1 (30.0 mm), 57°51.7′ N, 154°40.6′ W, 0–192 m depth, bongo net, 28 April 1981; UW 66839, 1 (21.0 mm), 57°49.4′ N, 154°56.0′ W, 0–72 m depth, bongo net, 29 April 1981; UW 70716, 1 (30.0 mm), 57°52.0′ N, 154°40.8′ W, 0–208 m depth, bongo net, 21 May 1981; UW 70755, 1 (30.0 mm), 57°28.5′ N, 154°45.3′ W, 0–126 m depth, bongo net, 21 May 1981; UW 70841, 1 (35.1 mm), 57°29.5′ N, 155°43.0′ W, 0–65 m depth, bongo net, 21 May 1981; UW 70885, 1 (31.0 mm), 57°23.9′ N, 154°57.3′ W, 0–208 m depth, bongo net, 22 May 1981; UW 37176, 1 (17.3 mm), 56°40.0′ N, 155°27.0′ W, 0–194 m depth, bongo net, 8 April 1982; UW 95054, 1 (25.5 mm), 55°14.1′ N, 159°2.0′ W, 0–189 m depth, bongo net, 29 May 1982; UW 37525, 2 (15.6–16.0 mm), 56°13.4′ N, 156°3.4′ W, 0–219 m depth, bongo net, 26 March 1985; UW 60334, 1 (21.5 mm), 57°0.9′ N, 155°37.0′ W, 0–244 m depth, bongo net, 6 May 1985; UW 60353, 1 (22.0 mm), 56°54.4′ N, 156°14.0′ W, 0–164 m depth, bongo net, 7 May 1985; UW 62957, 1 (44.5 mm), 59°7.6′ N, 150°21.0′ W, 0–162 m depth, bongo net, 19 May 1985; UW 63889, 1 (36.0 mm), 55°57.0′ N, 155°54.0′ W, 0–64 m depth, bongo net, 27 May 1985; UW 50984, 1 (12.6 mm), 57°44.0′ N, 155°5.8′ W, 0–294 m depth, bongo net, 7 April 1986; UW 60450, 1 (25.0 mm), 58°0.4′ N, 154°14.1′ W, 0–196 m depth, bongo net, 6 May 1986; UW 144705, 1 (36.0 mm), 56°24.0′ N, 153°23.4′ W, 0–60 m depth, Tucker trawl, 27 May 1986; UW 95115, 3 (28.0–36.0 mm), 53°25.8′ N, 166°31.8′ W, 0–58 m depth, Tucker trawl, 4 June 1986; UW 60932, 1 (15.5 mm), 57°40.0′ N, 155°18.1′ W, 0–285 m depth, bongo net, 5 April 1987; UW 60962, 2 (16.5–18.0 mm), 57°51.3′ N, 154°44.6′ W, 0–262 m depth, bongo net, 5 April 1987; UW 95069, 1 (16.1 mm), 57°51.4′ N, 154°22.2′ W, 0–205 m depth, bongo net, 5 April 1987; UW 61006, 1 (15.9 mm), 57°33.0′ N, 154°52.7′ W, 0–222 m depth, bongo net, 6 April 1987; UW 51920, 1 (15.8 mm), 58°14.2′ N, 154°2.0′ W, 0–256 m depth, bongo net, 5 April 1988; UW 51747, 1 (28.0 mm), 57°43.4′ N, 154°56.4′ W, 0–262 m depth, 7 April 1988; UW 51661, 1 (19.0 mm), 57°55.9′ N, 154°29.5′ W, 0–285 m depth, bongo net, 11 April 1988; UW 61461, 1 (23.5 mm), 57°34.2′ N, 155°17.7′ W, 0–282 m depth, bongo net, 29 April 1988; UW 61539, 1 (9.2 mm), 57°23.6′ N, 155°38.8′ W, 0–238 m depth, bongo net, 29 April 1988; UW 61551, 1 (27.5 mm), 57°27.0′ N, 155°44.6′ W, 0–147 m depth, bongo net, 29 April 1988; UW 142201, 1 (32.5 mm), 56°38.7′ N, 156°31.8′ W, 0–145 m depth, Tucker trawl, 21 May 1988; UW 95095, 1 (41.0 mm), 55°52.1′ N, 156°47.3′ W, 0–102 m depth, Tucker trawl, 6 June 1988; UW 67470, 3 (26.0–30.0 mm), 56°43.4′ N, 155°26.2′ W, 0–93 m depth, Tucker trawl, 24 May 1989; UW 52644, 1 (17.0 mm), 57°47.5′ N, 155°6.4′ W, 0–258 m depth, bongo net, 10 April 1990; UW 71418, 1 (40.0 mm), 58°0.1′ N, 152°0.3′ W, 0–100 m depth, bongo net, 28 May 1990; UW 141255, 1 (15.5 mm), 57°56.0′ N, 154°46.6′ W, 0–208 m depth, bongo net, 17 April 1991; UW 95076, 1 (17.5 mm), 57°46.8′ N, 155°7.7′ W, 0–259 m depth, bongo net, 26 April 1991; UW 95086, 1 (14.8 mm), 57°38.5′ N, 155°4.3′ W, 0–246 m depth, bongo net, 2 May 1991; UW 95087, 1 (19.5 mm), 57°15.8′ N, 156°3.3′ W, 0–105 m depth, bongo net, 2 May 1991; UW 95097, 1 (11.2 mm), 56°16.4′ N, 158°4.9′ W, 0–64 m depth, bongo net, 22 May 1991; UW 141557, 4 (12.9–17.3 mm), 57°46.7′ N, 155°0.2′ W, 0–309 m depth, bongo net (net 2), 7 April 1992; UW 143892, 1 (15.0 mm), 57°46.7′ N, 155°0.2′ W, 0–309 m depth, bongo net (net 1), 7 April 1992; UW 143372, 1 (12.2 mm), 56°54.3′ N, 156°16.0′ W, 0–100 m depth, bongo net, 9 May 1992; UW 95089, 1 (13.2 mm), 56°45.4′ N, 156°31.0′ W, 0–117 m depth, bongo net, 13 May 1992; UW 144493, 1 (5.8 mm), 56°56.1′ N, 155°10.9′ W, 0–101 m depth, bongo net, 10 May 1993; UW 95099, 1 (25.5 mm), 57°54.9′ N, 154°47.7′ W, 0–101 m depth, bongo net, 11 May 1993; UW 95103, 1 (27.0 mm), 56°18.8′ N, 155°22.4′ W, 0–41 m depth, bongo net, 6 May 1994; UW 95101, 1 (24.0 mm), 57°8.7′ N, 156°0.6′ W, 0–57 m depth, Tucker trawl, 10 May 1994; UW 95102, 1 (29.0 mm), 57°3.7′ N, 155°53.1′ W, 0–101 m depth, Tucker trawl, 11 May 1994; UW 95110, 1 (29.0 mm), 57°16.7′ N, 155°55.2′ W, 0–101 m depth, bongo net, 28 May 1995; UW 95107, 1 (24.0 mm), 57°36.3′ N, 155°0.3′ W, 0–201 m depth, bongo net, 4 May 1996; UW 94983, 1 (44.0 mm), 54°10.2′ N, 164°10.9′ W, 0–58 m depth, Methot net, 19 June 1998; UW 94982, 5 (45.5–53.0 mm), 55°3.0′ N, 161°4.0′ W, 0–101 m depth, Methot net, 20 June 1998; UW 95113, 1 (48.0 mm), 55°31.8′ N, 159°31.8′ W, 0–59 m depth, Methot net, 21 June 1998; UW 141719, 1 (19.0 mm), 54°39.8′ N, 162°47.6′ W, 0–68 m depth, bongo net, 26 May 2000; UW 141566, 1 (25.0 mm), 57°27.1′ N, 155°45.6′ W, 0–101 m depth, bongo net, 1 May 2001; UW 14454, 1 (29.5 mm), 56°31.3′ N, 156°16.4′ W, 0–199 m depth, bongo net, 4 May 2001; UW 141549, 1 (22.0 mm), 58°8.3′ N, 151°48.9′ W, 0–58 m depth, bongo net, 4 May 2003; UW 144287, 1 (46.0 mm), 56°47.0′ N, 155°0.7′ W, 0–63 m depth, bongo net, 30 May 2004; UW 141554, 1 (33.0 mm), 57°27.0′ N, 155°45.8′ W, 0–101 m depth, bongo net, 29 May 2005. Puget Sound, Washington: UW 95119, 1 (37.0 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 6 September 1988; UW 95111, 2 (34.0–42.0 mm), 48°19.8′ N, 123°8.9′ W, 0 m depth, dip net, 6 June 1989; UW 95112, 8 (11.7–14.1 mm), 48°19.4′ N, 123°0.3′ W, 0 m depth, dip net, 7 April 1992; UW 142295, 1 (34.3 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 14 May 1995. Location and depth unknown for the following specimen: UW 141561, 1 (42.5 mm), bongo net, May 1979. Location, depth, and date of collection unknown for the following specimen: UW 95118, 1 (36.0 mm), bongo net.

Poroclinus rothrocki. 70 specimens (5.5–48.0 mm) examined. Bering Sea: UW 66398, 1 (12.6 mm), 56°3.0′ N, 166°35.5′ W, 25–26 m depth, Tucker trawl, 3 June 1979; UW 65629, 1 (15.5 mm), 55°57.3′ N, 166°44.6′ W, 0–123 m depth, bongo net, 19 June 1979; UW 129895, 2 (26.0–28.0 mm), 56°27.4′ N, 169°28.4′ W, 0–96 m depth, Methot net, 12 June 1997. Gulf of Alaska: UW 65106, 1 (13.0 mm), 55°5.4′ N, 157°47.0′ W, 0–62 m depth, bongo net, 24 April 1981; UW 68662, 2 (10.6–12.1 mm), 56°53.2′ N, 153°23.0′ W, 0–127 m depth, bongo net, 21 May 1981; UW 68682, 1 (12.6 mm), 56°33.8′ N, 153°5.0′ W, 0–68 m depth, bongo net, 21 May 1981; UW 68770, 2 (11.2–11.4 mm), 56°38.0′ N, 155°25.0′ W, 0–96 m depth, bongo net, 23 May 1981; UW 68790, 7 (11.4–13.1 mm), 56°3.0′ N, 154°56.0′ W, 0–93 m depth, bongo net, 23 May 1981; UW 71106, 4 (11.0–12.3 mm), 56°40.4′ N, 155°22.0′ W, 0–122 m depth, bongo net, 23 May 1981; UW 36019, 1 (14.3 mm), 56°44.9′ N, 155°32.9′ W, 0–203 m depth, bongo net, 22 May 1983; UW 36380, 1 (16.0 mm), 55°45.3′ N, 157°21.5′ W, 0–78 m depth, bongo net, 25 May 1983; UW 36440, 3 (15.0–15.7 mm), 55°30.9′ N, 157°47.2′ W, 0–60 m depth, bongo net, 26 May 1983; UW 36484, 2 (14.7–15.6 mm), 55°15.3′ N, 158°41.4′ W, 0–196 m depth, bongo net, 27 May 1983; UW 60324, 1 (13.3 mm), 56°48.2′ N, 155°8.0′ W, 0–83 m depth, bongo net, 6 May 1985; UW 60378, 1 (13.1 mm), 55°50.9′ N, 156°49.0′ W, 0–90 m depth, bongo net, 8 May 1985; UW 62968, 1 (13.8 mm), 58°52.2′ N, 149°55.0′ W, 0–208 m depth, bongo net, 19 May 1985; UW 63121, 1 (15.3 mm), 59° N, 151°18.5′ W, 0–104 m depth, bongo net, 20 May 1985; UW 63205, 1 (18.3 mm), 58°55.7′ N, 152°51.5′ W, 0–168 m depth, 21 May 1985; UW 63751, 2 (14.8–15.8 mm), 56°25.8′ N, 153°29.0′ W, 0–62 m depth, 25 May 1985; UW 64286, 1 (13.9 mm), 55°16.8′ N, 158°40.8′ W, 0–190 m depth, bongo net, 1 June 1985; UW 145119, 1 (11.0 mm), 55°56.2′ N, 156°23.8′ W, 45–60 m depth, MOCNESS, 15 May 1986; UW 60840, 1 (10.4 mm), 56°22.4′ N, 156°45.2′ W, 0–114 m depth, bongo net, 16 May 1986; UW 67222, 1 (14.1 mm), 56°41.1′ N, 156°44.7′ W, 0–139 m depth, bongo net, 22 May 1987; UW 67299, 1 (11.8 mm), 56°32.7′ N, 156°32.8′ W, 0–191 m depth, bongo net, 23 May 1987; UW 145118, 1 (9.6 mm), 56°33.6′ N, 156°32.6′ W, 30–45 m depth, MOCNESS, 24 May 1987; UW 145121, 1 (11.5 mm), 56°33.9′ N, 156°32.7′ W, 1–15 m depth, MOCNESS, 25 May 1987; UW 145117, 1 (10.6 mm), 56°35.1′ N, 156°31.9′ W, 30–45 m depth, MOCNESS, 25 May 1987; UW 145138, 1 (10.0 mm), 56°16.7′ N, 157°10.0′ W, 0–104 m depth, Tucker trawl, 23 May 1988; UW 145127, 1 (10.1 mm), 56°38.9′ N, 156°31.5′ W, 0–101 m depth, Tucker trawl, 2 June 1988; UW 145128, 1 (18.0 mm), 56°21.4′ N, 157°3.8′ W, 23–46 m depth, Tucker trawl, 7 June 1988; UW 72252, 1 (22.0 mm), 57°1.0′ N, 156°18.9′ W, 0–95 m depth, bongo net, 3 June 1990; UW 129519, 1 (5.5 mm), 56°37.0′ N, 156°20.0′ W, 0–101 m depth, bongo net, 13 May 1993; UW 129629, 2 (12.0 mm), 55°29.0′ N, 158°8.2′ W, 0–101 m depth, bongo net, 23 May 1995; UW 129645, 1 (14.3 mm), 58°40.5′ N, 152°45.5′ W, 0–100 m depth, bongo net, 1 June 1996; UW 129681, 1 (22.5 mm), 55°31.8′ N, 159°31.8′ W, 0–60 m depth, bongo net, 21 June 1998; UW 129893, 1 (20.0 mm), 55°31.8′ N, 159°31.8′ W, 0–59 m depth, Methot net, 21 June 1998; UW 145133, 1 (24.0 mm), 59°15.3′ N, 149°34.4′ W, 0–113 m depth, bongo net, 31 May 2002; UW 145132, 1 (16.1 mm), 58°18.4′ N, 148°58.5′ W, 40–60 m depth, MOCNESS, 5 June 2002; UW 145134, 2 (17.9–18.8 mm), 59°35.2′ N, 147°0.4′ W, 0–200 m depth, bongo net, 12 May 2003; UW 113858, 1 (48.0 mm), 58° N, 152° W, 0–156 m depth, gear unknown, 25 July 2003; UW 145135, 1 (12.5 mm), 57°40.7′ N, 155°11.0′ W, 0–281 m depth, 31 May 2004; UW 145891, 1 (26.5 mm), 56°33.0′ N, 157°44.4′ W, 39–74 m depth, Tucker trawl, 14 September 2009. British Columbia, Canada: UW 42915, 1 (38.0 mm), 48°52.5′ N, 126°53.0′ W, depth and gear unknown, 8 September 1964. Washington coast: UW 145125, 1 (17.8 mm), 47°6.3′ N, 124°12.5′ W, 0–55 m depth, 1-m net, 6 May 1971; UW 145126, 1 (18.4 mm), 47°6.3′ N, 124°12.5′ W, 0–37 m depth, 1-m net, 6 May 1971; UW 58120, 1 (10.7 mm), 47°20.0′ N, 124°25.0′ W, 0–140 m depth, bongo net, 24 April 1980. Oregon coast: UW 145122, 3 (12.8–16.5 mm), 46° N, 124°8.0′ W, 0–91 m depth, 1-m net, 4 May 1971; UW 58255, 1 (17.3 mm), 46° N, 124°25.0′ W, 0–131 m depth, bongo net, 26 April 1980; UW 54125, 1 (16.5 mm), 43°40.0′ N, 124°21.5′ W, 0–109 m depth, bongo net, 22 May 1981. Location and depth unknown for the following specimen: UW 145114, 1 (16.2 mm), 1-m net, 3–6 May 1971.

Opisthocentrus ocellatus. 7 specimens (13.6–15.8 mm) examined (depths and gear unknown). Sea of Japan: HUMZ-L 02671, 2 (14.4–15.2 mm), 41°56.0′ N, 140°57.0′ E, 20 April 1983; HUMZ-L 03502, 5 (13.6–15.8 mm), 41°56.0′ N, 140°57.0′ E, 12 April 1985.

Plectobranchus evides. 17 specimens (7.0–49.0 mm) examined. Oregon coast: UW 145887, 1 (37.0 mm), 44°39.0′ N, 124°39.9′ W, 130 m depth, midwater trawl, 28 June 1970; OS 13628, 1 (7.0 mm), 45°23.7′ N, 124°10.2′ W, 0–138 m depth, 0.7-m bongo net, 28 March 1972; OS 13626, 1 (11.1 mm), 44°10.4′ N, 124°13.8′ W, 0–75 m depth, 0.7-m bongo net, 29 March 1972; OS 13627, 1 (7.8 mm), 44°2.4′ N, 124°4.8′ W, 0–80 m depth, 0.7-m bongo net, 29 March 1972; UW 145886 1 (20.0 mm), 44°17.5′ N, 124°20.6′ W, 0–86 m depth, 0.7-m bongo net, 20 April 1973; UW 145889, 1 (16.9 mm original length, 15.1 mm after preservative changed to ethanol), 44°6.0′ N, 124°22.1′ W, 75 m depth, 0.7-m bongo net, 20 April 1973; UW 145888, 1 (9.2 mm), 45°4.0′ N, 124°15.0′ W, 105 m depth, 0.7-m bongo net, 24 April 1973; UW 145113, 1 (34.0 mm), 44° N, 124°36.2′ W, 0–124 m depth, bongo net, 22 May 1981; UW 145115, 2 (23.0–28.0 mm), 43°57.6′ N, 124°16.3′ W, 0–75 m depth, bongo net, 14 May 1982; UW 55422, 1 (9.5 mm), 43°40.0′ N, 124°17.1′ W, 0–82 m depth, bongo net, 24 March 1984; UW 145116, 5

(33.5–49.0 mm), 44°23.6′ N, 124°22.8′ W, 0–266 m depth, midwater trawl, 20 July 2007. Location, depth, gear, and date of collection unknown for the following specimen: UW 145890, 1 (39.5 mm).

***Alectrias* spp.** 13 specimens (12.8–16.5 mm) examined (depths and gear unknown). Sea of Japan: HUMZ-L 02756, 2 (12.8–16.5 mm), 41°56.0′ N, 140°57.0′ E, 26 May 1983; HUMZ-L 02920, 1 (14.4 mm), 41°56.0′ N, 140°57.0′ E, 15 June 1985; HUMZ-L 03915, 10 (14.0–16.2 mm), 42°18.0′ N, 140°58.0′ E, 15 June 1984.

Alectrias alectrolophus. 6 specimens (10.7–16.6 mm) examined (depths and gear unknown). Sea of Japan: HUMZ-L 02576, 3 (10.7–16.6 mm), 41°56.0′ N, 140°57.0′ E, 26 May 1983; HUMZ-L 02920, 2 (15.0–16.4 mm), 41°56.0′ N, 140°57.0′ E, 15 June 1985; HUMZ-L 03439, 1 (14.1 mm), 41°56.0′ N, 140°57.0′ E, 12 June 1985.

Anoplarchus insignis. 178 specimens (5.2–36.5 mm) examined. Bering Sea: UW 141553, 1 (6.5 mm), 54°0.6′ N, 166°34.3′ W, 0–110 m depth, bongo net, 13 May 2002; UW 141737, 1 (6.6 mm), 54°14.6′ N, 165°49.6′ W, 0–79 m depth, bongo net (net 1), 18 May 2003; UW 141551, 4 (6.8–9.5 mm), 54°14.6′ N, 165°49.6′ W, 0–79 m depth, bongo net (net 2), 18 May 2003; UW 141735, 1 (6.3 mm), 54°7.3′ N, 166°12.1′ W, 0–80 m depth, bongo net (net 1), 18 May 2003; UW 141861, 2 (7.2 mm), 54°7.3′ N, 166°12.1′ W, 0–80 m depth, bongo net (net 2), 18 May 2003; UW 143915, 2 (11.6–15.2 mm), 54°24.8′ N, 165°8.9′ W, 0–146 m depth, bongo net, 18 May 2003; UW 140950, 4 (6.7–13.6 mm), 54°29.4′ N, 165°4.1′ W, 0–53 m depth, bongo net (net 1), 19 May 2003; UW 141567, 4 (6.4–8.9 mm), 54°29.4′ N, 165°4.1′ W, 0–53 m depth, bongo net (net 2), 19 May 2003; UW 141550, 3 (6.4–7.9 mm), 54°42.7′ N, 165°16.2′ W, 0–132 m depth, bongo net (net 1), 19 May 2003; UW 144184, 2 (6.3–7.9 mm), 54°42.7′ N, 165°16.2′ W, 0–132 m depth, bongo net (net 2), 19 May 2003; UW 141565, 5 (7.6–12.4 mm), 54°27.8′ N, 165°0.3′ W, 0–70 m depth, bongo net (net 1), 19 May 2003; UW 141560, 7 (6.6–12.2 mm), 54°27.8′ N, 165°0.3′ W, 0–70 m depth, bongo net (net 2), 19 May 2003; UW 144452, 1 (10.0 mm), 54°56.6′ N, 164°30.6′ W, 0–164 m depth, bongo net, 19 May 2003; UW 145894, 1 (7.3 mm), 55°9.2′ N, 165°41.7′ W, 0–114 m depth, bongo net, 23 May 2003. Gulf of Alaska: UW 141558, 1 (17.6 mm), 57°12.1′ N, 152°44.5′ W, 0 m depth, neuston net, 24 June 1978; UW 32887, 1 (19.2 mm), 58°11.5′ N, 152°15.2′ W, 90 m depth, Tucker trawl, 28 June 1978; UW 141559, 37 (5.2–8.3 mm), 56°18.9′ N, 155°23.1′ W, 0–37 m depth, 23 May 1988; UW 141090, 1 (12.7 mm), 56°38.4′ N, 156°44.0′ W, 50–75 m depth, Tucker trawl, 31 May 1988; UW 141726, 1 (13.1 mm), 55°49.1′ N, 156°40.4′ W, 0–101 m depth, Tucker trawl, 4 June 1988; UW 27394, 1 (36.5 mm), 60°12.0′ N, 147°50.0′ W, 0–25 m depth, rock dredge, 1 Aug 1989; UW 40411, 1 (17.0 mm), 60°21.0′ N, 147°49.0′ W, 0–40 m depth, beam trawl, 7 August 1989; UW 143886, 6 (7.0–9.8 mm), 56°49.1′ N, 154°56.2′ W, 0–50 m depth, bongo net, 10 May 1993; UW 143071, 4 (12.0–16.4 mm), 55°0.8′ N, 155°23.3′ W, 0–58 m depth, bongo net, 29 May 1998; UW 141564, 12 (6.6–20.6 mm), 55°50.7′ N, 155°50.7′ W, 0–46 m depth, bongo net, 25 June 1998; UW 140942, 5 (13.7–20.1 mm), 56°4.2′ N, 155°24.1′ W, 0–25 m depth, Tucker trawl, 29 June 1998; UW 141548, 1 (18.2 mm), 55°56.4′ N, 156°1.7′ W, 0–76 m depth, Tucker trawl, 29 June 1998; UW 141555, 8 (7.5–11.7 mm), 57°24.1′ N, 156°14.1′ W, 0–30 m depth, bongo net, 1 June 2000; UW 141562, 1 (13.7 mm), 58°57.2′ N, 150°55.9′ W, 0–138 m depth, bongo net, 29 May 2002; UW 143341, 1 (10.9 mm), 58°29.3′ N, 151°9.1′ W, 0–87 m depth, bongo net, 3 June 2004. Washington coast: UW 141720, 1 (18.5 mm), 47°59.6′ N, 124°50.1′ W, 0–49 m depth, bongo net, 3 May 1982. Puget Sound, Washington: UW 145147, 16 (6.3–13.8 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 22 May 1987; UW 145148, 17 (9.2–15.0 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 5 May 1988; UW 143894, 1 (12.1 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 5 May 1989; UW 145149, 1 (13.9 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 7 June 1989; UW 145150, 3 (13.7–15.8 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 5 April 1990; UW 145151, 1 (13.1 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 20 April 1991; UW 145152, 2 (13.1–15.6 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 5 May 1992; UW 145153, 7 (13.0–14.9 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 5 May 1995; UW 145154, 1 (12.7 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 12 May 1995; UW 145155, 10 (11.7–15.9 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 14 May 1995.

Anoplarchus purpurescens. 204 specimens (4.7–37.0 mm) examined. Bering Sea: UW 48963, 1 (28.0 mm), 51°32.5′ N, 178°59.0′ W, depth and gear unknown, 29 May 1956; UW 22417, 1 (17.1 mm), 51°30.0′ N, 179°2.4′ W, depth and gear unknown, 19 August 1968; UW 144877, 2 (6.5–7.1 mm), 54°15.0′ N, 165°49.5′ W, 0–74 m depth, bongo net, 13 May 2002. Gulf of Alaska: UW 48936, 1 (37.0 mm), 56°53.1′ N, 153°43.3′ W, depth and gear unknown, 11 May 1962; UW 27394, 1 (36.5 mm), 60°12.0′ N, 147°50.0′ W, 25 m depth, rock dredge, 1 August 1989; UW 25833, 1 (32.0 mm), 59°40.0′ N, 151°41.0′ W, depth and gear unknown, 3 June 1992; UW 144886, 1 (9.9 mm), 57°11.4′ N, 154°45.3′ W, 0–68 m depth, bongo net, 31 May 1994; UW 144884, 1 (14.3 mm), 56°18.3′ N, 155°24.8′ W, 0–43 m depth, bongo net, 28 May 1998; UW 144885, 35 (4.7–10.4 mm), 57°24.1′ N, 156°14.1′ W, 0–30 m depth, bongo net, 1 June 2000; UW 144878, 1 (9.6 mm), 55°4.2′ N, 159°9.2′ W, 0–65 m depth, bongo net, 27 May 2003; UW 144879, 2 (9.5–12.6 mm), 57°0.3′ N, 155°52.2′ W, 0–100 m depth, bongo net, 31 May 2003; UW 144880, 2 (7.3–8.9 mm), 57°43.5′ N, 152°54.8′ W, 0–20 m depth, bongo net, 23 May 2004; UW 144883, 11 (6.4–10.7 mm), 57°40.5′ N, 152°21.0′ W, 0–100 m depth, bongo net, 23 May 2004; UW 144881, 1 (6.6 mm), 56°20.0′ N, 153°43.4′ W, 0–72 m depth, bongo net, 24 May 2004; UW 144882, 1 (6.9 mm), 58°27.5′ N, 153°17.0′ W, 0–100 m depth, bongo net, 1 June 2004. British Columbia, Canada: UW 145873, 8 (7.3–9.0 mm), 49°21.6′ N, 123°29.3′ W, reared, 11 March 1976. Puget Sound, Washington: UW 144895, 2 (6.1–9.0 mm), 47°34.1′ N, 122°12.3′ W, reared, 1 March 1978; UW 144891, 46 (5.2–8.0 mm), 47°20.5′ N, 122°19.4′ W, 0–10 m depth, 0.5-m net, 11 April 1989; UW 145895, 1 (13.2 mm), 48°20.0′ N, 123°8.9′ W, 0 m depth, dip net, 11 May 1989; UW 144888, 1 (14.5 mm), 48°20.0′ N, 123°8.9′ W, 0 m depth, dip net, 12 May 1989; UW 144870, 1 (13.1 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 7 June 1989; UW 144896, 1 (6.0 mm), 48°56.0′ N, 122°24.1′ W, depth and gear unknown, 25 February 1992; UW 144892, 4 (5.8–13.2 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 5 May 1992; UW 145872, 1 (14.3 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 12 May 1995; UW 144894, 1 (16.8 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 14 May 1995; UW 144890, 5 (10.3–14.6 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 21 April 1998; UW 144893, 3 (12.6–14.3 mm), 47°20.5′ N, 122°19.4′ W, 0 m depth, dip net, 26 April 1998; UW 144889, 68 (6.4–11.2 mm), 48°19.4′ N, 123°0.3′ W, 0 m depth, dip net, 5 April 2000. Oregon coast: UW 144875, 1 (20.0 mm), 45°39.9′ N, 124°1.8′ W, 0–49 m depth, bongo net, 27 April 1985.

Cebidichthys violaceus. 10 specimens (6.2–14.4 mm) examined (depths unknown). California coast: UW 144868, 1 (13.6 mm), 35°12.0′ N, 120°50.5′ W, gear unknown, 9 June 1998; UW 144863, 3 (6.2–6.7 mm), 35°12.0′ N, 120°50.5′ W, bongo net, 22 May 1999; UW 144865, 3 (9.0–10.7 mm), 35°12.0′ N, 120°50.5′ W, bongo net, 22 May 1999; UW 144866, 1 (8.6 mm), 35°12.0′ N, 120°50.5′ W, bongo net, 22 May 1999; UW 144867, 1 (10.5 mm), 35°12.0′ N, 120°50.5′ W, bongo net, 22 May 1999; UW 144869, 1 (14.4 mm), 35°12.0′ N, 120°50.5′ W, bongo net, 25 May 1999.

Other material (illustrated specimens only)

***Eumesogrammus praecisus* (tentative).** Beaufort Sea: UW 145179, 1 (10.6 mm), 71°10.2′ N, 156°8.0′ W, 45 m depth, bongo net, 13 August 2008.

***Chirolophis* cf. *snyderi*.** 2 specimens (18.5–21.0 mm) examined. Gulf of Alaska: UW 144864, 1 (21.0 mm), 57°12.1′ N, 152°44.5′ W, 0 m depth, neuston net, 24 June 1978; UW 145178, 1 (18.5 mm), 56°37.1′ N, 156°10.8′ W, 0–101 m depth, bongo net, 13 May 1993.

Acantholumpenus mackayi. Norton Sound, Alaska: UW 145177, 1 (36.5 mm), 64°26.4′ N, 163°39.5′ W, 16 m depth, bottom trawl, 26 July 2002.

***Lumpenopsis hypochroma* (tentative).** Lambert Channel, British Columbia, Canada: UW 145180, 1 (10.3 mm), 49°30.6′ N, 124°43.5′ W, reared (Vancouver Public Aquarium [VPA]), 22 April 1990.

***Alectridium aurantiacum* (tentative).** Bering Sea: UW 145871 (specimen lost), 1 (21.0 mm), 56°42.5′ N, 152°35.9′ W, 25–64 m depth, Tucker trawl, 10 July 1997.

Xiphister atropurpureus. 2 specimens (6.3–16.0 mm) examined. British Columbia, Canada: UW 145176, 1 (16.0 mm), 49°21.6′ N, 123°29.3′ W, reared (VPA), 16 May 1973. Washington coast: UW 144848, 1 (6.3 mm), 48°15.9′ N, 124°15.2′ W, reared (VPA), 15 March 1991.

***Phytichthys chirus* (tentative).** Puget Sound, Washington: UW 145181, 1 (19.0 mm), 47°33.7′ N, 122°32.1′ W, 0 m depth, dip net, 5 May 1988.