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NOAA Technical Report NMFS Circular 402

Guide to the Identification of Scorpionfish Larvae (Family Scorpaenidae) in the Eastern Pacific With Comparative Notes on Species of *Sebastes* and *Helicolenus* From Other Oceans

H. Geoffrey Moser, Elbert H. Ahlstrom, and
Elaine M. Sandknop

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ABSTRACT

Developmental stages of 51 species or forms of scorpionfishes are described and illustrated in this identification guide. Thirty-eight are from the eastern Pacific and represent six of the eight scorpaenid genera known from that region—*Sebastes, Sebastolobus, Scorpaenodes, Scorpaena, Pontinus,* and *Ectreposebastes*. *Sebastes* is the most thoroughly treated; developmental series of six species from the eastern Pacific are described and illustrated; pigment patterns of early larvae of 33 species are given and 23 of these are illustrated. Larval series of three North Atlantic species of *Sebastes* are described and illustrated as is a series of *Sebastes* from off Chile; in addition, the published information on eight northwestern Pacific species is summarized and discussed in relation to the eastern Pacific and Atlantic species. The other genera are represented by one or two species. Since larvae of the eastern Pacific species of *Helicolenus* were not available, a larval series of *H. dactylopterus* from the Atlantic are described for comparative purposes. Larvae of the eighth eastern Pacific scorpaenid genus, *Trachyscorpia*, are unknown.

Two dichotomous keys to the eastern Pacific genera are included, one for the early larval stages up to the initiation of notochord flexion and one for postflexion larvae. In the text, a summary of the literature and definitive characters is followed by the descriptive accounts of the species. Each species account contains a literature summary, description, set of illustrations, and information on distribution and abundance.

INTRODUCTION

The scorpionfishes are among the most important groups of shore fishes in the eastern Pacific. The approximately 100 species of eastern Pacific scorpionfishes are distributed among eight genera—*Sebastes, Helicolenus, Sebastolobus, Scorpaenodes, Scorpaena, Pontinus, Ectreposebastes,* and *Trachyscorpia*. About two-thirds of the species belong to the single genus, *Sebastes*, which has undergone an extensive radiation in the northeast Pacific. These rockfishes or rockcods provide important commercial and recreational fisheries; one species alone, *Sebastes alutus*, yielded 283,000 metric tons to trawlers in a single year (Gulland 1970) and, in California, rockfishes comprise one-half of the total number of sport fish taken annually by recreational anglers (Young 1969).

The abundance of *Sebastes* is reflected in their prominence in the plankton collections of the California Cooperative Oceanic Fisheries Investigations (CalCOFI). They are live-bearers and, at birth, the 4- to 5-mm larvae rise to the surface waters where they may be sampled by plankton nets (Moser 1967a, b). As a group, they usually rank third or fourth in total abundance among all larvae collected annually by the CalCOFI plankton survey (Ahlstrom 1961). The task of identifying *Sebastes* larvae to species is a difficult one because of the large species complement of the genus; however, complete larval series of some important commercial species have been described (Moser 1967a, 1972, and in this guide). The most productive technique has been to remove late-stage embryos or prenatal larvae from identified pregnant females and to raise these in the laboratory to a point where they develop their specific pattern of melanophores. These larvae can then be used to identify developmental series of larvae from plankton collections.

During the investigation of *Sebastes* larvae, considerable knowledge of the larvae of other eastern Pacific scorpaenid genera has accumulated. One of these, *Sebastolobus*, inhabits northern waters and its larvae are found commonly in CalCOFI plankton samples from the California Current. The larvae and highly distinctive juvenile stages of *S. altivelis* and *S. alascanus* have recently been described (Moser 1974). The other eastern Pacific genera are primarily tropical-subtropical in distribution, with the exception of *Helicolenus* which occurs off southern Chile. The larvae of these warm water genera (*Pontinus, Scorpaena,* and *Scorpaenodes*) are encountered in the CalCOFI collections off southern Baja California and in the Gulf of California as well as in plankton collections from expeditions such as EASTROPAC, and each has a character or group of characters which distinguishes it from all other eastern Pacific genera. The genus *Ectreposebastes* is primarily

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equatorial in distribution and the larvae of *E. imus* were taken on a few EASTROPAC stations.

It is the purpose of this paper to present information and illustrations (including keys) for the identification of the larvae of eastern Pacific scorpaenids to genus and, for each genus, to describe and illustrate the larval stages of the species for which larvae are known.

Sebastes is the most extensively treated. In addition to summaries of the earlier descriptions of *S. paucispinis* and *S. macdonaldi*, we include new descriptions of larvae of *S. jordani*, *S. levis*, *S. cortezi*, and *S.* sp. (Gulf of California Type A). Also, we describe larval series of three North Atlantic species—*S. marinus*, *S. viviparus*, and *S. fasciatus*. Our purpose in doing this is to supplement the already substantial literature on larvae of these species with heretofore unreported characters and to provide a basis for comparison of larvae of Atlantic and Pacific *Sebastes*. Larval series of a *Sebastes* from off Chile and eight species from Japan are described and illustrated to allow comparison of northeastern Pacific larvae with those from the Southern Hemisphere and western Pacific. Essentially we are treating *Sebastes* on a worldwide basis.

Since larvae of the eastern Pacific representative of *Helicolenus*, *H. lengerichi*, were not available, we include a description of the Atlantic species, *H. dactylopterus*, so that larvae of *Helicolenus* may be compared with those of other eastern Pacific genera. Many of the characters presented in this description have not been previously reported.

Larvae and juveniles of *Sebastolobus* have been thoroughly described (Moser 1974) and are briefly summarized here. The larvae of *Trachyscorpia* are unknown but if their relationships are with *Sebastolobus* as Eschmeyer (1969) suggests, then they probably will resemble the larvae of *Sebastolobus* but with lower counts of most meristics.

Life history stages of *Scorpaenodes* have not been described and we give a detailed account of larvae and early juveniles of the single eastern Pacific species, *S. xyris*. The literature contains life history accounts of three Mediterranean and North Atlantic species of *Scorpaena* and descriptions of the eggs and newly hatched larvae of a single eastern Pacific species, *S. guttata* (see literature review for the genus). We include descriptions of a complete larval series of *S. guttata* and of another *Scorpaena* not identifiable to species. Larvae of *Pontinus* have not been previously described and we describe larvae of two forms of this genus. Two larval specimens of *Ectreposebastes imus* have been briefly described (Eschmeyer and Collette 1966) and we describe a complete developmental series of this species for the first time.

Seven of the eight genera of scorpaenids that occur in the eastern Pacific also occur in the Atlantic. According to Eschmeyer (1969, 1971) who reviewed the scorpionfishes of the Atlantic Ocean, 55 of the 60 species (i.e., 92%) of Atlantic scorpaenid fishes belong to these seven genera. Since there is a strong similarity between the scorpaenid fauna of the two oceans at the generic level, the guide provides a starting point for identification of scorpaenid larvae in the tropical and subtropical Atlantic.

In addition to the genera treated in this guide, the literature contains relatively few other life history descriptions of scorpaenid fishes. We are aware of publications on only three other genera: *Pterois* (*P. lunulata*, Mito and Uchida 1958; Mito 1963), *Inimicus* (*I. japonicus*, Fujita and Nakahara 1955), and *Sebastiscus* (*S. marmoratus*, Tsukahara 1962). We are hopeful that our guide will stimulate further investigations on the developmental stages of this large and diverse family.

Relationships among the eastern Pacific genera can be shown by their groupings into subfamilies. We are following the classification presented by Matsubara (1943) and amended for the subfamily Setarchinae by Eschmeyer and Collette (1966) and Sebastolobinae by Eschmeyer (1969). The eight genera of eastern Pacific scorpaenids belong to four subfamilies, as follows:

Subfamily Sebastinae
- *Sebastes* Cuvier
- *Helicolenus* Goode and Bean

Subfamily Sebastolobinae
- *Sebastolobus* Gill
- *Trachyscorpia* Ginsburg

Subfamily Scorpaeninae
- *Scorpaenodes* Bleeker
- *Scorpaena* Linnaeus
- *Pontinus* Poey

Subfamily Setarchinae
- *Ectreposebastes* Garman

Among the primary characters for separation of adult scorpaenid fishes into subfamilies are the shape of the 2nd suborbital (3rd infraorbital) bone, whether this bone is fastened to the preopercle or remains free, and the presence or absence of 3rd and 4th suborbital bones. The suborbital sensory canal, which runs backward from the preorbital to the 2nd suborbital in all scorpaenids has a branch extending through the 3rd and 4th suborbital bones to the 5th suborbital bone in some scorpaenids. The latter branch is developed in eastern Pacific scorpaenids that retain the 3rd and 4th suborbital bones. Characters associated with the suborbital bones are summarized for the eastern Pacific genera and subfamilies in Table 1 together with meristic characters, type of reproduction, and presence or absence of a gas bladder in juveniles and adults.

MATERIALS AND METHODS

Specimens used in this study were obtained from a variety of sources. The CalCOFI plankton collections from the California Current region provided most of the larval specimens of *Sebastes* and *Sebastolobus*. CalCOFI collections from the southern end of the station pattern off Baja California and from the Gulf of California provided larvae of *Sebastes*, *Scorpaena*, *Pontinus*, and *Scorpaenodes*. Larvae of the latter three genera were also

Table 1. Characters of the four subfamilies of scorpaenid fishes in the Eastern Pacific. Counts listed are typical ones and occasionally encountered atypical counts are given in parentheses.

Subfamily	Genera	Suborbital bones 2nd	Suborbital bones 3rd	Suborbital bones 4th	Suborbital sensory canal	Gas bladder	Type of reproduction	Vertebrae	Dorsal spines	Dorsal rays*	Anal rays*	Caudal principal rays	Caudal branched rays
Sebastinae	Sebastes	Tapering to a point, not attached to preopercle	Present	Present	Has extension from 2nd suborbital to 5th suborbital	Present	Ovoviviparous, internal fertilization, larvae spawned	26-28 (E.Pac.) 29-32 (N.Atl.)	XIII-XIV (E.Pac.) XIV-XVI (N.Atl.)	11-17	III 5-11	8+7	6+6
	Helicolenus	Narrowed posteriorly, firmly attached preopercle	Present	Present	Same as above	Absent	Probably ovoviviparous but eggs in gelatinous mass	25	XII (XI-XIII)	11-13	III,5	8+7	6+5
Sebastolobinae	Sebastolobus	Rounded posteriorly, firmly attached to preopercle	Present	Present	Same as above	Absent	Oviparous eggs in gelatinous masses	28-31	XV-XVII	8-10	III (4)5	8+7	6+5
	Trachyscorpia	Not known	Present	Present	Same as above	Absent	Same as above	25-26	XII	8-9	III,5	8+7	6+6
Scorpaeninae	Scorpaena	Uniformly broad, or becoming wider posteriorly, firmly attached to preopercle	Absent	Present	Lacks extension to 5th suborbital	Absent	Oviparous eggs in gelatinous masses (Scorpaena)	24	XII	8-10	III 5(6)	8+7	6+5
	Pontinus		Absent	Present		Absent		24	XII	8-9	III 5(6)	8+7	6+5
	Scorpaenodes		Absent	Absent		Present		24-(25)	XIII	9-11	III 5(6)	8+7	6+5
Setarchinae	Ectreposebastes	Same as above	Absent	Absent	Same as above	Absent or rudimentary	Oviparous	24	XII	9-10	III 5(6)7	8+7	6+6

*Last soft ray of doral and anal fins is a double ray and is counted as a single ray.

found in plankton collections of the wide-ranging EASTROPAC expeditions (Ahlstrom 1971, 1972) and in collections from cruises of the Scripps Tuna Oceanography Research (STOR) group (Blackburn et al. 1962). Pelagic and benthic juveniles were obtained largely from ichthyological collections of the Scripps Institution of Oceanography (SIO) and the Los Angeles County Museum (LACM). Larvae and juveniles of *Sebastes marinus, S. viviparus*, and *Helicolenus dactylopterus* were obtained from the collections of the *Dana* Expeditions at the University Zoological Museum, Copenhagen. A series of *Sebastes fasciatus* larvae from the American coast between lat. 38°52'N and lat. 44°22'N were supplied by the National Marine Fisheries Service (NMFS) Laboratory at Narragansett, R.I., and a collection of intraovarian larvae from this species was obtained from the NMFS Laboratory, Woods Hole, Mass.

Methods of analyzing meristic and morphometric development follow Moser (1967a, 1972, 1974), however some of the terms used in this study require further explanation. The larval stage of teleosts can be divided naturally into three substages based on the state of development of the caudal fin. The substage beginning with the termination of the yolk-sac stage and ending with the initiation of notochord flexion we call preflexion. The substage from the initiation of notochord flexion to its completion, when the posterior edge of the hypural plate arrives at a vertical position, we term flexion. From this substage to the initiation of transformation is termed postflexion. These substages provide a practical means of comparing larval development in different taxa.

The change from larva to juvenile is termed transformation or transition. The juvenile stage may also be subdivided. Many scorpaenid species have a pelagic juvenile substage that is marked by a distinctive pigment pattern of bands and/or saddles and often by structural features such as enlarged pectoral fins. When pelagic juveniles become benthic juveniles there is usually an abrupt change in pigment pattern and morphometry (e.g., *Sebastolobus altivelis*). In species which remain pelagic for much of their juvenile stage (e.g., *Sebastes jordani*) there is no abrupt change in pigment or morphometry.

In discussing distribution and abundance we use the term standardized number of larvae. This means the absolute number of specimens per tow adjusted to the number under 10 m^2 of sea surface (Kramer et al 1972).

SUMMARY OF LARVAL CHARACTERS OF SCORPAENIDAE WITH EMPHASIS ON THOSE IMPORTANT IN IDENTIFYING GENERA

The most salient characteristic of scorpionfish larvae is their elaborate head spination. In addition to marked development of spines on the preopercle, a feature shared with many families, the larvae develop a pair of crestlike parietal ridges that terminate in a single or double spine. This parietal spination differentiates scorpaenid larvae from those of most other teleost families. Larvae of the Triglidae, a related family, also have parietal crests, but these have scalloped margins and are supported by rodlike structures. The parietal crests in scorpaenids typically have a serrate margin and have a single strengthening rod at the posterior terminus.

In *Sebastes* the paired parietal spines on top of the head develop in larvae 6.0 to 7.0 mm in length, and by the midlarval period each projects backward from a serrated parietal ridge. Later in the larval period, a smaller nuchal spine usually develops adjacent and posterior to each parietal spine. In *Sebastolobus* and *Scorpaenodes*, the nuchal spines form soon after the parietals and rapidly become larger and more prominent than the parietals. This difference in size of the nuchals relative to the parietals is especially useful in separating larvae of *Sebastes* from those of *Sebastolobus*.

Spines also form on a number of head bones in addition to the parietals, e.g., the pterotics, frontals, nasals, and circumorbitals (Moser 1972). Head spination is best developed on postflexion larvae and is a primary character in the key to postflexion larvae. Although they begin to form on late preflexion larvae, head spines are seldom differentiated enough to be used for identifying larvae to genus before flexion is completed.

As in other families, meristic characters are essential in identifying larvae of scorpionfish to genus and species. The most fundamental meristic character is the number of myomeres, since it is the earliest to appear and is equivalent to the number of vertebrae that will develop. The temperate or boreal genera (*Sebastes, Sebastolobus, Helicolenus*) have higher counts than the tropical-subtropical genera (*Scorpaena, Scorpaenodes, Pontinus, Trachyscorpia, Ectreposebastes*) as summarized in Table 2.

Characters of the fins, including numbers of spines and rays, relative size, shape, and pigmentation are indispensable in identifying scorpaenid larvae. The pectorals are the first to appear and are usually the first in which ossified rays are formed, followed by ossification of principal caudal rays, rays and spines in the pelvics, dorsal and anal fins, and finally procurrent caudal rays. Ossified rays begin to form in the pectoral fins prior to notochord flexion; they form sequentially from the dorsal to the ventral margin. The 15 principal caudal rays and pelvic rays (I, 5) form during flexion, whereas the dorsal, anal, and procurrent caudal rays begin to ossify during late flexion and early postflexion stages. The complete complement of pectoral rays forms within a 3-mm size range whereas the pelvic, dorsal, and anal fins form within a 2-mm size range; only the formation of procurrent caudal rays is extended over a greater range of length.

The number of pectoral rays is not particularly useful in distinguishing among most genera of scorpaenids. Most genera dealt with in this report have 16 to 20 rays. The only striking exceptions are one species of *Sebastolobus* with 21 to 24 rays and *Trachyscorpia* with about 22 to 23 rays.

The size, shape, and pigment pattern of the pectoral fins are useful in distinguishing among genera and species of scorpaenids (see key to genera for postflexion larvae). Especially useful is the depth of the fin base, which is narrowest in *Sebastes*, widest in *Ectreposebastes*, and of intermediate depths in the other five genera. Values for this previously unutilized character are summarized by species and stage of development in Table 3.

There is a marked range in the proportional size of the pectoral fin among the genera included in this study. Larvae of *Ectreposebastes* have huge fan-shaped pectorals which extend posteriad to the base of the caudal fin; they increase in relative length during development to a maximum of one-half the body length (Table 3). The fan-shaped pectorals in *Scorpaenodes* are only slightly smaller than in *Ectreposebastes*, attaining a maximum of 45% of the body length. The pectorals in *Sebastolobus* and *Pontinus* are moderately large but differ strikingly in shape, being fan-shaped in the former and aliform in the latter. In *Scorpaena* they are fan-shaped and moderate in

Table 2. Meristics for scorpaenids included in this guide.

	Vertebrae	Dorsal Spinous Rays	Dorsal Soft Rays	Anal Soft Rays	Pectoral Rays	Caudal Rays: Principal	Caudal Rays: Branched	Procurrent: Sup.	Procurrent: Inf.
Sebastes jordani	27	XIII	13-16	8-11	19-22	8+7	6+6	13-14	13-14
" levis	26	XIII	12-13	6-7	17-18	8+7	6+6	11	11
" macdonaldi	26	XIII	13-14	7-8	18-20	8+7	6+6	13-14	13-14
" paucispinis	26	XIII	13-15	8-10	15-16	8+7	6+6	12-13	12-14
Sebastes cortezi	26	XIII	11-12	5-6	17-19	8+7	6+5	10-11	11-12
" capensis	26	XIII	12-14	5-6	18-20	8+7	6+6	?	?
Sebastes marinus	30-32	XIV-XVI	12-15	7-9	18-20	8+7	6+6	11-12	11-12
" viviparus	29-31	XIV-XVI	13-14	6-8	17-19	8+7	6+6	?	?
" fasciatus	30-31	XIV-XVI	12-15	6-8	17-20	8+7	6+6	?	?
Helicolenus dactylopterus	25	XII	11-13	5	17-20	8+7	6+5	11	10-12
Sebastolobus alascanus	30-31	XV-XVII	9-10	(4)5	21-22	8+7	6+5	8-10	8-9
" altivelis	28-29	XV-XVI	8-10	5	22-24	8+7	6+5	6-8	7-8
Trachyscorpia sp.	25	XII	9	5	22-23	8+7	6+6	5	6
Pontinus Type A	24	XII	8-9	5(6)	18-19	8+7	6+5	6	6-7
" Type B	24	XII	9	5	17-19	8+7	6+5	5-7	5-7
Scorpaena guttata	24	XII	8-10	5-6	17-19	8+7	6+5	6-8	7-9
" Type A	24	XII	8	5	19-20	8+7	6+5	5	5
Scorpaenodes xyris	24-25	XIII	9-11	5-6	16-19	8+7	6+5	4-5	4-5
Ectreposebastes imus	24	XII	9-10	5-7	18-20	8+7	6+6	6-7	6-7

Table 3. Depth of pectoral fin base and length of pectoral fin relative to body length for larvae of seven scorpaenid genera, expressed as mean percentage and range for three larval stages.

Species	Number specimens	Depth of pectoral fin base						Length of pectoral fin					
		Preflexion		Flexion		Postflexion		Preflexion		Flexion		Postflexion	
		x̄	range	x̄	range	x̄	range	x̄	range	x̄	range	x̄	range
Sebastes paucispinis	21	9.0	8-10	9.0	8-10	7.2	5- 8	16.4	11-21	27.2	25-31	35.5	34-37
macdonaldi	26	-	-	-	-	-	-	8.4	6-10	13.0	12-15	19.3	15-26
jordani	23	6.7	6- 7	7.8	7- 8	7.8	7- 9	6.6	6- 7	8.4	7-10	14.7	11-20
levis	12	8.0	-	12.8	12-14	11.7	11-12	9.0	-	34.9	24-46	43.3	41-45
cortezi	17	9.0	7-10	11.8	11-12	10.8	10-12	8.2	7- 9	10.6	9-12	17.5	11-21
Gulf Type A	13	7.8	5- 9	12.3	11-13	12.8	11-14	8.7	6-10	13.3	11-16	16.8	14-20
capensis	8	14.7	8-13	14.0	12-16	12.7	10-17	10.0	9-11	15.5	12-19	23.7	18-27
marinus	22	6.7	4- 8	8.2	8- 9	8.3	7- 9	6.0	3- 7	9.9	8-13	16.8	14-19
viviparus	14	7.5	6- 9	9.6	8-11	-	-	7.3	6- 9	9.9	8-12	-	-
fasciatus	14	6.8	6- 9	8.7	8- 9	8.7	8- 9	6.2	6- 7	8.0	6-10	15.3	13-18
Sebastolobus alascanus	40	11.0	6-15	15.8	13-19	14.4	13-16	12.7	7-17	22.2	19-25	29.0	26-31
altivelis	48	11.0	6-15	15.8	13-19	18.3	15-20	12.7	7-17	22.2	19-25	35.0	28-39
Helicolenus dactylopterus	16	11.0	9-12	12.5	12-13	12.4	10-14	11.4	11-12	14.8	13-16	18.0	16-20
Scorpaenodes xyris	36	15.0	8-18	18.7	17-20	18.0	16-21	22.2	10-28	34.2	29-41	39.0	36-45
Scorpaena guttata	16	13.8	8-16	16.0	15-17	15.9	14-17	15.4	7-22	20.8	19-22	21.7	18-23
Type A	18	13.8	12-15	14.6	13-16	17.3	16-18	12.2	10-15	16.2	15-18	20.7	19-23
Pontinus Type A	22	15.3	15-16	15.5	15-16	14.3	12-16	20.4	18-19	26.5	26-27	30.7	27-36
Type B	4	-	-	17.5	17-18	16.0	14-18	-	-	33.5	33-34	27.0	24-30
Ectreposebastes imus	12	20.4	19-22	22.0	-	21.0	19-22	32.6	24-38	38.0	-	44.4	37-49

relative length and in *Helicolenus* they are small and rounded. In *Sebastes* there is a great variety in relative size and shape among the numerous species. Also, different species attain maximum relative pectoral length at different developmental stages (Table 3).

Patterns of melanistic pigmentation on the pectorals are useful in identifying larvae to genus and species as demonstrated in the key to preflexion larvae. The patterns are too diverse to be summarized here and are best treated in the succeeding sections.

Anal fin ray counts are not of particular value in distinguishing among most genera of scorpaenids. The usual anal fin count is III, 5 (occasionally III, 4 or III, 6) in *Sebastolobus*, *Trachyscorpia*, *Helicolenus*, *Scorpaenodes*, *Scorpaena*, and *Pontinus*. In *Ectreposebastes* the count is typically III, 6 with a range of 5 to 7 rays. The number of anal rays has a greater range among species of *Sebastes*. The typical counts for eastern North Pacific species of *Sebastes* are III, 6 and 7, however some species have slightly higher ray counts and *S. jordani* has III, 8 to 11 anal rays. The second of the three anal spines is usually longer than the third and heavier in juvenile and adult specimens. It should be noted that the third anal spine is late in differentiating. When first formed in larvae, it has the appearance of a soft ray. It is not ossified as a spine until the early juvenile stage; however, we have designated the third element in the anal fin as a spine in all of our counts of larvae. The change in the third anal element to a spine is gradual. Even in a cleared and stained series it is sometimes difficult to determine just when it becomes a spine; however, the total count of spines plus rays in the anal fin remains constant. For example, whether the anal count for larvae of *Sebastolobus* is given as II, 6 or III, 5, the total count remains 8. An identical problem with regard to the change-over of the third element of the anal fin from a ray to a spine is encountered in larvae of *Mugil* (Anderson 1957, 1958), and striped bass, *Morone saxatilis* (Mansueti 1958). The anterior two spines of the anal fin are supported in secondary association by a single massive, elongated pterygiophore, possibly the product of the fusion of the first two; the remaining anal spine and the anal rays are each supported by a pterygiophore and are in secondary association with the following pterygiophore (except the last ray). The pterygiophore count is two less than the total count of anal spines and rays.

The number of dorsal fin spines is a particularly useful character (Table 2). The commonest count is XII, found in *Scorpaena*, *Pontinus*, *Helicolenus*, *Trachyscorpia*, and *Ectreposebastes*. Species of *Sebastes* in the eastern North Pacific normally have XIII dorsal spines, as does *Scorpaenodes*. North Atlantic species of *Sebastes* have XIV to XVI dorsal spines, whereas *Sebastolobus* has XV to XVII. The number of dorsal soft rays is usually 9 (8 to 10) in *Sebastolobus*, *Trachyscorpia*, *Scorpaena*, *Pontinus*, *Ectreposebastes*, and *Scorpaenodes*, 11 to 13 in *Helicolenus*, and 11 to 16 in *Sebastes*. The total number of dorsal fin rays and spines is 20 to 22 in *Pontinus*, *Trachyscorpia*, and *Scorpaena*, 21 or 22 in *Ectreposebastes*, 22 to 24 in *Scorpaenodes*, 23 to 25 in *Sebastolobus*, and 24 to 31 in *Sebastes*.

The last spine in the dorsal fin of all the above scorpaenids appears first as a soft-ray and later ossifies as a spine, just as in the third spine of the anal fin. The anterior two spines of the dorsal fin are supported in secondary association by a single wide (fused) pterygiophore. In eastern Pacific scorpaenids this pterygiophore lies between neural spines two and three and is always accompanied in this space by a second pterygiophore, which carries a single spine (the third). The succeeding several pterygiophores alternate one on one with neural spines. The first and second neural spines lie close together and often point forward, in contrast to the divergent angle between neural spines two and three necessary to accommodate the anterior two pterygiophores. In several genera a single, short predorsal bone was observed immediately before the first neural spine; this bone is more readily seen on cleared and stained specimens than on radiographs.

The number of principle caudal rays (those supported by hypurals and the parhypural according to our definition) in most scorpaenid fishes is 8 + 7 = 15. The number of branched rays is either 6 + 6 (*Sebastes*, *Ectreposebastes*) or 6 + 5 (*Sebastolobus*, *Helicolenus*, *Scorpaenodes*, *Scorpaena*, *Pontinus*). Hence in these scorpaenid genera there are two unbranched principal rays associated with the upper lobe of the caudal fin, and either one or two associated with the lower lobe—one unbranched if the branched ray count of the lower lobe is six, two unbranched if the branched ray count is five. The principal rays of both lobes of the caudal fin are supported exclusively by hypural bones (we include the parhypural as a hypural). The primitive condition, which we have observed in *Ectreposebastes imus*, is the retention of three superior and three inferior hypurals (including the parhypural). Among the genera included in this guide, *Scorpaenodes* and *Pontinus* retain the primitive complement of three superior hypurals, but have the inferior complement reduced to two. In the other four genera there are two superior and two inferior hypurals. The primitive complement of three epurals is retained by all scorpaenids studied. Only one pair of uroneurals was observed on specimens examined. The neural spine on the vertebral centra immediately anterior to the ural is markedly reduced or lacking. The haemal spine on this vertebra is autogenous, as is the haemal spine on the vertebra immediately anteriad.

Since changes in body shape during larval development are illustrated and are emphasized in the descriptions, we will discuss them only briefly here. Newly hatched larvae of all scorpaenids studied are more slender, often markedly more slender, than are later larval stages. Larvae of *Sebastes* and *Helicolenus* are usually more slender in later larval stages than are those of the other genera. The eastern Pacific *Sebastes* with the slenderest body is *S. jordani*; in postflexion larvae the average relative body depth is less than 25% standard length (range of 22 to 26%). Relative body depth for postflexion larvae of other species ranges from 30 to 37%. Average relative body depth for postflexion specimens in the other genera is as follows: *Sebastolobus*, 35 and 41% for its two species; *Scorpaenodes*, 39%; *Scorpaena*, 38 to 40% for two species; *Pontinus*, 39 and 42% for two species; and *Ectreposebastes* up to 55%.

A knowledge of the sizes at initiation of major developmental events such as hatching, notochord flexion, and transformation aids in identifying scorpaenid larvae. There is a major dichotomy between *Sebastes* and the other genera in the size at hatching—*Sebastes* hatches at 3.8 to 7.5 mm body length and the other genera hatch at 1.8 to 2.8 mm (Table 4). *Sebastes* larvae are also longer at notochord flexion (6 to 12 mm) than the tropical genera *Scorpaenodes*, *Scorpaena*, *Pontinus*, and *Ectreposebastes* (4 to 6 mm) and the other temperate-boreal genera, *Sebastolobus* and *Helicolenus*, are intermediate (6 to 8 mm). Size at transformation from larva to pelagic juvenile is highly variable among genera and species of scorpaenids (Table 4).

Also essential for identification of scorpaenid larvae is the locality of collection. Three of the seven genera dealt with here are cold-water forms, temperate to subarctic in distribution (*Sebastes*, *Sebastolobus*, and *Helicolenus*) and the other four genera are tropical to subtropical. *Trachyscorpia* will probably be shown to occur only in the deep coastal waters of the southeast Pacific. The single known specimen was taken from 580 to 600 m (Chirichigno 1974) and listed as *Trachyscorpia* sp.

Over much of the California Current (CalCOFI) area, the genera that commonly cooccur are *Sebastes* and *Sebastolobus*. Although adults of *Sebastolobus* have been taken as far south as Cape San Lucas, *Sebastolobus* larvae are seldom taken south of California (Moser 1974). Larvae of some species of *Sebastes* (e.g., *S. macdonaldi*) are distributed primarily off Baja California (Moser 1972), but larvae of most species of *Sebastes* have a more northern distribution.

In the area covered on EASTROPAC and STOR cruises, between lat. 20°N and lat. 20°S, the larvae commonly taken are those of *Pontinus* and *Scorpaenodes*, with larvae of *Scorpaena* collected occasionally and larvae of *Ectreposebastes* found in equatorial waters as far offshore as long. 126°W. To the south of the EASTROPAC area, three temperate genera (*Helicolenus*, *Sebastes*, and *Trachyscorpia*) occur. Larvae of *Scorpaena guttata* are occasionally taken off southern California and occur along Baja California south to Magdalena Bay, hence cooccur commonly with *Sebastes* larvae. Lar-

Table 4. Length (mm) at hatching, notochord flexion, transformation into pelagic juveniles, and known lengths of pelagic juveniles of scorpaenid fishes included in this guide.

Species	Length at hatching or birth	Length at flexion	Length at transformation	Length of pelagic juveniles
Sebastes paucispinis	4.6	7.2- 9.7	15	15-34
macdonaldi	4.0-5.0	7.7- 9.0	15	15-44
jordani	5.4	8.0-10.0	27-30	30-63
levis	5.0	7.6-10.4	19	19-58
cortezi	4.1	7.0- 8.3	ca 17	-
Gulf Type A	4.2	7.0- 7.6	-	-
capensis	3.8	6.2- 7.0	20	-
marinus	6.7-7.2	8.5-11.8	ca 24	24-52
viviparus	5.4-5.8	7.8-10.6	-	-
fasciatus	5.8	8.5-10.0	-	-
Sebastolobus alascanus	2.6	6.0- 7.3	14-20	20-27
altivelis	2.6	6.0- 7.3	14-20	20-56
Helicolenus dactylopterus	<2.8	6.0- 7.9	-	-
Scorpaenodes xyris	1.8	4.0- 5.4	11-14	-
Scorpaena guttata	1.9-2.0	4.5- 5.7	-	-
Type A	<2.2	4.0- 5.5	-	-
Pontinus Type A	<2.3	4.1- 4.6	ca 15	15-27
Type B	-	<5.0- 5.5	ca 10	10-23
Ectreposebastes imus	<2.8	5.5	ca 28	-

vae of *Pontinus* and *Scorpaenodes* have only occasionally been taken off Baja California and as far north as the vicinity of Cedros Island. The larvae of four genera may cooccur in the Gulf of California—*Scorpaena, Scorpaenodes, Pontinus,* and *Sebastes*. Larvae of *Sebastes* and *Scorpaena* are taken commonly in the upper and middle Gulf, whereas larvae of *Pontinus* and *Scorpaenodes* are taken in the middle and lower Gulf; however, there is a broad area of overlap of the four genera in the Gulf.

Larvae of scorpaenids are commonly taken at considerable distance from shore. In the CalCOFI area, larvae are taken as far offshore as 500 km, and on EASTROPAC cruises even further offshore. Scorpaenid larvae that are taken at considerable distances offshore often belong to species that have an extended pelagic juvenile stage. A prime example is *Sebastolobus altivelis*, which spend about 20 mo in the pelagic environment from spawning to settling and attain a length of up to 56 mm as pelagic juveniles (Moser 1974). Another example is *Pontinus* Type A, the common form in the EASTROPAC area. The larvae grow to about 15 mm before transforming to pelagic juveniles, which then attain lengths up to 27.4 mm. There apparently is a large size range over which juveniles of *Pontinus* Type A become demersal, since bottom-caught specimens as small as 17.2 mm are present in collections. This may be related to the extensive offshore distribution observed for this scorpaenid, with nearshore individuals settling out first.

KEYS TO LARVAE OF EASTERN PACIFIC SCORPAENID GENERA

The most obvious feature of the larval period of marine fishes is change. Changes in form and pigmentation from hatching to transformation into the juvenile stage range from substantial to spectacular. Because of this it is impossible to write a dichotomous key that would allow identification of a species or genus of scorpaenid during all phases of its early life history. To overcome this we have constructed two keys, one for larvae which have not undergone notochord flexion and have not formed median fins and the other for larvae which have completed notochord flexion. The characters used in these keys are summarized in the preceding section and discussed in detail in the generic and species accounts. Since larvae of the eastern Pacific species of *Helicolenus* and *Trachyscorpia* were not available to us we have omitted these genera from the keys.

Key to Early Preflexion Larvae of Eastern Pacific Scorpaenid Genera[2]

1a. Melanophores on tail portion of body restricted to two large opposing blotches on dorsal and ventral margins, sometimes expanded to a solid band . . . . *Sebastolobus*
1b. Melanophores on tail along ventral midline only, or along dorsal and ventral midline, but each series contains a number of discrete melanophores 2
2a. Series of both dorsal and ventral margin melanophores developed on tail . . . . *Sebastes* (some spp.)
2b. Only ventral margin melanophores series on tail 3
3a. Melanistic shield of pigment covering dorsolateral surface of gut 4
3b. No melanistic shield covering dorsolateral surface of gut; pigment restricted to deeply embedded blotch 5
4a. Larvae 2.0 to 3.0 mm at hatching, 24 myomeres, voluminous finfold . . . . . . *Scorpaena*
4b. Larvae 4.0 to 6.0 mm at hatching, 26 or 27 myomeres, moderate finfold . . .*Sebastes* (some spp.)
5a. Melanophores on pectoral fins restricted to distal margin of fin . . . .*Scorpaenodes*
5b. Melanophores on pectoral fins distributed over entire blade of fin 6
6a. Depth of pectoral fin base 18 to 22% of body length . . . . *Ectreposebastes*
6b. Depth of pectoral fin base 15 to 16% of body length . . . . *Pontinus*

Key to Postflexion Larvae of Eastern Pacific Scorpaenid Genera[3]

1a. Parietal ridge bifurcate posteriorly, with posterior (nuchal) spine large 2
1b. Parietal ridge ending in single spine (parietal) or if two spines are present the second (nuchal) is small and positioned basally . . . 3
2a. Myomeres, 29-31; dorsal spines, XIV-XVII . . . . *Sebastolobus*
2b. Myomeres, 24 or 25; dorsal spines, XIII . . . . *Scorpaenodes*
3a. Myomeres, 26 or 27; dorsal spines XIII . . . *Sebastes*
3b. Myomeres, 24; dorsal spines, XII 4
4a. Depth of pectoral fin base, 19 to 22% of body length . . . . *Ectreposebastes*
4b. Depth of pectoral fin base 8 to 18% of body length 5
5a. Pectoral fins wing-shaped . . . . *Pontinus*
5b. Pectoral fins with rounded posterior margin . . . . *Scorpaena*

DESCRIPTION OF LIFE HISTORY SERIES

Of the 19 life history series included in this guide, 11 have not appeared previously in the literature or have appeared as fragmentary accounts. These are *Sebastes jordani, S. levis, S. cortezi, S.* sp. (Gulf of California,

[2]Not included is *Helicolenus* from the southeastern Pacific which probably would key to couplet 4a based on the Atlantic species and *Trachyscorpia* which might key to 1a.

[3]*Trachyscorpia* probably would key to couplet 1a and *Helicolenus* to 5b.

Type A), *S. capensis*(?), *Scorpaenodes xyris*, *Scorpaena guttata*, *Scorpaena* Type A, *Pontinus* Type A, *Pontinus* Type B, and *Ectreposebastes imus*.

For each genus there is a summary of the literature and a section in which the distinguishing features of the larvae and early juveniles are summarized and compared with related genera. Our format for the species descriptions consists of a literature summary, a section entitled distinguishing features which contains the body of the description, and a description on distribution. Where there was adequate material, new descriptions are given in more detail than are those which have appeared in the literature previously. Morphometric tables and illustrations of developmental stages are included for all species. Meristic tables were prepared for only eight of the series: *Sebastes paucispinis*, *S. macdonaldi*, *S. jordani*, *Sebastolobus altivelis*, *S. alascanus*, *Scorpaenodes xyris*, *Pontinus* Type A, and *Pontinus* Type B. For the others, there were either too few specimens to sacrifice for staining or most of the specimens were leached of calcium and would not stain. Where there is no meristic table, data on fin counts are given in the distinguishing features section.

Sebastes Cuvier

Literature.—Larvae of the genus *Sebastes* are the best known of all scorpaenid genera although descriptions of only a few species have been published. Planktonic larval stages of the North Atlantic redfish, *Sebastes marinus*, were first described and illustrated by Collett (1880). This was followed by other descriptions and illustrations of intraovarian stages (Ryder 1886; Williamson 1911; Goodchild 1924; Lüling 1951; Templeman and Sandeman 1959) and planktonic stages (Dannevig 1919; Jensen 1922; Bigelow and Welsh 1925; Einarsson 1960; Tåning 1961) of that species. The taxonomy of North Atlantic *Sebastes* has long been in a state of confusion and it is likely that some of the early larval descriptions are referable to species other than *S. marinus*. Templeman and Sandeman (1959) reviewed these papers and attempted to correct the mistakes of the earlier workers. In the papers by Einarsson (1960) and Tåning (1961), the larvae of the smaller North Atlantic species, *Sebastes viviparus*, were described, illustrated, and compared with those of *S. marinus*.

Eigenmann (1892) was the first to describe the intraovarian larvae of a species of *Sebastes* from the North Pacific, *S. rubrivinctus*, and this was followed by descriptions and illustrations of intraovarian larvae of other northeastern Pacific species (Wales 1952; Morris 1956; DeLacy et al. 1964; Ahlstrom 1965; Moser 1967a, 1972; Waldron 1968; Efremenko and Lisovenko 1970; Westrheim 1975). Complete planktonic larval series of only 2 of the 65 northeastern Pacific species of *Sebastes*, *S. paucispinis* and *S. macdonaldi*, have been described and illustrated (Moser 1967a, 1972).

Larvae of the less speciose sebastine fauna off Japan have been described by a number of investigators. Fujita (1957, 1958) raised two species, *S. pachycephalus nigricans* and *S. oblongus*, in aquaria up to the stage of fin formation. Shiokawa and Tsukahara (1961) raised *S. pachycephalus pachycephalus* from egg to juvenile, the only time that a species of *Sebastes* has been raised through transformation. Planktonic larval series of two other Japanese species, *S. hubbsi* and *S. inermis*, have been described by Uchida et al. (1958) and Harada (1962), respectively. Takai and Fukunaga (1971) described the larval development of *S. longispinis*, and recently Sasaki (1974) has described preextrusion larvae of *S. schlegeli*, *S. steindachneri*, and *S. taczanowskii*.

Distinguishing features.—Despite the large species complement and resulting variety in larval form and pigmentation, there is a group of characters that allow *Sebastes* larvae to be distinguished from those of the other eastern Pacific genera.

In the earliest stages of larval development, there is a marked dichotomy in size between *Sebastes* and the other genera. At birth, *Sebastes* larvae are 3.8 to 7.5 mm long, have utilized all or most of their yolk, and have well-developed eyes and jaws. Where it is known, embryonic development of the other eastern Pacific genera occurs in floating egg masses and, at hatching, the larvae are 2.0 to 3.0 mm long, have large elliptical yolk sacs, poorly developed eyes and jaws, and a voluminous finfold that has an inflated appearance. Development is more advanced in relation to body length in these genera compared with *Sebastes*. For example, the size at initiation of notochord flexion ranges from 6.2 to 8.5 mm (mean of 7.5 ± 0.72 SD) for 10 species of *Sebastes* studied and at completion of flexion ranges from 7.0 to 11.8 mm (mean of 9.5 ± 1.39). Comparative sizes for the other genera are 4.0 to 6.0 mm (mean of 4.8 ± 0.97) at initiation of flexion and 4.5 to 7.9 mm (mean of 6.1 ± 1.32) at completion of flexion.

The extent and pattern of melanistic pigmentation is useful in distinguishing *Sebastes* larvae from those of other eastern Pacific genera. Intraovarian embryos develop a shield of melanophores over the dorsolateral surface of the gut and a series of melanophores along the ventral midline of the tail. Almost half of the known species also develop a series of melanophores along the dorsal midline of the tail before hatching. Melanophores may be added to the tail series after hatching, but the length, anteroposterior position, and number of constituent melanophores of these rows are usually stabilized at the completion of yolk absorption (Table 5). This combination of characters may be diagnostic for a particular species but, usually, species identification requires supplementary characters such as the pattern of melanophores on the pectoral fins and the presence or absence of melanophores on the lower jaw, brain lobes, and nape.

Larvae of *Sebastolobus* can be separated from *Sebastes* on the basis of the tail pigment described above. Early *Sebastolobus* larvae have two large melanistic blotches midway along the tail, which disap-

Table 5. Mean number and range of midline melanophores on tail portion of body of 33 species of Sebastes. All larvae were collected from identified pregnant females.

Species of Sebastes	Number of specimens examined	Ventral row		Dorsal row	
		x̄	range	x̄	range
melanostomus	27	8	4-11	0	0
macdonaldi	60	8	6-14	0	0
paucispinis	20	9	6-14	0	0
flavidus	20	10	8-12	0	0
ensifer	20	11	8-17	0	0
miniatus	40	11	8-18	0	0
eos	20	12	8-14	0	0
wilsoni	20	12	9-15	0	0
rosaceus	20	12	8-14	0	0
chlorostictus	20	13	11-14	0	0
rosenblatti	14	14	11-16	0	0
constellatus	20	14	11-17	0	0
serranoides	3	14	12-15	0	0
elongatus	20	17	12-19	0	0
diploproa	20	17	13-20	0	0
levis	20	17	13-22	0	0
brevispinis	20	18	15-23	0	0
serriceps	27	19	15-24	0	0
goodei	11	20	18-24	0	0
umbrosus	20	22	17-29	0	0
rufus	20	9	5-13	1	0-3
ovalis	20	12	10-15	15	12-18
marinus	18	18	11-24	13	8-21
jordani	18	24	21-27	19	13-28
hopkinsi	20	26	22-31	13	9-18
dallii	20	29	25-34	12	8-17
caurinus	20	42	35-58	14	9-18
saxicola	20	43	34-55	10	7-16
gilli	20	46	32-69	8	3-13
semicinctus	20	50	40-63	20	15-23
auriculatus	20	52	39-63	25	15-31
carnatus	20	55	49-63	16	11-23
maliger	20	63	54-69	13	8-19

pear in larvae 5.0 to 6.5 mm long. The warm-water genera, *Ectreposebastes, Pontinus, Scorpaena*, and *Scorpaenodes*, develop a row of about a dozen melanophores on the ventral midline of the tail in very small larvae but these are lost before the completion of notochord flexion. The dorsal midline row that forms on some species of *Sebastes* never appears on the larvae of these genera.

Late-stage larvae of *Sebastes* can be differentiated from those of other eastern Pacific genera on the basis of meristic characters. Eastern Pacific species, with a single exception, normally have 26 vertebrae and 13 spinous dorsal rays. The exception, *S. polyspinis*, has 28 vertebrae and 14 spines. *Sebastolobus* has higher counts (29 to 31 vertebrae and 15 to 17 dorsal spines) and the warm-water genera have lower counts (24 vertebrae and 12 dorsal spines). The only departure from this generalization is *Scorpaenodes* which, like *Sebastes*, has 13 dorsal spines.

Of the 69 known eastern Pacific species, complete developmental series, from newborn larvae to juvenile, are described only for *S. paucispinis* (Moser 1967a) and *S. macdonaldi* (Moser 1972), however, intraovarian and newborn larvae have been described and/or illustrated for a total of 39 eastern Pacific species. This paper contains illustrated descriptions of *S. paucispinis, S. macdonaldi, S. jordani, S. levis*, and two larval forms from the Gulf of California. Also presented are illustrations of pre- or postextrusion larvae of 23 other eastern Pacific species (Figs. 1-4). For comparative purposes, brief illustrated descriptions of *Sebastes* larvae from other regions are also given. These include eight Japanese species, a larval form from off Chile (probably *S. capensis*), and three species from the North Atlantic. Research on the larvae of the latter group is problematic because of the taxonomic confusion that surrounds the adults. Adults of the widely distributed redfish, *S. marinus*, are readily distinguished from those of *S. viviparus*, the diminutive shallow-water form of the northern European coast. The problem has been whether the deep-water "mentella" form, which cooccurs geographically with *S. marinus*, is specifically distinct from *S. marinus* and whether the "American" form is a distinct species. The work of Barsukov (1968, 1972) and Barsukov and Zakharov (1972) indicates that *S. marinus, S. mentella*, and the "American" form, *S. fasciatus*, are distinct species, making a total of at least four species in the North Atlantic. Eschmeyer's systematic review of North Atlantic redfishes (in progress, cited in Hallacher 1974) confirms this.

Sebastes paucispinis (Ayres), Figure 5

Literature.—Newly hatched larvae of the bocaccio, *S. paucispinis*, were illustrated by Morris (1956) and larval stages up to 12 mm were illustrated in Ahlstrom (1965). A complete description of the development of embryos, larvae, and juveniles was given by Moser (1967a).

Distinguishing features.—Bocaccio larvae hatch and are extruded at a length of 4.0 to 5.0 mm. Beginning at about 15 mm they undergo certain changes (e.g., diminution of parietal and preopercular spines and development of dorsal pigment saddles) that mark the beginning of the pelagic juvenile stage. Transformation into demersal juveniles occurs at 30 to 35 mm in length.

The larvae are comparatively slender. Body depth at the base of the pectoral fin averaged 20% of the body length before notochord flexion, 23% during flexion, and 30% in larvae which have completed notochord flexion (Table 6). They develop the complement of head spines typical for all species of *Sebastes* (Moser 1967a).

The most distinct morphological features of bocaccio larvae are the elongate paired fins. The pectorals begin to elongate and become aliform soon after hatching. They reach a maximum relative length of about 37% of the body length in larvae about 13 mm long. They gradually diminish in relative length during the remainder of the larval and pelagic juvenile stages and are 25% of the body length in late pelagic juveniles. Ossification of the rays begins in 6-mm larvae and the unusually small adult

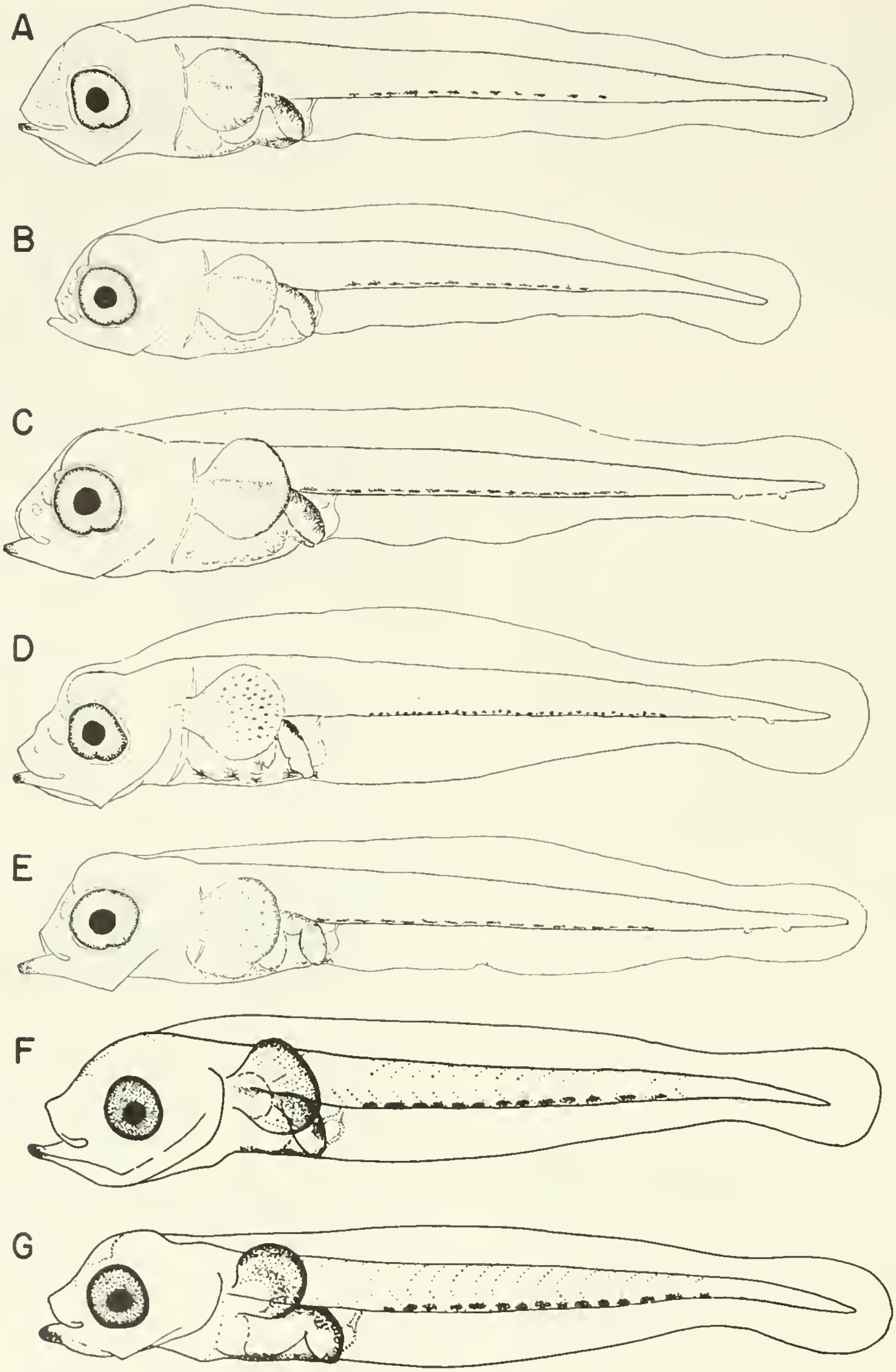

Figure 1.—Larvae of *Sebastes* (subgenus *Sebastomus*) removed from pregnant females and cultured to the point of yolk exhaustion. A. *S. constellatus*, 4.2 mm; B. *S. rosaceus*, 3.9 mm; C. *S. ensifer*, 4.2 mm; D. *S. umbrosus*, 4.2 mm; E. *S. chlorostictus*, 4.2 mm; F. *S. rosenblatti*, 4.6 mm; G. *S. eos*, 4.4 mm.

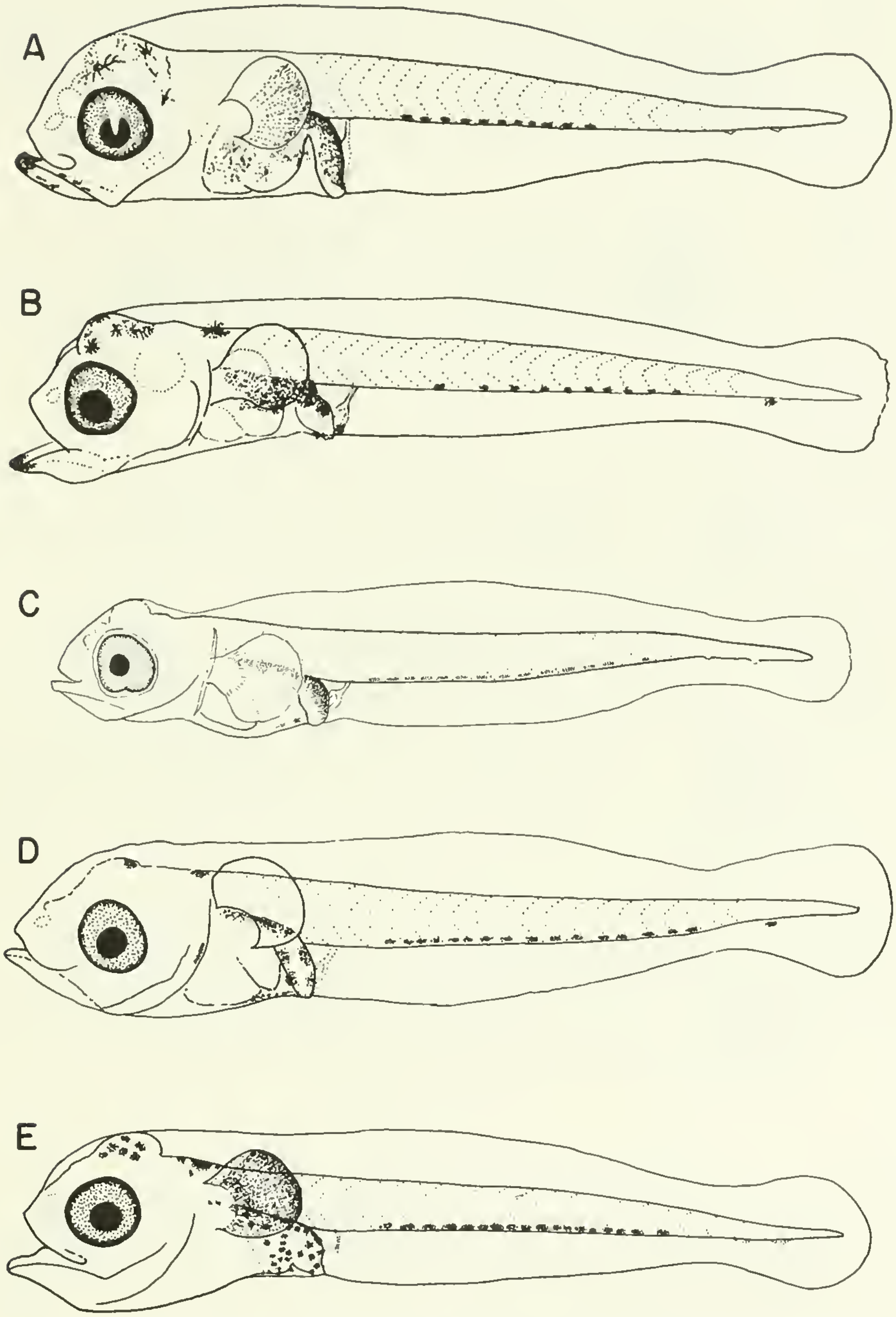

Figure 2.—Larvae of *Sebastes* at stage of yolk exhaustion. A. *S. melanostomus*, 4.4 mm; B. *S. miniatus*, 4.3 mm; C. *S. elongatus*, 4.9 mm; D. *S. serriceps*, 4.8 mm; E. *S. goodei*, 5.8 mm.

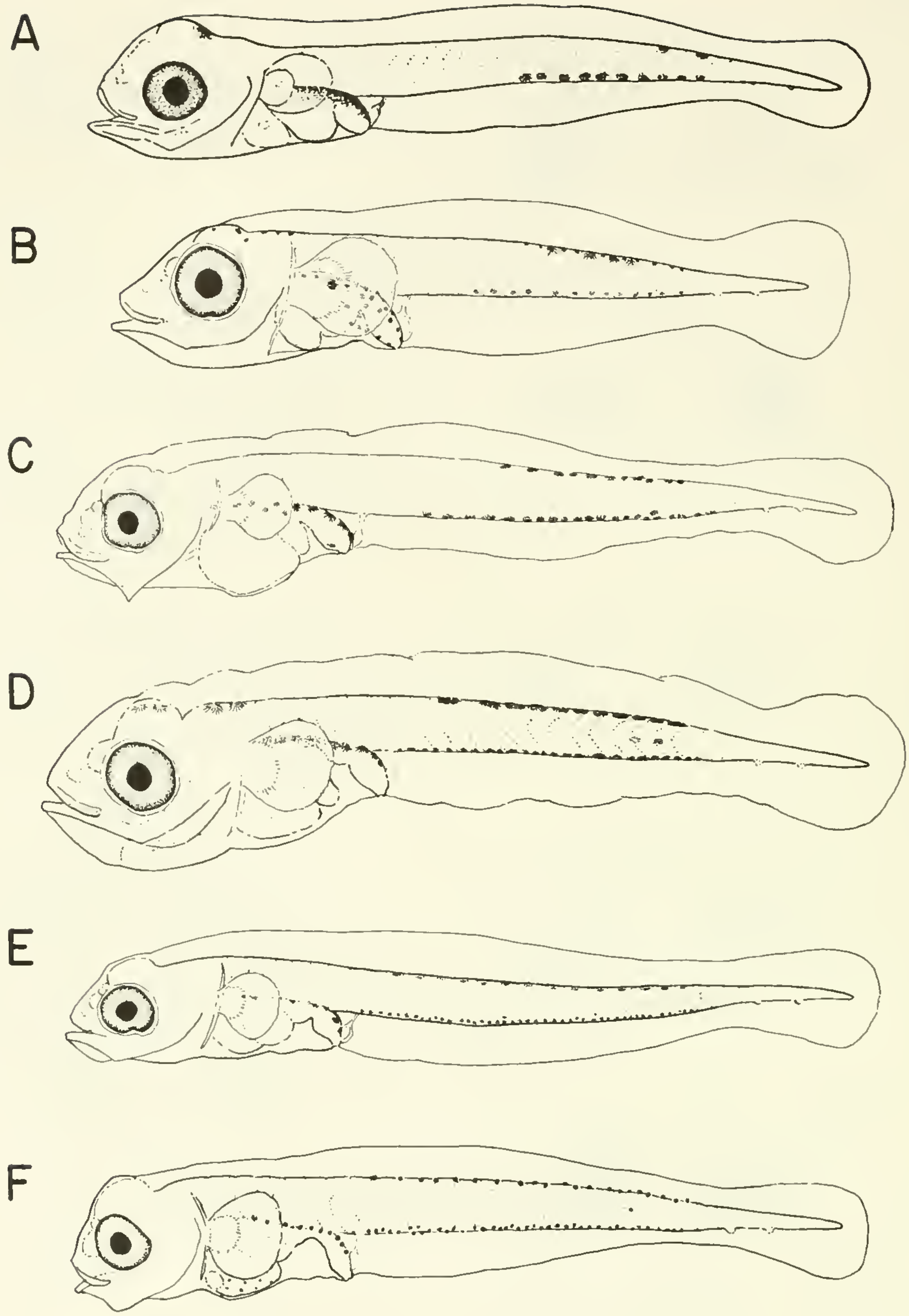

Figure 3.—Larvae of Sebastes at stage of yolk exhaustion. A. *S. rufus*, 5.3 mm; B. *S. ovalis*, 4.5 mm; C. *S. hopkinsi*, 4.7 mm; D. *S. dallii*, 4.9 mm; E. *S. semicinctus*, 5.5 mm; F. *S. carnatus*, 4.6 mm.

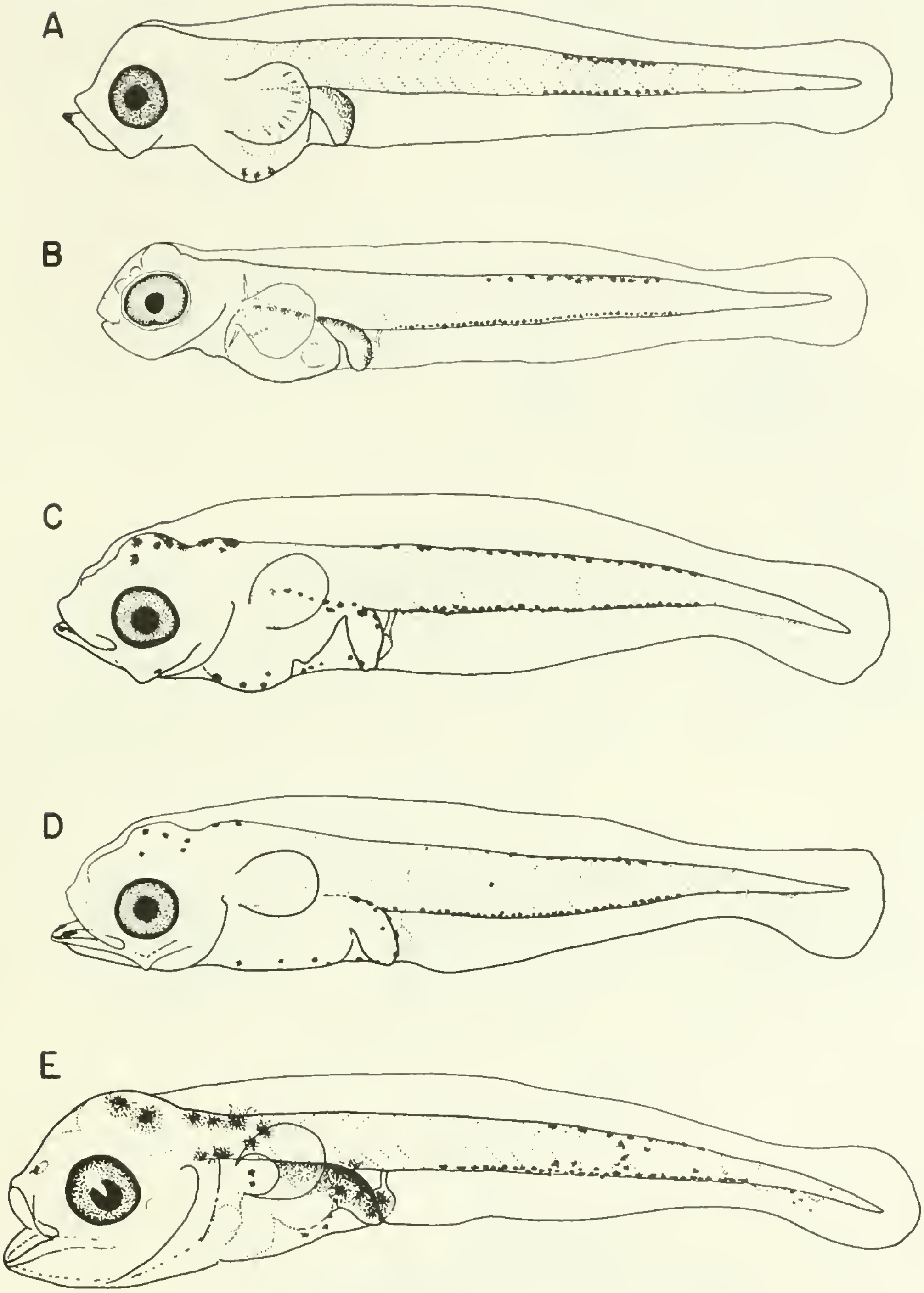

Figure 4.—Larvae of *Sebastes* at stage of yolk exhaustion. A. *S. pinniger*, 4.0 mm, redrawn from Waldron (1968); B. *S. saxicola*, 4.7 mm; C. *S. auriculatus*, 5.2 mm; D. *S. caurinus*, 5.5 mm; E. *S. gilli*, 5.2 mm. Specimens C and D supplied by C. R. Hitz.

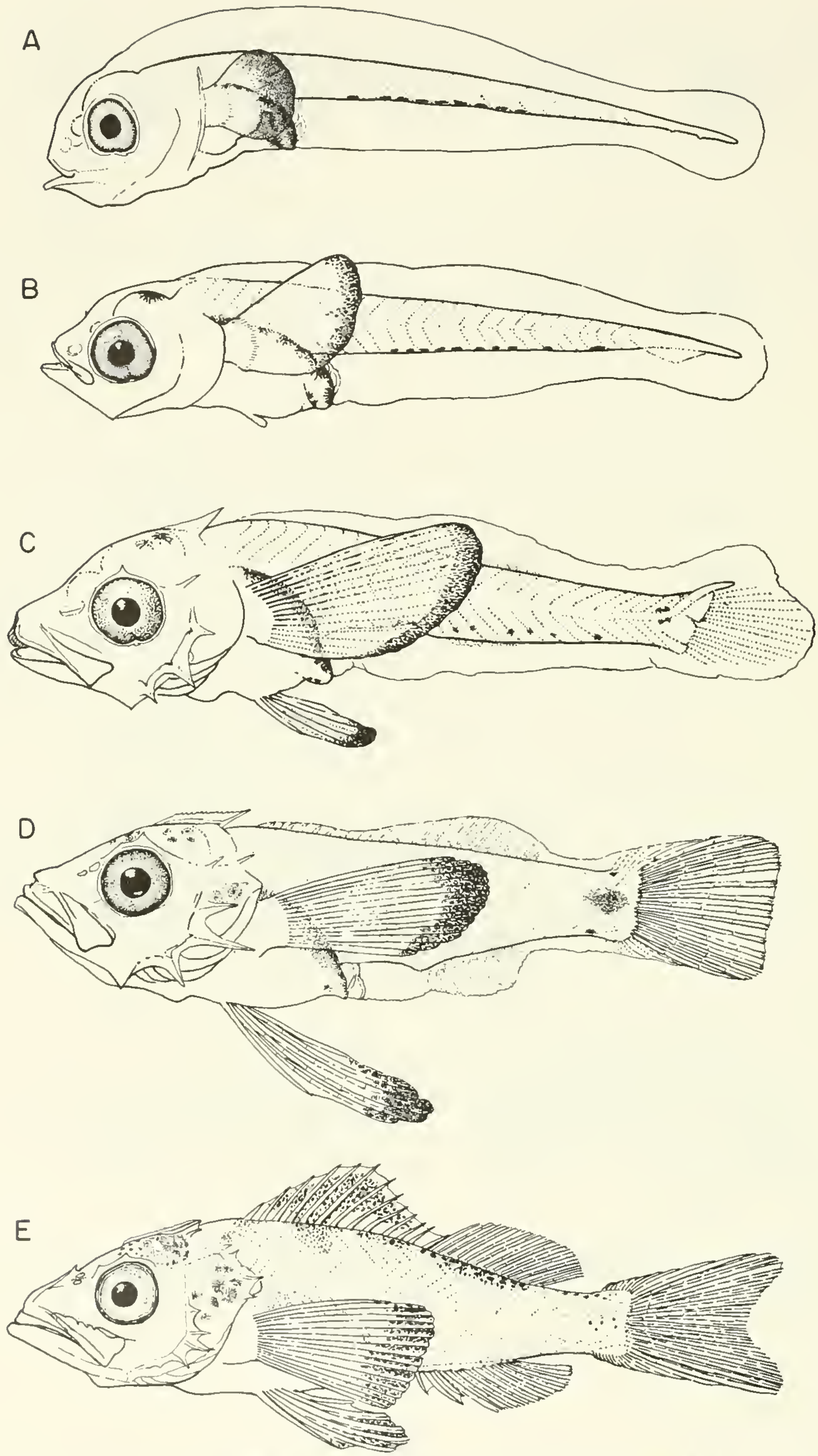

Figure 5.—Developmental series of *Sebastes paucispinis*. A. 4.7-mm larva; B. 6.1-mm larva; C. 8.7-mm larva; D. 14.0-mm larva; E. 24.2-mm pelagic juvenile.

Table 6. Measurements (mm) of Sebastes paucispinis larvae. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
4.6	1.7	1.1	0.3	0.4	0.8	0.5	0.4	-	-
4.8	1.9	1.2	0.3	0.4	0.9	0.6	0.4	-	-
5.1	2.1	1.4	0.4	0.4	1.0	0.8	0.5	0.1	-
5.8	2.5	1.7	0.4	0.5	1.2	1.2	0.5	0.2	-
6.6	2.9	1.9	0.6	0.7	1.4	1.4	0.6	0.7	-
7.2	3.2	2.1	0.6	0.6	1.7	1.8	0.7	0.9	-
7.5	3.0	2.0	0.6	0.6	1.6	1.9	0.7	0.7	-
8.2	3.5	2.4	0.7	0.8	1.8	2.3	0.7	1.1	4.9
8.8	4.2	2.7	0.9	0.8	2.1	2.4	0.8	1.4	5.2
9.7	4.8	3.1	1.0	0.9	2.3	3.0	0.8	2.5	6.0
10.3	5.3	3.8	1.2	1.2	2.9	3.7	0.8	3.3	6.3
10.5	5.7	3.9	1.3	1.2	3.1	3.6	0.8	3.7	6.9
12.0	7.0	4.5	1.4	1.4	3.5	4.4	1.0	4.7	7.9
12.7	7.1	4 6	1.5	1.5	3.7	4.6	1.0	4.6	8.1
13.7	8.2	5.0	-	1.4	4 1	5.1	1.0	5.1	9.2
14.2	8.6	5.5	1.8	1.7	4.2	4.8	1.0	4.4	9.2
15.0	9.1	5.5	1.7	1.8	4.6	5.4	1.1	5.4	9.7
24.2	15.2	8.8	2.9	2.6	6.9	8.3	1.3	5.7	-
29.4	19.0	11.3	2.9	3.0	8.1	7.4	1.7	7.3	-
*32.0	19.2	11.7	3.4	3.0	8.8	8.3	1.7	7.8	-
*34.4	20.6	11.5	3.8	3.1	9.4	8.8	2.0	7.5	22.3

*Transforming specimens.

complement of pectoral rays is present in 9-mm larvae (Table 7). The pelvic fins begin to develop in 5-mm larvae and, like the pectorals, reach a maximum relative length of 37% of the body length in 13-mm larvae.

Bocaccio larvae may be readily identified by their pigment pattern. The most striking melanistic pigment is on the posterior margins of the pectoral and pelvic fins. This pigment remains throughout the larval period and is found in juveniles up to about 70 mm. Other patches of melanophores develop above the brain, on the opercle, and at the base of the caudal fin. The number of melanophores in the ventral midline series is small compared with other species of *Sebastes*. Their number ranged from 6 to 14 with a mean of 9 for 20 larvae counted.

Distribution.—Adults of *S. paucispinis* have been taken as far south as Punta Blanca, Baja California, and as far north as Kodiak Island, although the principal distribution of the species is off California; they have been reported offshore to depths of 320 m (Miller and Lea

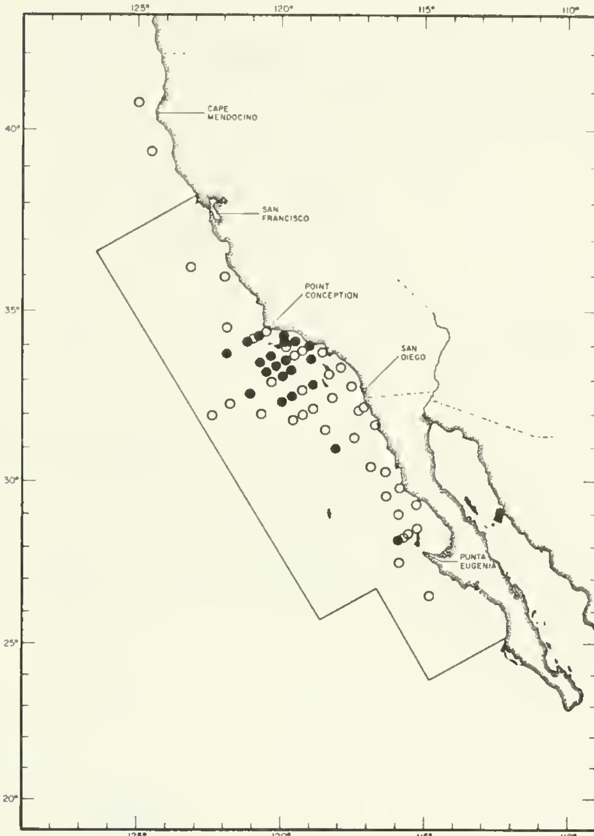

Figure 6.—Stations at which larvae of *Sebastes paucispinis* were collected by CalCOFI plankton surveys during 1953 and 1956. Solid circles indicate stations where number of larvae exceeded mean number (6.7) for all positive stations. Area of frequent occupancy is outlined (see Ahlstrom 1961 for complete grid).

Table 7. Meristics from cleared and stained larvae of Sebastes paucispinis.

Length (mm)	Principal caudal fin rays		Procurrent caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	superior	inferior	superior	inferior	left	right	left	right	superior	inferior	upper limb	lower limb			left	right	
6.6	3	3	-	-	4	4	10	10	-	-	-	3	-	-	-	I-2	-
7.2	5	5	-	-	5	5	12	12	-	-	-	6	-		I-3	I-3	-
8.8	7	7	-	1	6	6	14	14	-	-	-	7	-	-	I-4	I-4	4
9.3	7	7	-	-	7	7	15	15	-	-	2	11	-	-	I-5	I-5	22
10.3	8	7	2	3	7	7	15	15	1	2	2	12	I-7	IV-9	I-5	I-5	23
11.0	8	7	4	4	7	7	15	15	1	2	4	13	II-9	XIV-14	I-5	I-5	26
11.8	8	7	6	7	7	7	15	15	1	2	4	14	III-9	XIII-14	I-5	I-5	26
12.0	8	7	7	8	7	7	15	15	1	2	5	15	III-9	XIII-14	I-5	I-5	26
13.4	8	7	8	8	7	7	15	15	1	2	5	15	III-9	XIII-15	I-5	I-5	26
14.2	8	7	11	11	7	7	15	15	1	2	6	17	III-9	XIII-14	I-5	I-5	26

1972). Information from CalCOFI samples shows that bocaccio larvae occur as far south as Punta San Hippolito, Baja California, and seaward to about 400 km (Fig. 6). The distribution of bocaccio larvae is not known north of California since the CalCOFI sampling pattern usually is terminated at the California-Oregon border. Bocaccio larvae are present in CalCOFI samples for an 8-mo period from November to June with a peak abundance in January and February. Seasonal changes in abundance and size of larvae are shown in Table 8.

Table 8. Mean lengths (mm) of Sebastes paucispinis larvae collected on cruises of the California Cooperative Oceanic Fisheries Investigations during 1953 and 1956. (Standardized numbers of larvae are shown in parentheses.)

	JAN	FEB	MAR	APR	MAY	JUN	NOV	DEC
1953	5.3(88)	5.2(221)	8.2(82)	10.2(47)	13.2(5)	12.2(10)	4.0(7)	4.5(56)
1956	4.9(89)	5.4(43)	7.8(27)	8.4(19)	15.7(12)	7.9(5)	—	4.5(37)

Sebastes macdonaldi (Eigenmann and Beeson), Figure 7

Literature.—A description of the larvae and pelagic and benthic juveniles of *S. macdonaldi*, the Mexican rockfish or "coral cod," is presented in Moser (1972).

Distinguishing features.—Larvae of *S. macdonaldi* are born at a length of 4.0 to 5.0 mm. The gradual transformation into pelagic juveniles begins at about 15 mm. The pelagic juvenile phase appears to be highly protracted, since the smallest demersal juveniles known are about 60 mm in length.

Larvae of this species are relatively deep-bodied. Body depth at the base of the pectoral fins averages 23% of the body length before notochord flexion, 33% during notochord flexion, and 34% in larvae which have completed notochord flexion (Table 9). The sequence of development of the head spines is described in detail in Moser (1972).

Table 9. Measurements (mm) of larvae and pelagic juveniles of Sebastes macdonaldi. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-Anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pelvic fin length	Snout-anal fin distance
4.5	1.8	1.1	0.38	0.37	0.09	0.27	-	-
4.7	1.8	1.2	0.30	0.45	1.0	0.40	-	-
5.0	1.8	1.2	0.30	0.46	1.0	0.33	-	-
5.2	2.1	1.4	0.48	0.51	1.2	0.36	-	-
5.7	2.4	1.6	0.47	0.57	1.3	0.52	-	-
5.9	2.6	1.8	0.48	0.55	1.5	0.45	-	-
6.3	2.8	1.8	0.56	0.57	1.6	0.60	0.05	-
6.7	2.9	1.9	0.56	0.63	1.7	0.61	0.04	-
6.8	3.1	1.9	0.55	0.70	1.8	0.62	0.15	-
7.0	3.3	2.1	0.75	0.70	1.9	0.60	0.12	-
7.6	3.5	2.2	0.79	0.73	2.0	0.68	0.20	-
7.7	3.8	2.7	0.82	0.84	2.3	0.90	0.33	4.2
7.9	3.8	2.7	0.80	0.90	2.5	0.93	0.25	4.2
8.2	4.2	2.9	1.1	1.0	2.5	1.1	0.52	4.8
8.5	4.7	3.2	1.2	1.0	3.0	1.3	0.80	4.9
9.0	5.0	3.2	1.1	1.0	2.8	1.2	0.65	5.4
9.2	5.3	3.4	1.1	1.1	3.1	1.4	0.89	5.4
9.5	5.2	3.6	1.3	1.2	3.1	1.5	1.1	5.6
9.7	5.4	3.5	1.2	1.2	3.2	1.6	1.1	5.8
10.0	6.2	3.7	1.2	1.3	3.5	1.8	1.2	6.4
10.3	6.3	3.8	1.4	1.3	3.5	1.7	1.2	6.5
11.2	6.8	3.8	1.4	1.3	4.0	2.1	1.5	7.0
12.0	7.7	4.5	1.4	1.5	4.2	2.4	1.8	7.7
15.0	9.4	5.8	1.7	1.9	5.2	3.5	3.1	9.7
15.4	9.3	5.8	1.7	1.8	5.5	4.0	2.9	9.6
15.9	10.0	6.5	2.1	2.0	5.2	3.6	2.8	10.1
*22.6	14.0	8.4	2.7	2.3	7.5	6.7	4.8	14.7
*27.8	18.6	10.6	3.1	2.8	8.9	8.8	6.2	19.3
*29.2	19.1	10.8	2.9	3.2	10.0	9.8	6.5	19.9
*32.7	20.7	11.8	3.2	3.6	10.1	9.7	-	20.8
*34.5	20.9	11.8	3.2	4.0	10.5	10.6	7.7	21.4
*38.8	25.0	12.8	3.2	4.0	11.7	11.2	8.3	25.6
*40.5	26.8	13.0	3.5	4.2	12.0	12.2	8.5	27.4
*44.4	30.2	14.0	3.8	4.7	13.2	13.2	9.2	31.2

*Pelagic juvenile.

The pectoral fins are short and compact, although they gradually increase in length during the larval period. Fin length averages 8% of the body length before notochord flexion, 13% during flexion, and 19% in larvae which have completed flexion. The fin elongates markedly in pelagic juveniles, where its average length is 31% of the body length. The sequence of ossification of the fins and bony skeleton is given in Table 10.

The most distinctive pigment is on the paired fins. The pectorals are covered solidly with melanophores in newborn larvae. When rays develop the solid pigmentation is restricted to the membranes between the rays but the overall appearance is a dark compact fin with light striations. The pelvic fins develop similar pigmentation. When the paired fins become elongate in pelagic juveniles, they retain their distinct dark pigmentation. Early larvae have a group of melanophores on the nape and an unusually low number of melanophores in the ventral tail series. In a sample of 60 newborn larvae, the number of ventral midline melanophores ranged from 6 to 14 with a median of 8. Patches of melanophores develop over the brain, on the opercle and preopercle. Late in the larval period, melanophores form lateral to the base of the dorsal fin. It is from these elongate patches that the striking pigment saddles extend ventrad in pelagic juveniles.

Distribution.—This species has the most southerly distribution of any species of *Sebastes* in the eastern North Pacific. Adults have been taken as far north as Pt. Sur, Calif., and as far south as Morgan Bank, near Cape San Lucas, Baja California. Its abundance on the banks off southern Baja California, and in certain areas of the Gulf of California, suggests that the outer coast populations and the Gulf populations may be continuous (Moser 1972).

CalCOFI data show that larvae of this species are most abundant off central Baja California. Larval abundance declines sharply to the north of this region and larvae do not occur north of Los Angeles (Fig. 8). Larval abundance falls off less sharply to the south of Punta Eugenia; however, the CalCOFI sampling pattern does not allow exact delimitation of the southern range of *S. macdonaldi* larvae.

The larvae are present in CalCOFI samples over a 6-mo period from January to June with a peak abundance in March. Seasonal changes in abundance and size of larvae are shown in Table 11. A few larvae of this species were taken in the Gulf of California.

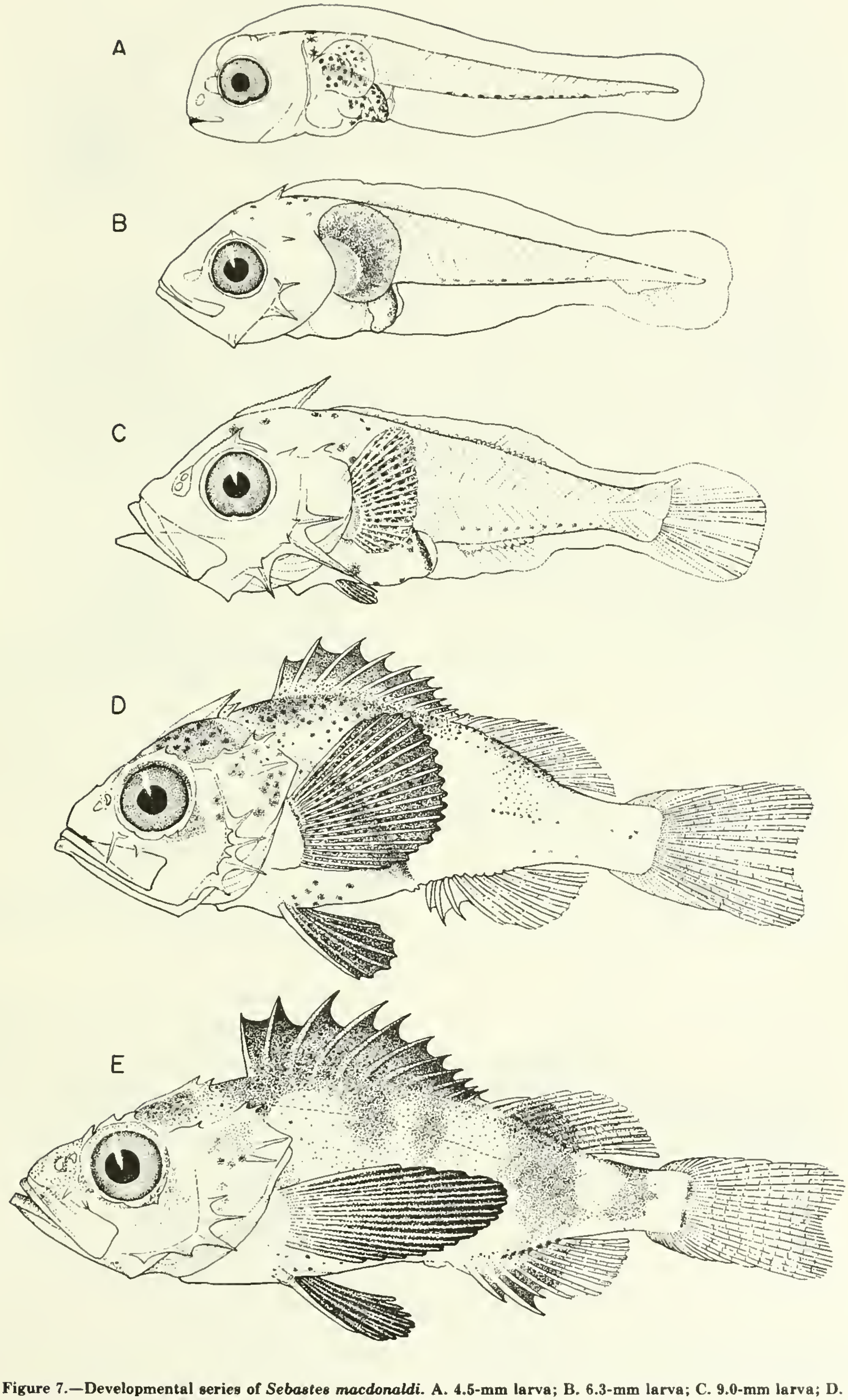

Figure 7.—Developmental series of *Sebastes macdonaldi*. A. 4.5-mm larva; B. 6.3-mm larva; C. 9.0-mm larva; D. 15.4-mm transforming specimen; E. 29.2-mm pelagic juvenile.

Table 10. Meristics from cleared and stained larvae of Sebastes macdonaldi.

Length (mm)	Principal caudal fin rays		Procurrent caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	superior	inferior	superior	inferior	left	right	left	right	superior	inferior	upper limb	lower limb			left	right	
6.3	-	-	-	-	2	2	2	2	-	-	-	-	-	-	-	-	-
6.7	-	-	-	-	3	3	3	3	-	-	-	-	-	-	-	-	-
6.8	-	-	-	-	3	3	3	-	-	-	-	4	-	-	-	-	-
7.0	3	3	-	-	4	4	6	6	-	-	-	5	-	-	-	-	-
7.1	4	3	-	-	5	5	6	6	-	-	-	6	-	-	-	-	-
7.2	3	3	-	-	5	5	-	8	-	-	-	6	-	-	-	-	-
7.7	6	6	-	-	6	6	11	11	-	-	-	9	-	-	I-0	I-0	5
7.9	4	4	-	-	5	5	9	10	-	-	-	9	-	-	-	-	3
8.2	8	7	2	2	7	7	17	17	-	-	1	12	III-4	VII-0	I-3	I-3	24
8.5	7	7	-	1	6	6	15	15	1	1	1	11	-	-	I-3	I-3	18
8.7	8	7	-	1	7	7	16	16	-	-	1	12	-	IV-0	I-3	I-3	18
9.2	8	7	2	3	7	7	19	18	2	3	3	14	-	VII-8	I-4	I-4	23
9.4	8	7	4	4	7	7	19	19	2	3	3	15	III-7	XIII-13	I-5	I-5	24
9.7	8	7	3	4	7	7	19	19	2	3	3	16	III-7	XIII-13	I-5	I-5	24
10.0	8	7	5	6	7	7	19	19	2	3	5	17	III-7	XIII-13	I-5	I-5	26
10.3	8	7	5	5	7	7	19	20	2	3	-	-	III-7	XIII-13	I-5	I-5	26
11.3	8	7	4	4	7	7	19	19	2	3	5	18	III-7	XIII-13	I-5	I-5	26
12.0	8	7	8	7	7	7	19	19	2	2	5	18	III-7	XIII-13	I-5	I-5	26
15.0	8	7	10	11	7	7	19	19	3	2	-	-	III-7	XIII-13	I-5	I-5	26
15.9	8	7	10	11	7	7	19	19	3	2	9	21	III-6	XIII-12	I-5	I-5	26
27.8	-	-	-	-	7	7	18	18	2	2	10	25	III-7	XIII-13	I-5	I-5	26

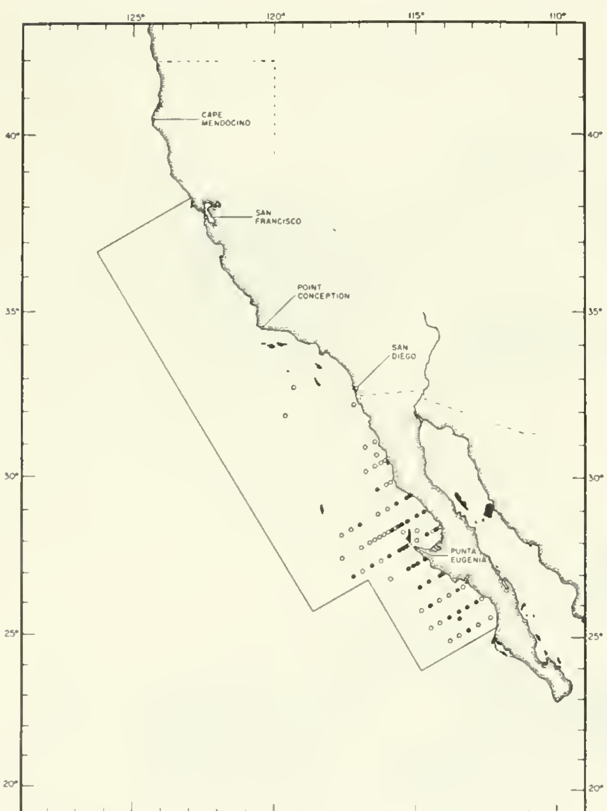

Figure 8.—Stations at which larvae of *Sebastes macdonaldi* were collected during 4 yr (1953, 1960, 1965, and 1966) of CalCOFI plankton surveys. Solid circles indicate stations where number of larvae exceeded mean number (4.8) for all positive stations. Area of frequent occupancy is outlined (see Ahlstrom 1961 for complete grid).

Table 11. Mean lengths (mm) of Sebastes macdonaldi larvae collected on cruises of the California Cooperative Oceanic Fisheries Investigations during 1953 and 1960. (Standardized numbers of larvae are shown in parentheses.)

	JAN	FEB	MAR	APR	MAY	JUN
1953	4.3 (45)	4.6 (109)	4.9 (632)	5.6 (163)	5.2 (22)	7.8 (2)
1960	4.2 (3)	4.8 (65)	5.1 (1042)	5.1 (248)	5.2 (48)	4.6 (15)

Sebastes jordani Gilbert, Figure 9

Literature.—Morris (1956) described briefly the newly extruded larvae of *S. jordani* and illustrated a 6.8-mm specimen.

Distinguishing features.—The larvae of the shortbelly rockfish, *S. jordani*, are larger at hatching than other eastern Pacific species studied to date. Morris (1956) illustrated a newly hatched *S. jordani* larva 6.8 mm in length, however, the mean for 20 measured specimens was 5.4 mm. This is 0.75 mm larger than the mean length for the next largest species listed by Morris. Newly hatched larvae of most other eastern Pacific species are between 3.8 and 5.0 mm. The 6.8-mm length of Morris' illustrated specimen is above the upper range of any eastern Pacific species known to us and is more like the lengths of newly hatched larvae of the *S. marinus* group of the Atlantic and some Japanese species. Other similarities between the larvae of *S. jordani* and the *S. marinus* group suggest that the two may be closely related. *Sebastes jordani* larvae have an extended larval period. Transformation into the pelagic juvenile stage occurs at about 27 mm and specimens in the 28- to 30-mm

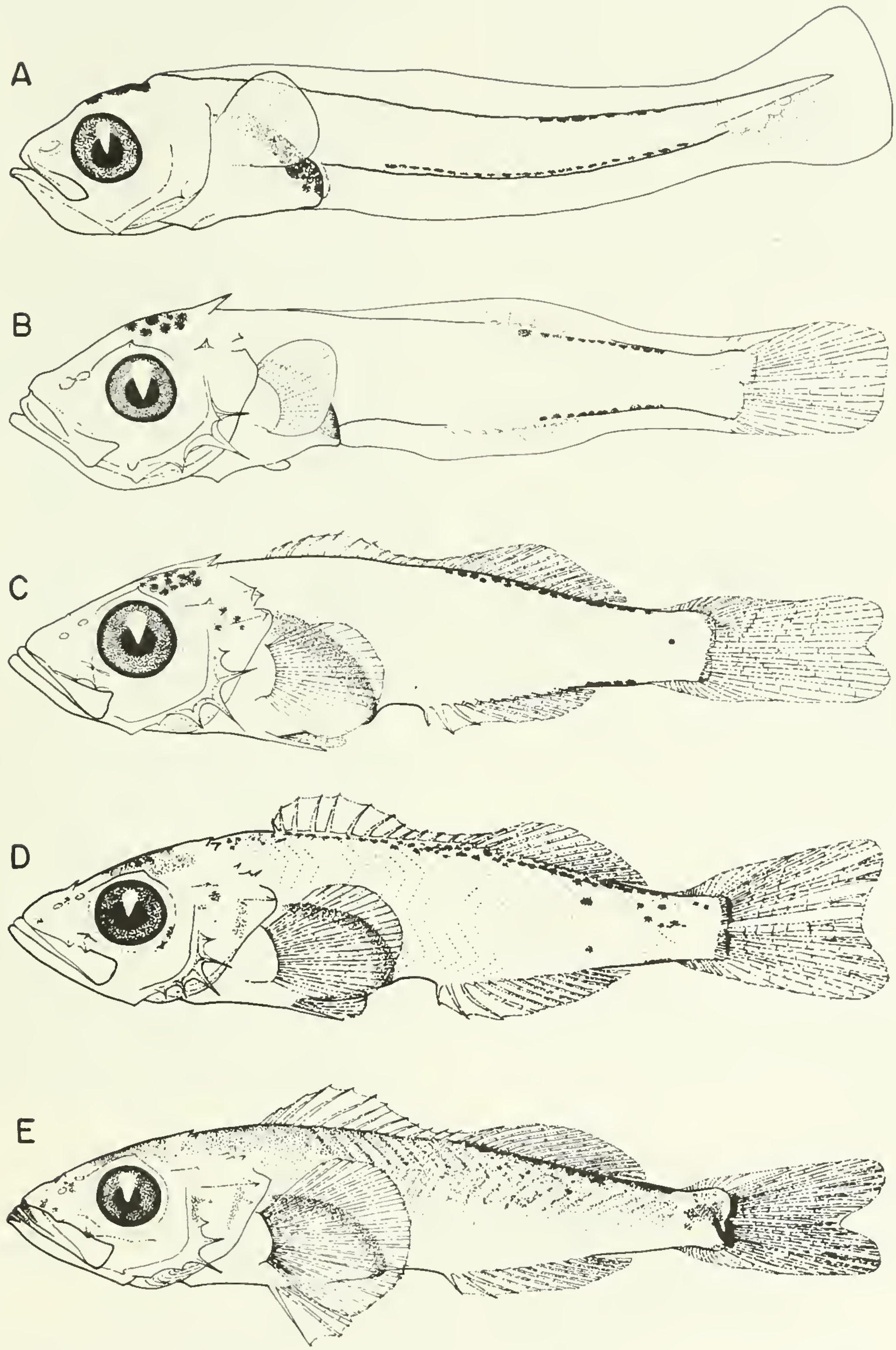

Figure 9.—Developmental series of *Sebastes jordani*. A. 7.2-mm larva; B. 10.0-mm larva; C. 15.5-mm larva; D. 21.0-mm larva; E. 29.6-mm pelagic juvenile.

size range have the morphological and pigmentary features of pelagic juveniles. This is also true for *S. marinus*. Pelagic juveniles remain in the surface waters; they appear to form schools soon after transformation and are particularly susceptible to dip netting under nightlights. Juveniles in the 30- to 50-mm size range are commonly dip netted and a 62.8-mm specimen was taken by this method (Table 12).

Larvae of *S. jordani* are the most slender of all *Sebastes* yet described. Body depth averages 17% of the body length before notochord flexion, 21% during flexion, and 23.5% following flexion. Pelagic juveniles 28 to 68 mm long appear to be slightly more slender, with a mean of 22%.

The rounded pectoral fins are the shortest of any eastern Pacific rockfish larvae yet described. Pectoral fin length averages 7% of the body length prior to notochord flexion and 8% during flexion. This percentage increases gradually following notochord flexion from 11% immediately after flexion to 20% in the largest larvae. There is only a slight increase in relative pectoral fin length during the pelagic juvenile stage, up to 22% in the largest specimen available (62.8 mm). The small pectorals in *S. jordani* and the ontogenetic changes in relative size agree closely with the condition in the larvae of the *S. marinus* group. The sequence of ossification of the pectorals and other fins is shown in Table 13.

Table 12. Measurements (mm) of larvae of *Sebastes jordani*. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
5.4	2.0	1.2	0.28	0.46	0.85	0.38	0.32	---	---
5.8	2.1	1.2	0.31	0.45	0.95	0.32	0.38	---	---
6.1	2.2	1.3	0.30	0.49	1.0	0.43	0.43	---	---
6.4	2.4	1.6	0.48	0.60	1.2	0.45	0.45	---	---
7.2	2.6	1.6	0.45	0.61	1.2	0.48	0.46	---	---
7.7	2.8	1.8	0.55	0.65	1.4	0.50	0.50	---	---
8.0	3.3	2.1	0.72	0.74	1.6	0.62	0.60	0.07	4.4
8.6	3.7	2.2	---	0.78	1.8	0.64	0.63	0.08	4.8
9.0	3.7	2.7	0.94	0.87	1.8	0.70	0.70	0.10	5.2
9.4	4.2	2.8	1.0	0.92	2.1	0.83	0.75	0.18	5.2
10.0	4.2	3.0	1.1	0.88	2.2	1.0	0.82	0.18	5.8
10.5	4.8	3.3	1.2	1.0	2.4	1.2	1.0	0.35	6.4
11.6	5.3	3.9	1.4	1.1	2.5	1.4	1.0	0.44	6.9
12.8	6.2	4 1	1.6	1.2	3.1	1.7	1.1	0.50	7.6
13.4	7.2	4.8	1.7	1.3	3.2	2.0	1.1	1.0	8.8
15.5	8.0	5.0	1.7	1.7	4.1	2.5	1.2	1.4	9.2
21.0	11.3	6.7	2.2	2.1	5.2	3.9	1.7	2.2	12.2
22.8	11.7	7.4	2.6	2.1	5.3	4.1	1.6	2.5	13.2
23.5	12.0	7.5	2.6	2.2	5.6	4.6	1.8	2.7	13.8
24.5	12.8	8.2	2.9	2.2	5.4	4.7	1.7	3.0	15.0
25.5	13.8	8.1	2.7	2.3	6.3	4.8	1.8	2.9	15.0
26.4	13.8	8.3	2.8	2.4	6.3	5.0	1.9	3.3	15.7
27.0	14.0	8.5	2.8	2.7	6.4	5.3	1.9	3.4	16.4
•28.4	15.0	9.5	3.2	2.6	6.4	5.4	2.0	3.3	17.2
•29.6	15.7	9.4	3.2	2.6	6.9	5.8	2.2	3.7	18.1
•30.3	16.7	10.0	3.8	2.6	6.7	6.2	2.1	3.8	19.3
•40.7	22.0	12.8	4.6	3.1		8.5	2.7	5.4	25.8
•50.7	26.5	15.0	4.8	4.2	11.2	11.0	3.3	7.5	31.5
•62.8	33.0	17.4	5.2	4.6	13.5	13.5	4.2	9.2	38.3

•Pelagic juvenile.

A character which separates adults and juveniles of *S. jordani* from all other known species of *Sebastes* is the anterior placement of the anus. In his key Phillips (1957) indicated that the distance between the anus and the first anal spine in *S. jordani* is 1.1 to 1.5 orbit diameters, whereas this distance is 0.1 to 0.8 orbit diameters in other species. This wide space between the anus and the anal fin origin is conspicuous in pelagic juveniles and is a useful character in identifying all but the smallest larvae. Snout-anus distance averages 36% of the body length in the larvae prior to notochord flexion, 42% during flexion, and 51% following flexion. In pelagic juveniles it is 54%. Comparative mean percentages for larvae of *S. paucispinis* are 41 before flexion, 45 during flexion, and 59 following flexion. For larvae of *S. macdonaldi*, the percentages are 42, 52, and 60.

The pigment pattern of early *S. jordani* larvae is similar to that of the *S. marinus* group in the Atlantic. Newborn larvae have the melanistic shield over the gut, a group of melanophores above the brain, and a series of melanophores along the dorsal and ventral midlines of the tail. The ventral row begins at the 3rd to 5th postanal myomere and extends to the 14th and 16th postanal myomere. Typically, in the anterior two-thirds of the series, the melanophores are positioned singly, but in the posterior two-thirds the melanophores are in two irregular rows along the ventral midline. For 15 specimens counted, the total number in the ventral row ranged from 21 to 27 with a mean of 23.7 ± 1.75 SD. The dorsal row is considerably shorter, beginning at the 7th to 12th postanal myomere and extending posteriad to the 14th to 16th myomere. The melanophores are bunched together in an irregular row that contains a mean of 18.9 ± 4.64 melanophores (range of 13 to 28) for 18 larvae counted.

Table 13. Meristics from cleared and stained larvae of *Sebastes jordani*.

Length (mm)	Principal caudal fin rays		Procurrent caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	superior	inferior	superior	inferior	left	right	left	right	superior	inferior	upper limb	lower limb			left	right	
9.4	8	7	0	1	7	7	10	10	-	-	0	11	-	-	-	-	18
10.0	8	7	0	0	7	7	13	13	-	-	1	12	-	-	-	-	20
10.5	8	7	2	2	7	7	16	16	2	3	2	15	-	-	I-3	I-3	24
11.2	8	7	0	3	7	7	16	16	2	3	2	15	-	-	I-3	I-3	27
12.5	8	7	3	4	7	7	19	19	2	2	4	18	III-6	XIII-6	I-5	I-5	27
12.8	8	7	5	5	7	7	19	19	2	2	4	19	III-11	XIII-13	I-4	I-4	27
22.0	8	7	10	12	7	7	21	21	2	2	10	26	III-11	XIII-14	I-5	I-5	27

Development of pigment pattern in later larval stages is also similar to that in the *S. marinus* group of the Atlantic. The ventral series on the tail becomes embedded and obscure; beginning at the anterior end of the series this process gradually proceeds posteriad until, in 15-mm larvae, only those melanophores posterior to the anal fin are visible. With further development, these too are obscured. The dorsal series follows an opposite course. Melanophores are added anteriorly to form streaks on either side of the developing dorsal fin. Melanophores are also added posteriorly so that the dorsum is pigmented from head to caudal fin. Melanophores begin to appear on the side of the tail just anterior to the caudal fin in larvae of about 15 mm in length. Also, the posterior margins of the hypural elements become outlined with embedded pigment.

At transformation, which begins in specimens about 27 mm long, the upper half of the body above the lateral line begins to be covered with fine melanophores. These melanophores are more concentrated at the myosepta and accent them. The streaks along the soft dorsal fin and the streak above the caudal peduncle are darker than on the more anterior region of the dorsum. In 40-mm pelagic juveniles, the general body pigmentation begins to extend below the lateral line, but even in later juveniles and in adults, the ventral region of the body is paler than the dorsal half. The pectoral and pelvic fins develop no melanistic pigmentation in larvae or pelagic juveniles.

Distribution.—According to Miller and Lea (1972), *S. jordani* ranges from British Columbia south to Cape Colnett, Baja California (about lat. 31°N). A 45.2-mm juvenile (SIO 71-120) dip netted off west San Benito Island (lat. 28°18.0′N, long. 115°34.25′W) extends the range of this species about 270 km south. The distribution of *S. jordani* larvae in the CalCOFI sampling area during 1966 is shown in Figure 10. The sampling area obviously stops short of the northward extent of spawning, however, it shows the southern extent of larval occurrence to be just south of the border with Mexico (CalCOFI Line 100). Another obvious feature is the coastal nature of *S. jordani* distribution. All larvae were taken in the shoreward region of the sampling grid and the largest individual catches were made on stations next to the coast.

Frequency of occurrence of *S. jordani* is 7.7% off central California and decreases to 5.7% off southern California and 1.5% off northern Baja California (Table 14). Percentage of *S. jordani* larvae to total *Sebastes* larvae was highest (20%) off southern California. Spawning occurs over a short time period compared with other species studied (Table 15); it extends from January to April with a peak in February or March.

Figure 10.—Stations at which larvae of *Sebastes jordani* were collected by CalCOFI plankton surveys during 1966. Solid circles indicate stations where number of larvae exceeded mean number (43.8) for all positive stations. Area of frequent occupancy is outlined.

Table 14. Relative abundance and frequency of occurrence of Sebastes jordani in CalCOFI collections for 1966.

CalCOFI regions and lines	Total stations occupied	Total stations containing Sebastes larvae	Percentage of stations containing Sebastes	Total stations containing S. jordani	Percentage of stations containing S. jordani	Standardized number of S. jordani larvae	Standardized number of Sebastes larvae in hauls containing S. jordani	Percentage of S. jordani larvae to total Sebastes larvae
Central California 60-77	235	56	23.8	18	7.7	992	8,562	11.6
Southern California 80-93	511	263	51.5	29	5.7	1,355	6,822	19.9
Northern Baja California 97-107	459	122	26.6	7	1.5	40	692	5.8
Upper central Baja California 110-120	418	91	21.8	0	0	0	0	0
Lower central Baja California 123-137	325	36	11.1	0	0	0	0	0

Table 15. Standardized numbers (A), mean length in mm with standard deviation (B), and size range in mm of *Sebastes jordani* larvae taken on CalCOFI cruises of 1966. There was no cruise during March, and *S. jordani* were not taken from May to December. Stations in central California were not occupied in February.

CalCOFI regions and lines	January			February			April		
	A	B	C	A	B	C	A	B	C
Central California 60-77	781.9	4.9 ± 0.59	4.0 - 7.0	-	-	-	205.2	7.5 ± 3.31	5.1 - 24.5
Southern California 80-93	459.0	5.1 ± 1.01	4.5 - 8.0	863.3	4.9 ± 1.51	4.4 - 8.0	54.6	5.8 ± 1.38	5.0 - 11.0
Northern Baja California 97-107	0	0	0	15.3	6.8 ± 1.49	5.2 - 10.0	0	0	0

Sebastes levis (Eigenmann and Eigenmann), Figure 11

Literature.—Newborn larvae of *S. levis*, the cow rockfish or cowcod, were illustrated in Moser (1967a).

Distinguishing features.—Larvae of *S. levis* are about 5.0 mm long at birth; they achieve the relatively large size of about 20 mm. A specimen 21.3 mm was just beginning to develop the lateral pigment saddles typical of pelagic juveniles, whereas transformation has progressed far enough in a 19.1-mm specimen to classify it as a pelagic juvenile. The pelagic juvenile phase appears to be protracted since pelagic juveniles up to 58 mm were taken in midwater trawls and the smallest demersal juvenile found was 66.5 mm.

The large fanlike pectoral fins are diagnostic features of cow rockfish larvae and attain the greatest size of any species of *Sebastes* in the CalCOFI collections. Their length increases from 9% of the body length in newborn larvae to 46% at the completion of notochord flexion (Table 16). Pectoral fin length in the few large larval specimens is 41 to 45% of the body length. The large pectoral fins are characteristic of pelagic juveniles; 19- and 33-mm specimens had fin lengths 46 and 47% of the body length. In larger pelagic juveniles the pectorals become relatively smaller; fin length in a 47-mm specimen was 38% of the body length and in a 58-mm specimen it was 32%.

The melanistic pigmentation of cow rockfish larvae is also an aid to identification. Newborn larvae have a melanistic shield over the gut, a patch of melanophores over the brain, heavy pigmentation on the tip of the lower jaw, and a moderate number of melanophores in the ventral midline series (mean of 17 with a range of 13 to 22 for 20 specimens counted). The pectoral fin is covered with fine melanophores that are concentrated in a band at the distal margin. With the rapid growth of the fin in larvae between 6 and 7 mm, the melanophores on the major part of the pectoral are lost but the marginal band remains prominent. With further development, the marginal band widens so that in larvae of 11 mm the fin is covered solidly with fine melanophores. This pigment is retained in pelagic juveniles. When the larvae transform into pelagic juveniles at about 20 mm, pigment saddles begin to develop along the anterior region of the trunk. Additional saddles develop posteriorly and with further enlargement they become distinct bands. These are evident in pelagic juveniles as small as 33 mm and are retained in demersal juveniles and adults.

Table 16. Measurements (mm) of *Sebastes levis* larvae. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
5.0	2.0	1.2	0.26	0.38	0.90	0.43	0.40	-	-
7.6	3.4	2.2	0.75	0.66	1.8	1.8	0.90	0.12	-
8.7	4.1	2.4	0.82	0.77	2.4	2.8	1.2	0.34	5.0
8.9	4.2	2.9	1.0	0.91	2.5	3.2	1.2	0.51	5.2
9.2	4.3	2.8	1.0	0.92	2.3	2.9	1.2	0.44	5.4
9.4	4.7	2.9	1.0	0.93	2.8	3.5	1.2	0.50	5.2
9.8	4.7	2.8	1.0	0.90	2.6	2.9	1.2	0.50	5.8
10.1	5.2	3.1	1.1	1.1	3.1	4.2	1.3	1.0	5.8
10.4	5.8	3.4	1.2	1.2	3.6	4.8	1.3	1.2	6.2
11.3	6.4	4.3	1.2	1.2	3.7	5.0	1.3	1.8	6.8
12.3	7.0	4.2	1.3	1.3	4.2	5.1	1.5	2.2	7.4
21.3	13.5	7.2	2.1	2.2	7.1	9.6	2.4	5.1	13.8
*19.1	11.8	6.3	1.8	2.0	7.1	8.7	2.1	4.8	12.2
*32.8	20.9	10.8	3.0	2.8	11.2	15.4	3.5	9.2	21.9
*47.5	29.9	16.4	5.2	4.1	16.2	18.2	4.8	10.6	31.0
*58.4	36.8	20.1	6.7	5.0	20.3	18.9	5.4	13.0	38.5
**66.5	42.3	24.1	6.7	6.0	22.4	19.5	6.6	14.7	43.1

*Pelagic juvenile.

**Benthic juvenile.

Distribution.—Adult cow rockfish have a comparatively limited geographic range from central California to central Baja California with a principal distribution off southern California. The larvae are rare in CalCOFI samples; only 30 (standardized number) were found in collections from 1951, 1952, 1953, 1961, and 1969. Their geographic distribution suggests that, in terms of reproduction, the cow rockfish is essentially a species of the California Bight (Fig. 12). Cow rockfish larvae were taken from January to June but in such low numbers that months of maximum abundance could not be determined.

Sebastes cortezi (Beebe and Tee-Van), Figure 13

Literature.—The literature contains no descriptions of *Sebastes* larvae from the Gulf of California. The taxonomy of adult *Sebastes* in the Gulf is poorly known; however, Chen (1975) has recently reviewed the species of *Sebastes* from these waters. The larval series described herein as *S. cortezi* was identified by meristic characters and transitional specimens provided by Chen.

Distinguishing features.—At birth, *S. cortezi* larvae, like *Sebastes* larvae of the outer coast are 4.0 to 5.0 mm long. The largest specimen in the series (17.1 mm) was beginning to transform.

The most notable morphological features of *S. cortezi* larvae are the short pectoral fins which have a slight dorsad orientation for most of the larval period, and the

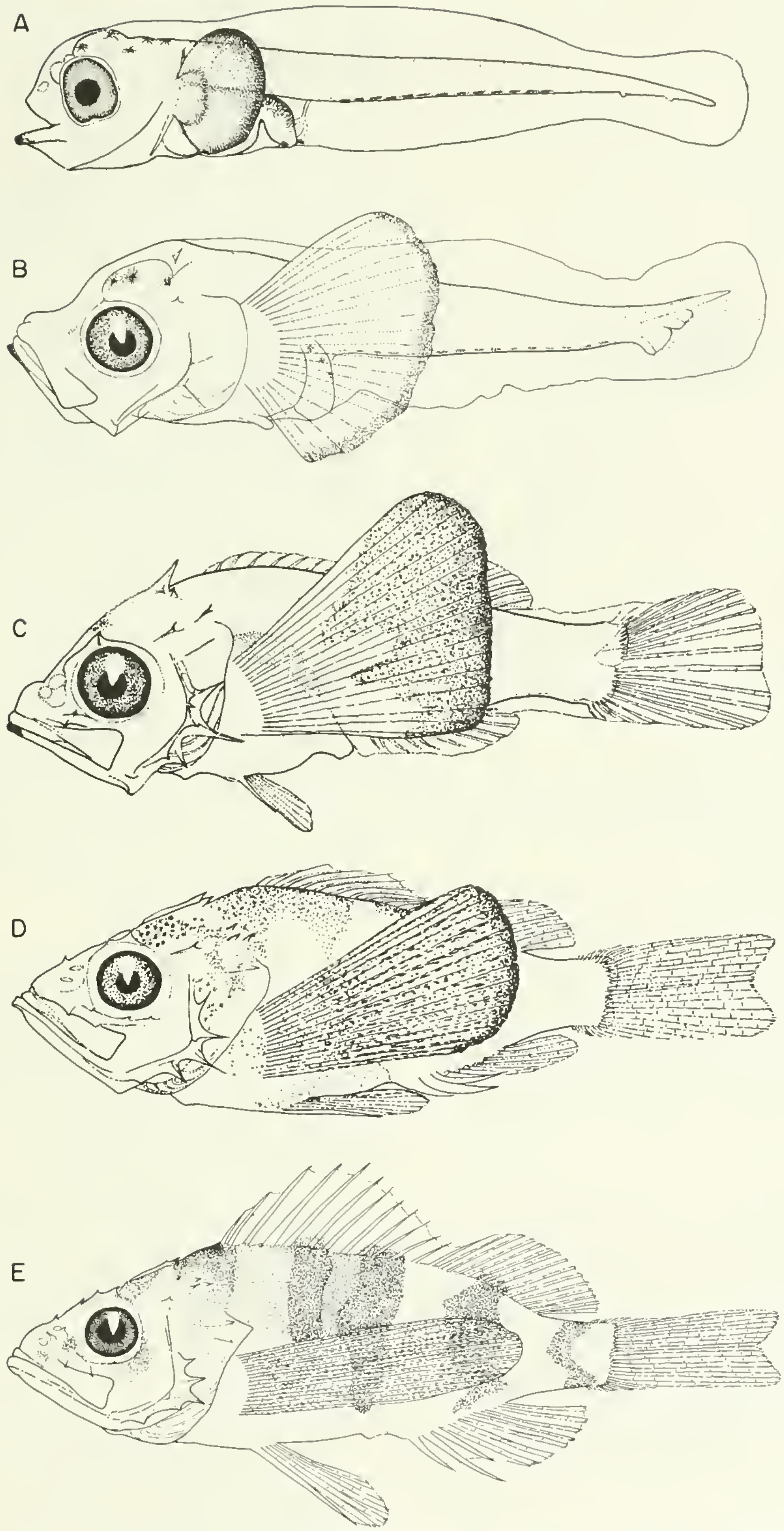

Figure 11.—Developmental series of *Sebastes levis*. A. 5.0-mm larva; B. 7.2-mm larva; C. 10.4-mm larva; D. 19.1-mm transforming specimen; E. 32.8-mm pelagic juvenile.

Figure 12.—Stations at which larvae of *Sebastes levis* were taken during 4 yr (1951, 1955, 1968, and 1969) of CalCOFI plankton surveys. Area of total grid is outlined.

length of parietal spines. Pectoral fin length is 7 to 9% of the body length in larvae up to the beginning of notochord flexion, 9 to 12% during notochord flexion, and has increased to a maximum of 21% following notochord flexion. It is 23% in the transforming specimen (Table 17). A morphological feature which helps to distinguish *S. cortezi* larvae from Type A Gulf larvae is the length of the parietal spines, the spines being relatively shorter in

Table 17. Measurements (mm) of larvae of *Sebastes cortezi*. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
4.1	1.7	1.0	0.25	0.34	0.75	0.37	0.28	---	---
4.5	1.8	1.2	0.30	0.38	0.95	0.30	0.40	---	---
4.7	1.9	1.2	0.37	0.47	1.2	0.37	0.38	---	---
5.1	2.2	1.5	0.43	0.49	1.3	---	---	---	---
5.7	2.5	1.7	0.48	0.54	1.3	0.41	0.57	---	---
6.1	2.6	1.7	0.52	0.55	1.4	0.57	0.60	---	---
6.4	2.9	1.9	0.63	0.60	1.6	0.60	0.64	0.06	---
7.0	3.5	2.1	0.68	0.78	---	0.65	0.82	0.07	4.2
7.2	3.7	2.2	0.78	0.85	2.0	0.73	0.90	0.10	4.2
7.8	3.8	2.5	0.75	0.86	2.1	0.77	0.91	0.14	4.5
8.0	4.0	2.7	0.75	0.94	2.2	0.93	0.94	0.15	4.7
8.3	4.8	2.6	---	0.90	2.3	1.0	0.92	0.15	4.9
8.8	4.5	2.6	0.90	1.0	2.5	1.0	1.0	0.16	5.2
11.8	7.5	4.4	1.4	1.4	4.1	2.3	1.4	1.5	7.8
12.5	7.8	4.7	1.5	1.4	4.2	2.6	1.2	1.5	8.1
13.5	8.9	5.5	---	1.4	4.3	2.6	1.3	1.6	9.3
*17.1	10.3	6.3	1.9	1.8	5.6	3.9	1.6	2.5	10.8

*Transforming specimen.

S. cortezi. In larvae between 8.0 and 9.0 mm, when the spines reach their greatest length relative to the head length, those of *S. cortezi* are 21 to 22% of the head length and those of Type A are 25 to 34%.

Melanistic pigmentation is more useful than morphology in distinguishing *S. cortezi* larvae from other rockfish larvae. At birth the larvae have the usual pigment shield over the gut and a series of melanophores along the ventral midline of the tail (mean of 15 with a range of 10 to 21 melanophores for 15 larvae counted). A large melanophore is located in the position of the future caudal fin and remains there throughout the larval period. The pectoral fins have an unusual pigment pattern; there is a melanistic patch in the proximal ventral sector of the fin and the dorsal and distal portions are clear. With further development, the entire proximal region becomes pigmented but the distal clear zone widens. The medial surface of the fin base is covered with large melanophores. The pelvic fins are pigmented in larvae 11.8 mm and larger.

Other pigment develops above the brain and, late in the larval period, on other regions of the head. In larvae about 8.0 mm long a short series of five to six pairs of melanophores develops along the dorsal midline of the tail. With further development this series lengthens, and extends along the entire dorsum in larvae 12.5 mm and longer. The ventral series of melanophores becomes restricted to the caudal peduncle after the anal fin is developed (about 8.0 mm). The 11.8-mm larva has a large patch of melanophores on the lateral surface of the caudal peduncle. In later stages, melanophores extend anteriad along the lateral line from this patch and, in the 17.1-mm specimen, the entire trunk above the lateral line is becoming pigmented.

Distribution.—Eight CalCOFI cruises into the Gulf of California in 1956 and 1957 and a U.N. Food and Agriculture Organization (FAO) cruise in March of 1972 provide information on the distribution and abundance of *S. cortezi* larvae. Like the adults (Chen 1975), the larvae occur in the western side of the Gulf and range latitudinally from off Point San Fermin south to about Carmen Island (Fig. 14). Most of the larvae were taken just north and just south of the large islands, Tiburon and Angel de la Guarda, in the upper Gulf. Although the results of the various cruises are not strictly comparable because they differed in area covered and in the number of stations occupied, Table 18 gives some indication of the seasonality of spawning. Larvae are present during the cold-water months and appear to have a maximum abundance in March.

Table 18. Mean length (mm) with total standardized number of larvae of *Sebastes cortezi* and *S.* Type A in plankton collections from the Gulf of California.

	February		March		April		June
Species	$\bar{x}$ length	Standard number	$\bar{x}$ length	Standard number	$\bar{x}$ length	Standard number	Standard number
S. cortezi	4.3	31	7.2	121	6.2	23	0
S. Type A	5.2	177	6.5	75	6.6	25	0

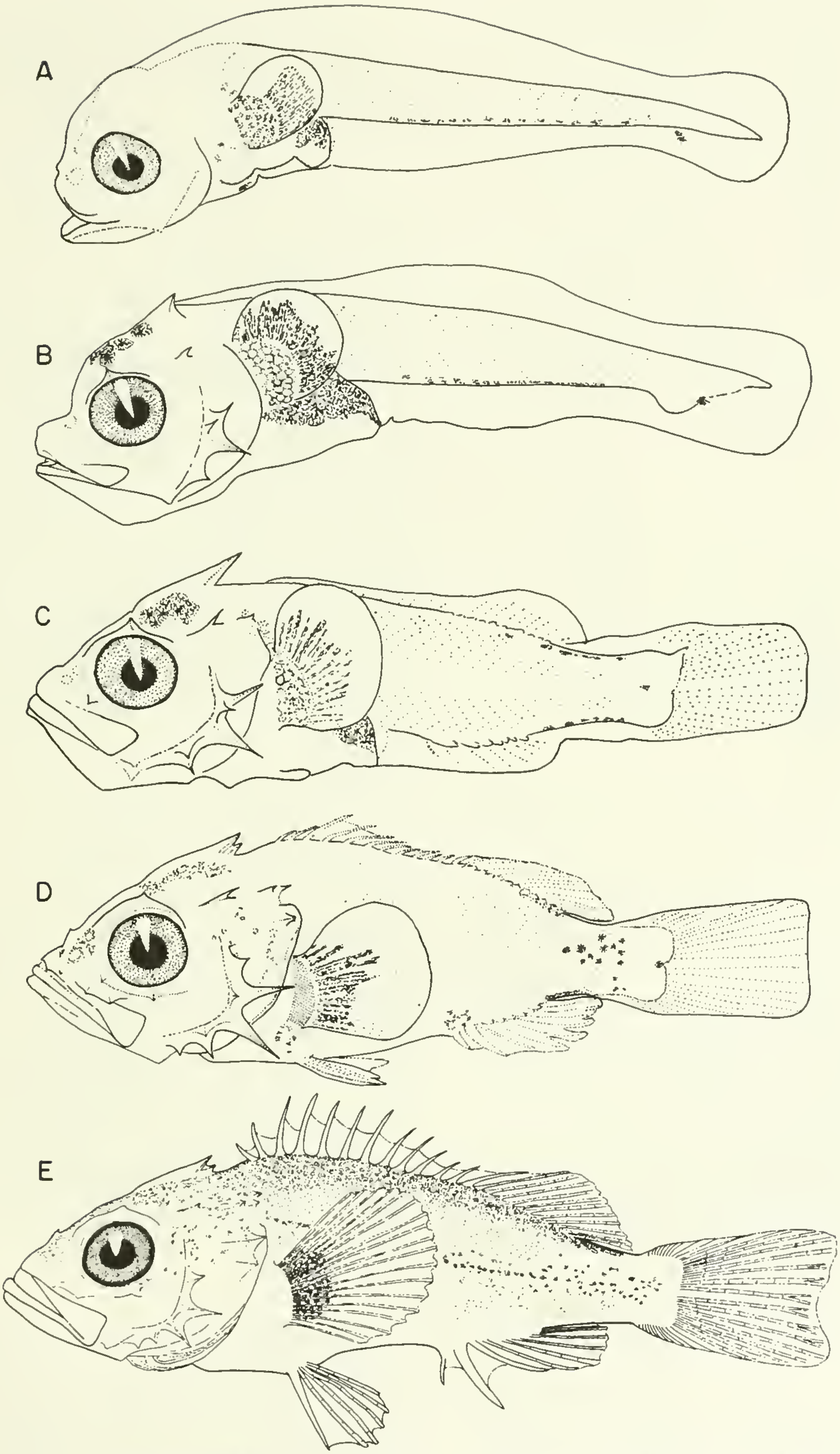

Figure 13.—Developmental series of *Sebastes cortezi*. A. 4.5-mm larva; B. 6.8-mm larva; C. 8.8-mm larva; D. 11.8-mm larva; E. 17.1-mm pelagic juvenile.

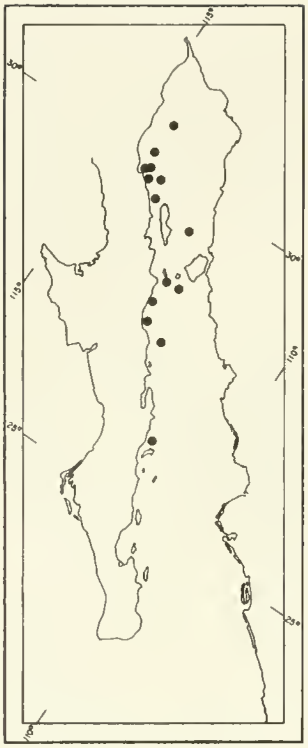

Figure 14.—Stations in the Gulf of California at which larvae of *Sebastes cortezi* were taken on CalCOFI cruises during 1956 and 1957.

***Sebastes* sp.—Gulf of California Type A, Figure 15**

Literature.—See previous species account.

Distinguishing features.—At birth, Type A larvae are 4.0 to 5.0 mm long. The maximum size obtained before transformation is not known since the largest larva in the collection is 10.8 mm.

Type A larvae, like those of *S. cortezi*, have short pectoral fins. Pectoral fin length is 6 to 9% of the body length before onset of notochord flexion, and thereafter increases to 20% in the longest larva (Table 19). At comparable sizes, the parietal spines are longer in Type A than in *S. cortezi*.

Type A larvae have a distinctive pattern of melanophores. As in *S. cortezi*, newborn larvae of Type A have a shield of pigment over the gut and a series of melanophores along the ventral midline of the tail (mean of 16 with a range of 12 to 21 for 13 larvae). Unlike *S. cortezi* larvae, those of Type A have a blotch of pigment at the symphysis of the lower jaw, that persists in larvae up to about 8 mm. The pectoral fins have fine melanophores distributed over the entire blade of the fin and have the medial surface of the fin base covered with large melanophores. At about 8 mm, pigment appears above the brain. No pigment forms on the dorsal surface of the tail as in *S. cortezi*. The pigment pattern is similar to that of the subgenus *Sebastomus* from outer coastal waters, suggesting that Type A larvae might be referable to *S.* (*Sebastomus*) *exsul.*

Table 19. Measurements (mm) of larvae of *Sebastes* sp. [Gulf of California Type A]. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
4.2	1.5	0.84	0.23	0.33	0.78	0.33	0.22	---	---
4 7	1.8	1.00	0.28	0.35	0.80	0.30	0.32	---	---
5.4	2.2	1.3	0.37	0.45	1.1	0.47	0.43	---	---
5.8	2.4	1.5	0.41	0.48	1.2	0.54	0.55	---	---
6.1	2.6	1.7	0.48	0.50	1.4	0.61	0.58	---	---
6.4	2.6	1.7	0.50	0.55	1.4	0.63	0.60	---	---
7.0	3.6	2.4	0.90	0.73	2.1	0.90	0.90	---	4.3
7.3	3.4	2.3	0.82	0.69	1.9	0.81	0.82	0.09	4.3
7.6	4.2	2.7	0.92	0.86	2.4	1.2	1.0	0.25	4.7
8.2	4.3	2.7	1.0	0.90	2.7	1.2	1.1	0.44	4.8
8.5	4.4	2.9	1.0	0.95	2.5	1.2	1.2	0.32	5.2
9.5	5.4	3.5	1.2	1.1	3.2	1.7	1.2	0.80	5.7
10.8	6.8	4.4	1.4	1.4	3.8	2.2	1.2	0.70	7.2

Distribution.—Eight CalCOFI cruises into the Gulf in 1956 and 1957 and an FAO cruise in March of 1972, provide information on the distribution and abundance of Type A larvae. Their latitudinal range, from Gonzaga Bay south to Concepcion Bay, is more constricted than that of *S. cortezi*, but they are not nearly so restricted to the western side of the Gulf as are larvae of *S. cortezi* (Fig. 16). Their heaviest concentration is around Tiburon and Angel de la Guarda islands in the upper Gulf. Table 18 shows that spawning occurs during the cold-water months with a possible peak in February.

***Sebastes marinus* (Linnaeus), Figure 17**

Literature.—The numerous descriptions and illustrations of intraovarian and planktonic larvae of North Atlantic *Sebastes* were cited above in the literature review for the genus. Those of Tåning (1961) are especially useful, since they incorporate observations on chromatophores that can only be made in live material. A series of illustrations from Tåning's (1961) paper are reproduced here. The larvae used for our study are from the *Dana* collections and were identified by A. V. Tåning, but Eschmeyer (pers. commun.) has suggested that the series may contain some specimens of *S. mentella* and that the identification should be considered tentative until additional material is available. These were measured to establish a table of morphometrics, which to our knowledge has not yet appeared in the literature. The following description, which includes morphometric and other previously overlooked characters, is intended as a supplement to the extensive literature on *S. marinus* larvae.

Distinguishing features.—At birth the larvae of *S. marinus* are considerably larger than those of the eastern Pacific species. A series of full-term intraovarian larvae ranged in length from 6.7 to 7.2 mm. Also, they reach a comparatively large size before undergoing a gradual transformation into pelagic juveniles. In the measured series the transition occurs at about 24 mm (Table 20).

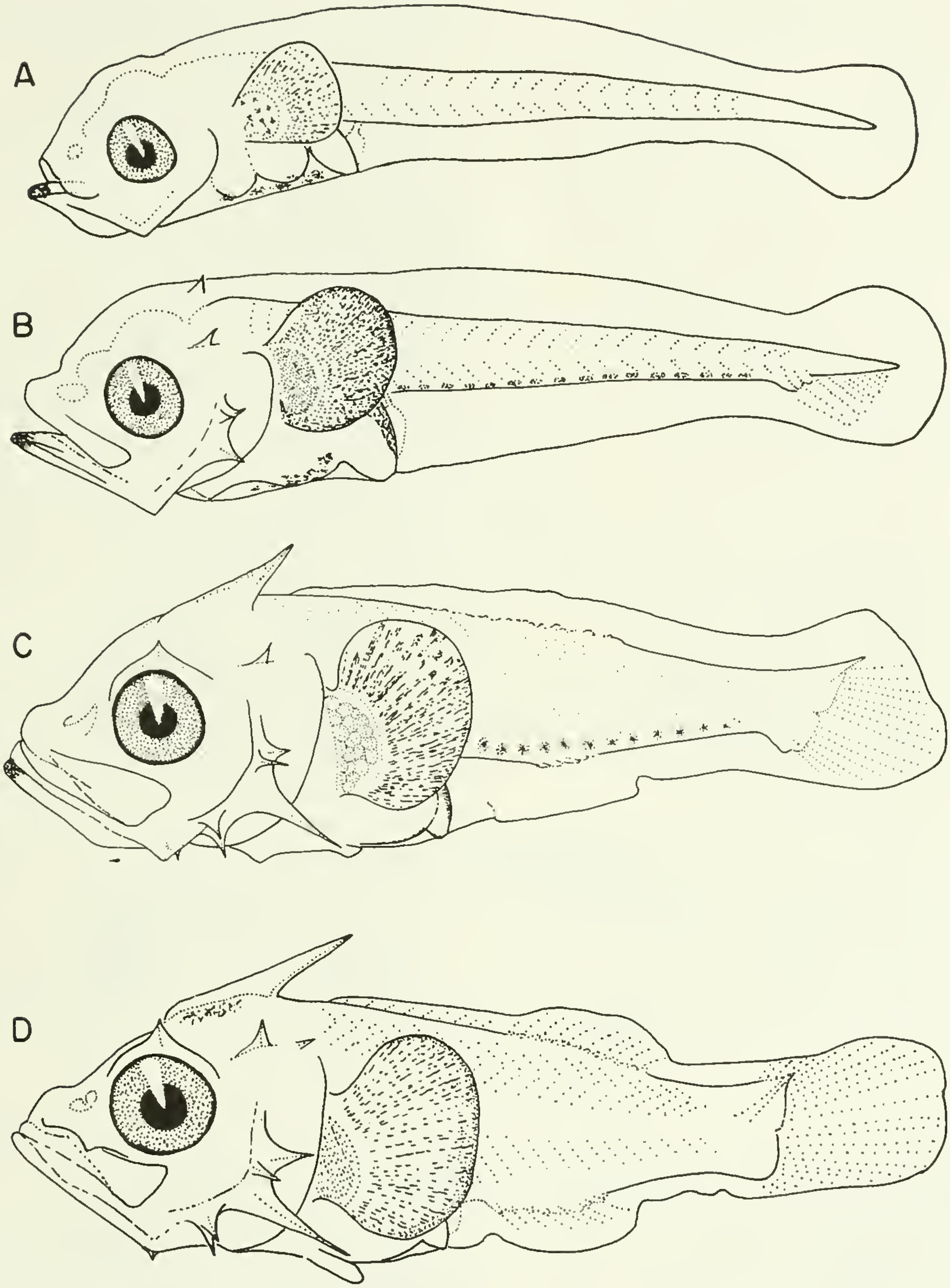

Figure 15.—Larvae of *Sebastes* Gulf of California Type A. A. 4.7 mm; B. 6.2 mm; C. 7.2 mm; D. 8.3 mm.

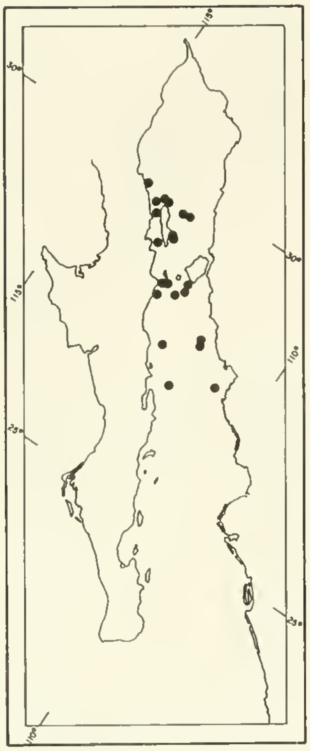

Figure 16.—Stations in the Gulf of California at which larvae of *Sebastes* Gulf of California Type A were taken on CalCOFI cruises during 1956 and 1957.

Table 20. Measurements (mm) of larvae of *Sebastes marinus*. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
7.1	2.2	1.2	0.33	0.51	1.3	0.18	0.26	---	---
7.3	2.9	1.8	0.50	0.66	1.4	0.50	0.55	---	---
8.1	2.9	1.8	0.48	0.73	1.4	0.58	0.61	---	---
8.5	3.2	2.1	0.55	0.78	1.6	0.68	0.66	0.04	4.5
9.0	3.8	2.5	0.73	0.87	1.9	0.75	0.74	0.06	4.1
9.3	3.9	2.5	0.68	0.86	1.8	0.74	0.75	0.09	5.3
9.6	4.0	2.7	0.75	0.91	1.9	0.82	0.80	0.12	5.6
10.0	4.5	2.8	0.93	1.0	2.2	1.0	0.82	0.15	5.7
10.6	4.8	3.2	1.0	1.1	2.3	1.1	0.87	0.18	6.0
11.0	5.2	3.3	1.0	1.2	2.3	1.2	1.0	0.20	6.2
11.3	5.8	3.7	1.2	1.2	2.6	1.4	1.0	0.40	6.8
11.8	6.4	4.0	1.2	1.3	3.1	1.5	1.0	0.41	7.4
12.7	7.0	4.2	1.3	1.5	3.2	1.8	1.2	0.60	7.8
13.5	7.3	4.5	1.5	1.5	3.4	2.0	1.2	0.75	8.2
14.4	8.3	4.8	1.5	1.8	4.0	2.2	1.3	1.2	9.0
15.0	8.8	4.9	1.6	1.7	3.9	2.3	1.3	1.2	9.4
16.6	9.8	5.8	2.0	1.9	4.3	2.6	1.3	1.5	10.3
17.2	10.0	5.8	1.7	2.2	4.2	3.2	1.4	1.8	10.5
18.4	10.2	5.8	1.7	2.3	4.6	3.3	1.4	1.9	10.6
19.3	11.0	6.6	2.1	2.4	4.9	3.5	1.6	2.1	11.7
20.5	11.7	6.7	2.0	2.4	4.9	3.8	1.5	2.3	12.3
22.3	12.8	7.1	2.1	2.6	5.2	4.2	1.7	2.8	13.4
*24.1	14.0	7.7	2.1	2.8	5.9	4.8	1.9	2.9	14.9
*26.0	15.4	8.7	2.4	3.0	6.5	5.8	2.1	3.6	16.2
*28.1	16.6	8.7	2.5	3.0	6.8	6.3	2.2	3.8	17.6
*30.4	18.2	9.4	2.9	3.2	7.7	6.8	2.3	4.3	19.3
*38.7	22.9	11.2	3.1	3.8	8.9	9.2	2.8	6.0	24.8

*Pelagic juvenile.

The larvae are more slender than all but the slenderest of eastern Pacific *Sebastes*, such as *S. jordani*, which they resemble in a number of other characters. Body depth averaged 18% of body length in preflexion larvae, 21% during flexion, and 25% in postflexion larvae and early pelagic juveniles.

The gut is compact and relatively shorter than most eastern Pacific *Sebastes*. In larvae less than 10 mm, the relative snout-anus length is equal to or less than in *Sebastes jordani* (Fig. 18). In developmental stages larger than this, relative snout-anus length is intermediate between *S. jordani* and the other eastern Pacific species measured. Snout-anus distance increases from an average of 35% of body length in preflexion larvae to 45% during notochord flexion, and further to 58% in postflexion larvae and small pelagic juveniles.

The head is relatively small as in other species of *Sebastes*. Head length averages 21% of the body length in preflexion larvae, 29% in larvae undergoing flexion, and 32% in postflexion larvae and small pelagic juveniles. Snout length averages 28% of head length in preflexion larvae, increases to an average of 31% in later larval stages, and then decreases slightly to an average of 29% in small pelagic juveniles. Relative eye diameter is greatest in preflexion larvae (mean of 40% of head length) and then decreases to a mean of 35% of head length in later developmental stages.

A prominent feature of *S. marinus* larvae is their relatively short rounded pectoral fins. Fin length averages 6% of body length before notochord flexion, 10% during flexion, 17% in postflexion larvae, and 22% in small juveniles. Relative fin length is less than in all eastern Pacific species studied with the exception of *S. jordani* which has similarly small pectorals (Fig. 19). Pelagic juveniles of *S. marinus* have a slightly longer pectoral fin than in pelagic juveniles of *S. jordani* (Fig. 19). The sequence of ossification of the pectorals and other fins could not be determined because of calcium leaching in the Formalin-preserved specimens.

The pigment pattern of *S. marinus* larvae is similar to that of other North Atlantic *Sebastes* species and is also similar to that of *S. jordani* of the eastern Pacific. Newborn larvae have a group of melanophores above the optic lobes of the brain, a melanistic shield over the dorsolateral surface of the gut, an embedded spot at the nape, and a series of melanophores along the ventral and dorsal midlines of the tail. The ventral row begins at the 4th to 7th postanal myomere and extends to the 19th to 22nd postanal myomere. In a sample of 18 full-term intraovarian larvae, the total number of melanophores in the ventral row ranged from 11 to 24 with a mean of 18.0 ± 4.07 SD. The dorsal row is shorter, beginning on the 10th to 15th postanal myomere and ending on the 18th to 22nd postanal myomere; the number of melanophores ranged from 8 to 21, with a mean of 13.1 ± 3.16 for the 18 specimens.

The ventral midline series of *S. marinus* is shorter and contains fewer melanophores than in larvae of the other North Atlantic species and in *S. jordani* of the Pacific. In 120 newborn specimens of the American form, the number of ventral melanophores ranged from 26 to 42 and in three newborn specimens of *S. viviparus* from the Faeroe Islands the number ranged from 18 to 29. In 15 specimens

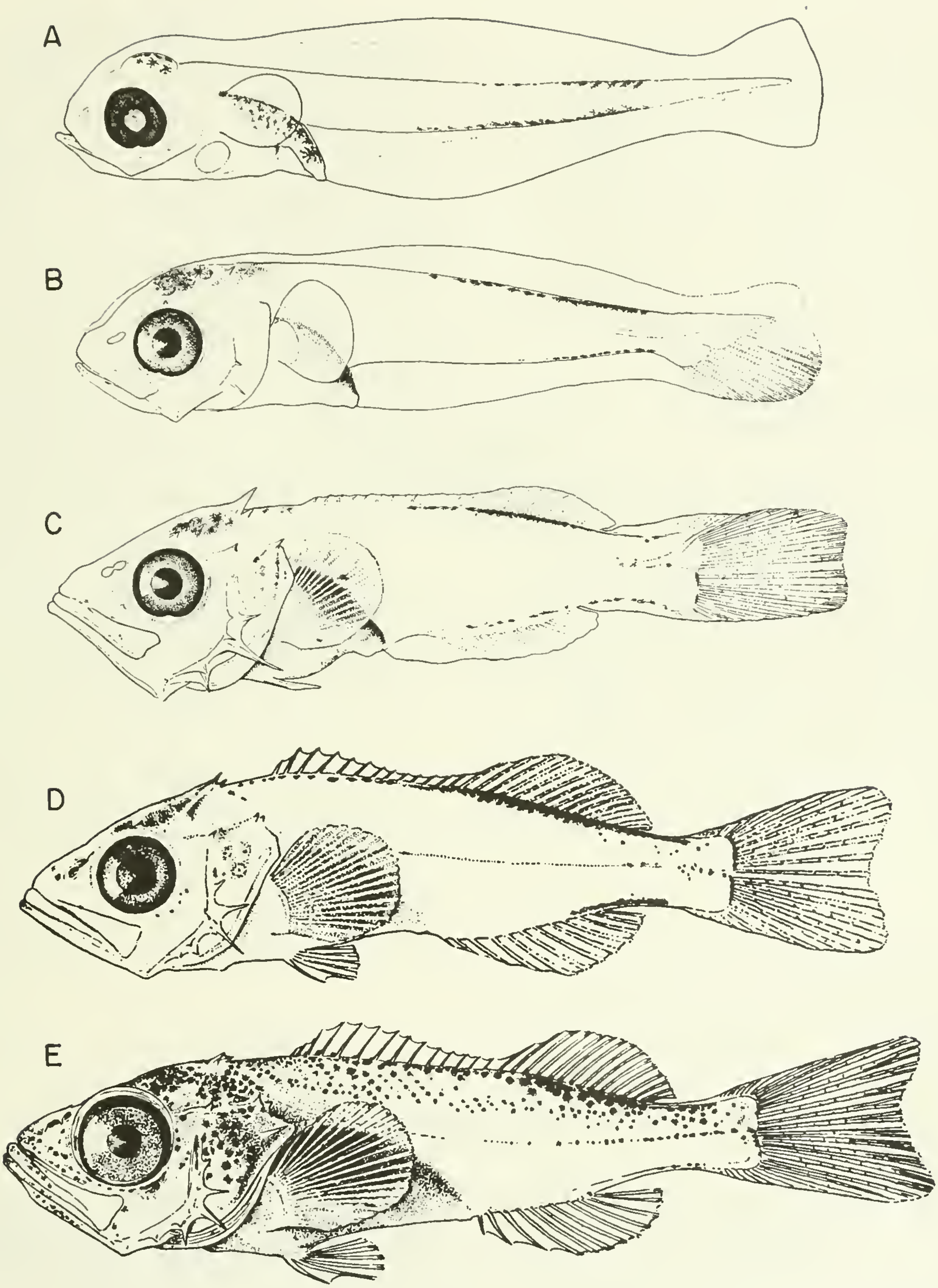

Figure 17.—Developmental series of *Sebastes marinus* from Táning (1961). A. 6.8-mm larva; B. 10.5-mm larva; C. 15.7-mm larva; D. 20.9-mm larva; E. 27.0-mm pelagic juvenile.

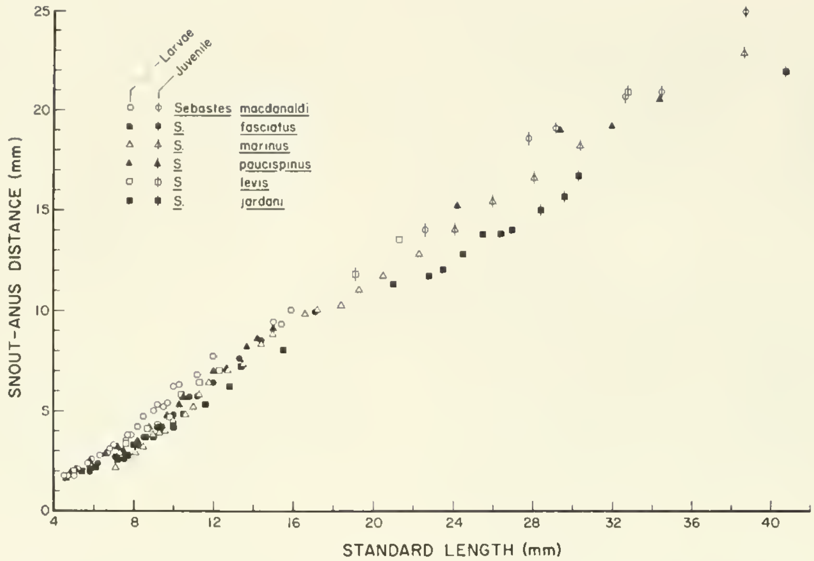

Figure 18.—Relation of snout-anus length to body length in developmental stages of *Sebastes* spp.

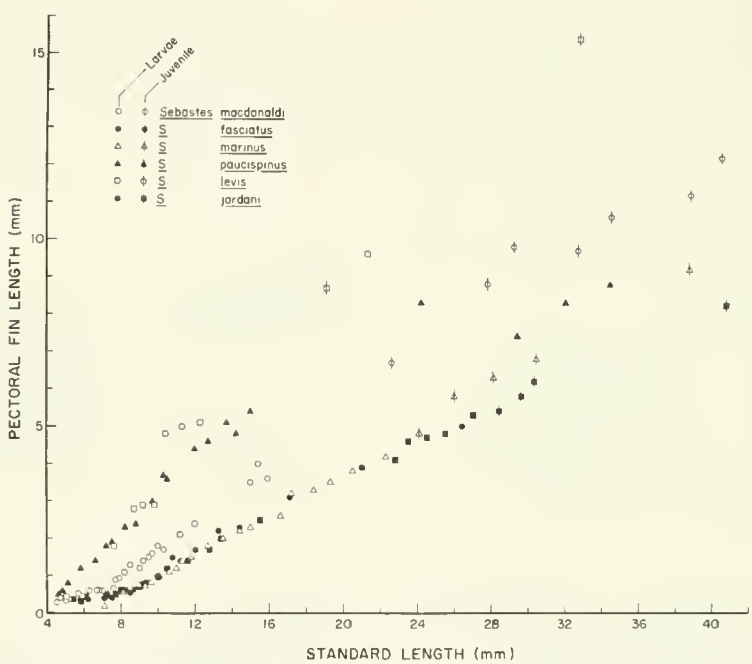

Figure 19.—Relation of pectoral fin length to body length in developmental stages of *Sebastes* spp.

of *S. jordani*, the number of ventral melanophores ranged from 21 to 27 with a mean of 23.7 ± 1.75 SD. Larvae of *S. marinus* differ also from those of the American form and *S. viviparus* in lacking the one to several caudal melanophores present in these latter species.

The dorsal and ventral midline pigment series of *S. marinus* larvae have opposite fates. The ventral series becomes embedded in the developing musculature and obscured by the developing anal fin. At the completion of notochord flexion only those melanophores posterior to the anal fin are visible. The dorsal series is augmented anteriad and in 9-mm larvae divides into two streaks, one on each side of the developing dorsal fin. When the larvae reach 14.5 mm the streaks extend anteriad along the entire dorsum.

In addition to the initial pigment pattern, melanophores are added gradually to the head region. In 9-mm larvae a pair of melanophores appears on the ventrolateral surface of the medulla, the olfactory region of the brain becomes covered with a patch of melanophores, and a pair of melanistic streaks appears along the premaxillaries. At about 11.0 mm, a melanistic patch appears on the opercle and enlarges with further development. At about 12.5 mm, a blotch appears at the symphysis of the lower jaw. In 15-mm larvae, blotches appear around the nares, ventroposterior to the eyes, and at the isthmus. At about 17.0 mm, melanophores cover most of the dorsal and lateral surfaces of the head.

On the body the initial pigment pattern is augmented by the appearance of melanophores at the posterior edge of the hypural plates in 9-mm larvae. At the completion of notochord flexion, the posterior edge of each hypural plate is outlined by a pigment streak. At about 10.0 mm, deeply embedded pigment begins to form along the dorsal aspect of the more posterior vertebral centra. This spreads anteriorly and at about 16.0 mm the dorsal aspect of the entire vertebral column is covered. At about 13.5 mm a line of melanophores forms along the posterior segment of the lateral line and extends progressively anteriad with further larval development. Also, each of the distal radial elements of the dorsal fin develops a melanistic spot as do the distal radials of the anal fin in 15-mm larvae.

The epaxial region of the trunk begins to be covered with melanophores in 16-mm larvae. These are concentrated along the myosepta. At about 24.0 mm the entire half of the trunk above the lateral line is covered, marking the transition to the pelagic juvenile phase. The pectoral and pelvic fins develop no melanistic pigmentation in larvae or pelagic juveniles.

Distribution.—The geographic and bathymetric distribution of *Sebastes* in the North Atlantic is the subject of an enormous literature and need not be discussed here. Much of the information on distribution of adults is summarized in Templeman (1959) and in the proceedings of an international symposium on redfish (Templeman 1961), although most of his references to *S. marinus mentella* refer to *S. fasciatus* (Eschmeyer, pers. commun.). The symposium proceedings also contain a summary of information on distribution of larvae (Einarsson 1961).

Sebastes viviparus (Krøyer), Figure 20

Literature.—Literature references on *S. viviparus* larvae were cited in the literature review for the genus. In the earlier literature, larvae of *S. viviparus* were sometimes confused with *S. marinus*. Templeman and Sandeman (1959) have reviewed this literature and attempted to correct the errors. The two most useful papers on *S. viviparus* larvae are by Tåning (1961) and Einarsson (1960). In these papers, larvae of *S. viviparus* and *S. marinus* are described and compared with emphasis on the differentiating characters of pigmentation and spination.

A series of larvae up to 10.6 mm was obtained from the collections of the *Dana* Expeditions and measured to provide a table of morphometrics for comparison with other North Atlantic species (Table 21). This is presented with a brief description that incorporates previously unreported characters together with those of Tåning (1961)

Table 21. Measurements (mm) of larvae of *Sebastes viviparus*. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
5.4	2.0	1.2	0.28	0.55	1.0	0.35	0.43	---	---
5.9	2.2	1.2	0.37	0.57	1.2	0.53	0.44	---	---
6.5	2.4	1.3	0.32	0.59	1.2	0.40	0.41	---	---
6.8	2.3	1.3	0.31	0.60	1.2	0.45	0.46	---	---
7.0	2.8	1.8	0.48	0.72	1.5	0.57	0.56	---	---
7.3	2.9	1.9	0.50	0.74	1.5	0.55	0.63	---	---
7.8	3.0	1.9	0.50	0.80	1.7	0.62	0.69	---	---
8.0	3.2	2.0	0.58	0.82	1.7	0.62	0.68	---	3.7
8.5	3.7	2.3	0.69	0.92	1.8	0.78	0.80	0.13	4.6
9.0	3.9	2.6	0.78	1.0	2.1	0.90	0.95	0.19	5.1
9.4	4.2	2.8	0.86	1.0	2.2	0.92	1.0	0.17	5.3
9.9	4.5	2.9	0.97	1.1	2.3	1.1	1.0	0.18	5.7
10.4	4.8	3.2	1.0	1.2	2.4	1.2	1.0	0.28	6.1
10.6	5.2	3.3	1.0	1.2	2.6	1.2	0.90	0.23	6.2

Distinguishing features.—*Sebastes viviparus* larvae are born at a size 1 to 2 mm smaller than *S. marinus* larvae. Tåning (1961) illustrated a 5.8-mm full-term intraovarian larva of *S. viviparus*; the smallest planktonic larvae in our series was 5.4 mm. Other developmental events also occur at a smaller size in *S. viviparus* compared with *S. marinus*. Notochord flexion begins at about 7.8 mm in our series and is completed at about 10.6 mm. In *S. marinus* it begins at about 8.5 mm and is completed at about 11.8 mm. Einarsson (1960) and Tåning (1961) pointed out that development of the head spines, particularly the preopercular series, is at a relatively advanced state in *S. viviparus* larvae of the same size as those of *S. marinus*. The size at transformation into the pelagic juvenile stage cannot be ascertained from our series since the largest larva is 10.6 mm. There are no literature references to size at transformation for this species.

Developmental changes in body proportions follow those of *S. marinus* with some apparent differences in mean values for the principal larval stages. Means for relative eye diameter, body depth, and pectoral fin base depth are greater than in *S. marinus* for preflexion larvae and larvae undergoing notochord flexion (Table 22).

The pattern of melanistic pigmentation is similar to that of *S. marinus*; however, the presence of one or more caudal melanophores in *S. viviparus* larvae separates this species from *S. marinus* (Templeman and Sandeman 1959; Einarsson 1960; Tåning 1961). The incompleteness of our series precludes a thorough comparison of pigment pattern in *S. viviparus* with those of other North Atlantic species, but, we have discovered some previously unreported differences.

Pigment features develop in smaller sized larvae of *S. viviparus* compared with *S. marinus*. Several heretofore unreported features begin to appear in larvae about 6.0 mm long. A group of melanophores form at the tip of the snout and remain prominent up to the termination of our series at 10.6 mm. Although a melanophore may be present in this region in occasional specimens of *S. marinus*

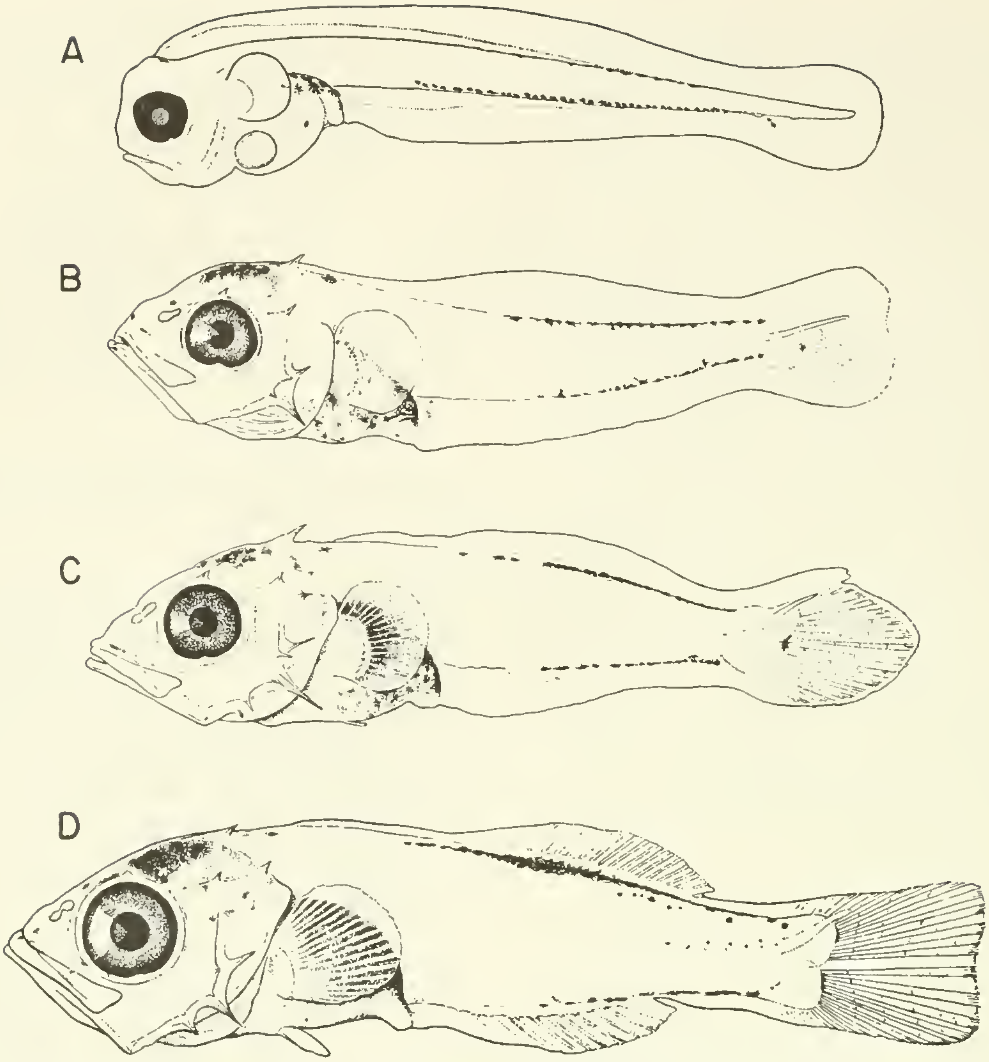

Figure 20.—Larvae of *Sebastes viviparus* from Tåning (1961). A. 5.8 mm; B. 8.9 mm; C. 10.1 mm; D. 13.5 mm.

TABLE 22. Morphometric comparison of larvae of three species of Sebastes from the North Atlantic. Mean percentage and range of body proportions are given for preflexion (A), flexion (B), and postflexion (C) larvae. Measurements in mm.

Sebastes		Snout-anus distance / SL		Head length / SL		Snout length / Head length		Eye diameter / Head length		Body depth / SL		Pectoral fin length / SL		Pectoral fin base depth / SL		Pelvic fin length / SL		Snout-anal fin distance / SL	
		x̄ ± SD	Range	x̄ ± SD	Range	x̄ ± SD	Range	x̄ ± SD	Range	x̄ ± SD	Range	x̄ ± SD	Range	x̄ ± SD	Range	x̄ ± SD	Range	x̄ ± SD	Range
	A	37.2±2.6	34-40	22.0±2.6	19-26	27.6±2.9	23-31	42.8±3.3	38-46	18.4±3.5	13-22	6.2±0.4	6-7	6.7±1.5	6-9	- -	-	- -	-
fasciatus	B	46.0±2.0	44-48	29.0±2.0	27-31	30.0±2.6	28-33	37.7±3.1	35-41	24.7±1.1	24-26	8.0±2.0	6-10	8.3±0.6	8-9	1.6±0.6	1-2	57.3±3.1	54-60
	C	55.2±3.2	51-59	32.7±1.2	31-34	31.0±2.1	27-33	34.8±1.6	33-37	28.2±1.7	26-31	15.3±2.0	13-18	8.7±0.5	8-9	6.8±3.4	3-12	60.2±3.1	58-61
	A	35.7±4.5	31-40	21.3±4.0	17-25	27.7±0.6	27-28	40.3±3.1	37-43	18.0±1.0	17-19	5.7±2.3	3-7	6.7±2.3	4-8	- -	-	- -	-
marinus	B	45.1±5.0	38-54	29.2±2.9	25-34	30.3±3.1	26-36	34.6±1.6	32-37	21.4±2.2	19-26	9.9±1.8	8-13	8.2±0.4	8-9	1.7±1.1	0.5-4	56.3±4.7	53-63
	C	56.9±1.7	54-59	33.2±0.9	32-35	31.2±1.7	29-34	36.2±2.2	33-40	25.1±1.4	23-28	16.8±2.0	14-19	8.3±0.7	7-9	9.1±2.4	5-13	61.0±1.5	58-63
	A	37.5±2.6	34-40	22.2±3.1	19-26	26.0±2.8	24-31	44.0±3.6	39-48	19.5±1.4	18-21	7.3±1.2	6-9	7.5±1.0	6-9	- -	-	- -	-
viviparus	B	43.7±3.4	38-49	28.2±2.7	24-31	30.0±2.0	26-33	38.6±2.2	36-42	22.6±1.3	21-25	9.9±1.5	8-12	9.6±1.1	8-11	2.2±0.4	2-3	55.4±4.5	46-59
	C	- -	-	- -	-	- -	-	- -	-	- -	-	- -	-	- -	-	- -	-	- -	-

and the American form, larvae of these species lack the obvious patch of melanophores that is present in *S. viviparus*. Gut pigmentation is slightly different in *S. viviparus* larvae compared with the other species. The dorsolateral surfaces of the gut are covered with a melanistic shield as in the other species; however, in *S. viviparus* a covering of less densely distributed melanophores extends ventrad over the ventral surface of the gut. The ventral surface of the gut is unpigmented at comparative larval stages in *S. marinus* and *S. fasciatus*.

The most outstanding difference in pigmentation is in the pectoral fins. *Sebastes marinus* and *S. fasciatus* lack pectoral fin pigment throughout the larval period while *S. viviparus* larvae have distinctive pectoral fin pigment. At about 6.0 mm, the medial surface of each fin base begins to develop a covering of melanophores, which remains throughout the larval stages available to us. Also, a series of fine melanophores forms along the bases of the rays and may extend distally for a short distance between the rays in some specimens. This character should be of considerable help in separating larvae of *S. viviparus* from those of other North Atlantic species.

The few early larvae of *S. viviparus* available to us precludes analysis of the number of melanophores in the ventral midline series. Of the three smaller larvae counted, the ventral row began on the 3rd or 4th postanal myomere and terminated on the 19th or 21st myomere. The number of melanophores ranged from 18 to 29 with a mean of 25. This suggests that the mean number of melanophores is greater in *S. viviparus* than in *S. marinus*, a supposition that can only be verified by analysis of an adequate sample of intraovarian larvae.

Distribution.—See Templeman (1961).

Sebastes fasciatus (Storer), Figure 21

Literature.—Bigelow and Welsh (1925) briefly described and illustrated a series of *Sebastes* larvae from the Gulf of Maine. Barsukov (1968, 1972) and Barsukov and Zakharov (1972) have established that the common form of this region is specifically distinct and should be referred to as *S. fasciatus* Storer. This is confirmed by Eschmeyer's recent work on gas bladder myology (cited in Hallacher 1974). A larval series of *Sebastes* (Table 23) collected off New England from lat. 38°52'N to lat. 44°22'N by the NMFS Laboratory, Narragansett, is described briefly below and compared with those of *S. marinus* and *S. viviparus*.

Distinguishing features.—It would appear that larvae of this form are born at a smaller size than those of *S. marinus* (Tables 17, 20); however, judging from the appearance of our small specimens of *S. fasciatus*, this difference could be a result of shrinkage in preservative. Larvae of both forms begin notochord flexion at about 8.5 mm; however, flexion is completed at 10.0 mm length in *S. fasciatus* and at about 11.8 mm in *S. marinus*. Information on the size of transformation is not available since the largest larva is 17.1 mm.

Developmental changes in body proportions follow closely those of *S. marinus* and need not be repeated here (Tables 20, 23). One feature which appears to differ is relative body depth. Table 22 shows that mean relative body depth is greater during the three larval phases in *S. fasciatus* than in *S. marinus*. Mean relative eye diameter is greater in *S. fasciatus* than in *S. marinus* for preflexion larvae and larvae undergoing flexion, but is less in postflexion larvae. Mean relative pectoral fin length is greater in *S. fasciatus* than in *S. marinus* in preflexion larvae but is less during and after flexion.

Pigmentation is similar to that of *S. marinus*; however, analysis of our specimens has revealed some differences which have not been previously reported. As in *S. marinus* larvae, the initial pigment pattern consists of a group of melanophores above the brain, a gut shield, an embedded spot at the nape, and a series of melanophores along the dorsal and ventral midlines. There appears to be a difference in the number of melanophores composing the ventral midline series of *S. marinus* and *S. fasciatus* larvae. Ventral melanophores were counted in 10 late-stage intraovarian larvae from each of 12 females of *S. fasciatus* taken in the Gulf of Maine. The mean numbers of melanophores for the 12 samples were as follows: 31.4, 32.2, 32.6, 32.8, 32.8, 33.3, 34.9, 35.2, 35.5, 37.5, 38.3, 40.4. The range for all specimens was 26 to 42. In a sample of 18 *S. marinus* larvae of comparative developmental stage from Greenland, the mean was 18.0 with a range of 11 to 24. Also, the ventral pigment line is relatively longer in *S. fasciatus*, beginning on the 1st to 4th (mean of 2.9 ± 0.40 SD for 112 specimens) postanal myomere and ending on the 19th to 23rd (mean of 21.3 ± 0.85) postanal myomere. In the sample of *S. marinus* the series begins on the 4th to 7th (mean 5.4 ± 0.78 for 18 specimens) postanal myomere and ends on the 19th to 22nd (mean of 20.9 ± 0.86) postanal myomere. The dorsal midline row appears to contain fewer melanophores in *S. fasciatus* compared with *S. marinus*. Mean counts for the 12 samples are: 3.0, 5.4, 6.6, 6.9, 7.2, 7.2, 7.3, 7.6, 7.9, 8.0, 8.6, 9.1. In the sample of *S. marinus* the mean was 13.1 with a range of 8 to 21. In the samples of *S. fasciatus* the dorsal series began on

Table 23. Measurements (mm) of larvae of Sebastes fasciatus. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
5.8	2.0	1.1	0.25	0.51	1.0	0.35	---	---	---
6.2	2.4	1.3	0.36	0.58	1.1	0.36	0.40	---	---
7.1	2.7	1.6	0.44	0.71	1.4	0.40	0.42	---	---
7.5	2.6	1.6	0.44	0.66	1.5	0.42	0.43	---	---
8.2	3.3	2.1	0.65	0.80	1.8	0.61	0.72	0.07	4.2
8.5	3.7	2.3	0.77	0.95	2.0	0.55	0.67	0.11	4.6
9.2	4.2	2.7	0.75	1.0	2.2	0.76	0.80	0.15	5.5
10.0	4.8	3.1	0.90	1.1	2.6	1.0	0.85	0.25	5.8
10.8	5.7	3.4	1.1	1.2	3.0	1.5	1.0	0.42	6.3
11.2	5.7	3.6	1.1	1.2	2.9	1.4	1.0	0.37	6.8
12.0	6.4	3.8	1.2	1.4	3.4	1.7	1.1	0.55	7.1
13.3	7.6	4.4	1.2	1.6	3.9	2.2	1.2	1.1	8.1
14.4	8.5	4.9	1.6	1.7	3.9	2.3	1.2	1.3	8.8
17.1	9.9	5.8	1.8	1.9	4.8	3.1	1.4	2.1	10.5

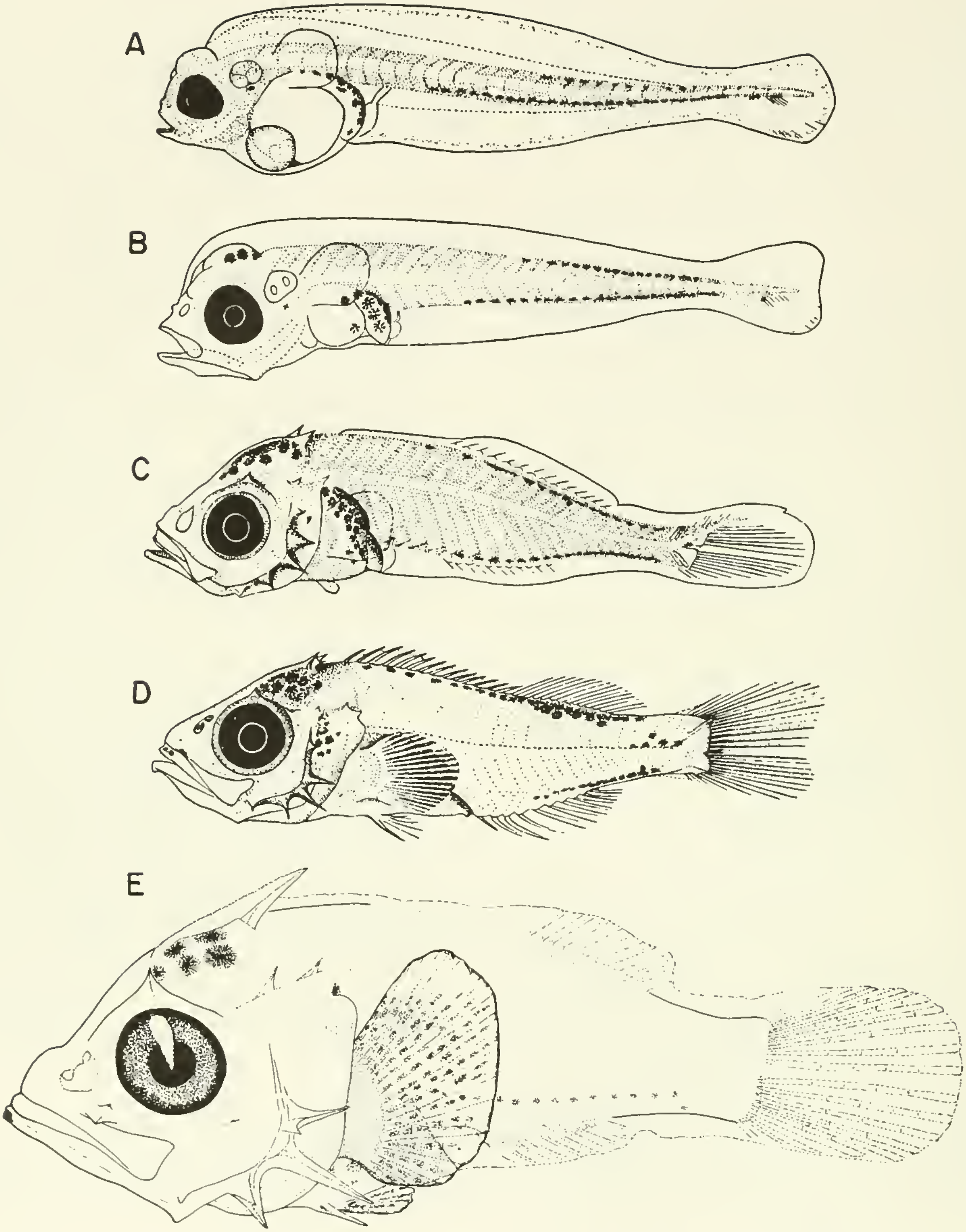

Figure 21.—Larvae of *Sebastes fasciatus* (A-D) from Bigelow and Welsh (1925) and a larva of *Sebastes capensis* (E). A. 6 mm; B. 9 mm; C. 12 mm; D. 20 mm; E. 7.2 mm.

the 7th to 14th (mean of 10.9 ± 1.35 for 111 specimens) postanal myomere and ended on the 14th to 22nd (mean of 19.1 ± 1.19 for 110 specimens) postanal myomere. In *S. marinus* the series began on the 10th to 15th (mean of 12.7 ± 1.41) postanal myomere and ended on the 18th to 22nd (mean of 20.3 ± 1.08) postanal myomere. In contrast to the ventral row in which the number of constituent melanophores is fixed during late intraovarian life, the dorsal row is gradually augmented before and after birth. The fact that the sample of *S. marinus* larvae was further advanced than any of the broods of *S. fasciatus* studied may account for the greater number of dorsal melanophores in the former. Consequently, a detailed study of comparable pre- and postnatal larvae of the two species would be necessary to evaluate the utility of this character in separating their larvae.

A well-known difference in the initial pigment pattern of the two larval types is the presence of one or more melanophores at the caudal region in *S. fasciatus* and the absence of caudal melanophores in most larvae of *S. marinus* (Templeman and Sandeman 1959). Caudal melanophores were present in all intraovarian larvae of *S. fasciatus* studied. The frequency was as follows: 40 larvae had 1 melanophore, 64 had 2, 14 had 3, and 2 had 4.

The subsequent development of pigment pattern in larvae of *S. fasciatus* is similar to that in *S. marinus*, although a number of differences are apparent. The ventral midline series becomes embedded gradually but some melanophores remain along each side of the base of the anal fin even in our largest larvae. In *S. marinus* larvae the developing anal fin obscures the ventral midline series and the remnants are visible only posterior to the fin in larvae longer than 11.8 mm. The dorsal midline series extends anteriad and splits into two lines with the developing dorsal fin between. The entire dorsum is spanned when the larvae are about 10.8 mm. In *S. marinus* larvae the entire dorsal midline is not spanned until the larvae reach about 15.0 mm.

The appearance of pigment characters at a smaller size (usually 1 to 3 mm smaller) in larvae of *S. fasciatus* compared with *S. marinus* larvae is a general developmental feature. For instance, pigment appears above the olfactory region of the brain in *S. fasciatus* larvae about 7.0 mm long and in *S. marinus* larvae about 9.3 mm long.

Another difference is the absence of certain pigment characters in *S. fasciatus* larvae and their presence in *S. marinus* of comparative size. Pigment does not appear on the isthmus, ventroposterior to the eye, and on the distal radials of the anal fin in *S. fasciatus* larvae of the size range studied, while in *S. marinus* larvae, these pigment features appear at about 15.7 mm. A more complete series of *S. fasciatus* larvae will be necessary to ascertain at what size these features appear or whether they appear at all.

Distribution.—Information on the geographic and bathymetric distributions of *S. fasciatus* is given by Templeman (1959).

Sebastes capensis (?) (Gmelin), Figure 21E

Literature.—Larvae of *Sebastes* from the Southern Hemisphere have not been previously described. The taxonomic status of this genus in the Southern Hemisphere is confusing, and Chen (1971) in his review of the subgenus *Sebastomus*, to which the southern forms belong, lumped the 11 nominal species into one. Eschmeyer and Hureau (1971) and Eschmeyer (pers. commun.), after examining specimens in South American museums, feel that there are at least three species off Chile. A total of 13 larval specimens from off Chile are available—five from the Marchile VI Expedition, six from Piquero IV, and two large specimens dip netted under a night-light in Valparaiso Harbor by Richard McGinnis of Pacific Lutheran University. Although some of these specimens are in poor condition and the series is incomplete, a brief description of them accompanied by an illustration serves as a basis for comparison with *Sebastes* from other regions of the world's oceans.

Distinguishing features.—Newborn larvae are small (about 3.8 mm), a feature which agrees with *Sebastes* larvae of the northeastern Pacific, and particularly the subgenus *Sebastomus* (Fig. 1). The larvae attain a large size, since the 19.6-mm dip net specimen is just beginning to transform.

Morphometric information on this species is incomplete because of the brevity of the developmental series (Table 24). The proportions generally follow those of other species, however, the depth of the pectoral fin base appears to be slightly greater in this species than in others measured, with a mean of 12.4% of the body length and a range of 8 to 17% for the seven larvae measured.

Pigmentation is similar to many of the *Sebastomus* species of the northeastern Pacific. Initially, the larvae have a spot above the nape, a spot on each side of the medulla, a group of melanophores at the symphysis of the lower jaw, a melanistic shield dorsolaterally on the gut, a group of melanophores on the ventral surface of the gut, and a series of melanophores along the ventral midline of the tail. The number of melanophores in the ventral midline ranged from 15 to 19 in four small larvae. The pectoral fins are distinctly pigmented with a group of melanophores on the medial surface of the fin base and melanophores distributed over the blade of the fin.

One or more melanophores lie above the optic lobes of the brain in larvae 4.6 mm and longer. As the pectoral fin

Table 24. Measurements (mm) of larvae of *Sebastes capensis*. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
3.8	1.5	0.80	0.19	0.35	0.85	0.33	0.32	---	---
4.6	1.8	1.1	0.36	0.43	1.2	---	---	---	---
5.5	2.6	1.8	0.60	0.59	1.7	0.62	0.72	0.05	---
6.2	2.8	1.9	---	---	1.8	0.77	0.75	0.06	3.7
7.0	3.7	2.3	0.83	0.93	2.6	1.3	1.1	0.28	4.3
7.2	4.0	2.7	0.93	0.94	2.7	1.3	1.2	0.65	4.3
14.8	8.9	5.6	1.5	1.7	5.5	3.8	1.7	2.5	9.4
19.6	12.0	7.1	2.1	2.1	6.9	5.3	2.0	3.7	12.8

rays differentiate, the melanophores become restricted to the interradial membrane and the distal margin of the pectoral fin develops a melanistic outline. The 7.2-mm larva has added a melanophore above the olfactory lobes, a spot on the ventrum at the juncture of the cleithra, and a covering of melanophores on the pelvic fins.

The gap in the series between 7.2 and 14.8 mm prevents study of pigment changes in this size range. The 14.8- and 19.6-mm specimens are pigmentless except for a wide band of melanophores on the caudal peduncle. Interestingly, many and possibly all species of *Sebastomus* from the northeast Pacific have a caudal peduncle band at this stage.

Fin counts on the two dip net specimens (dorsal, XIII, 13; anal, III, 6; pectoral, 18) fit known meristics for *S. capensis*. A count of 42 lateral line pores on the 19.6-mm specimen falls within the range for *S. capensis*.

Distribution.—Chen (1971) summarized the distributional information on this species.

Sebastes—Northwestern Pacific Species, Figure 22

Literature.—According to Chen (pers. commun.) there are 31 species of *Sebastes* in the northwestern Pacific. Life history series have been published on eight of these.

Fujita (1957) reared larvae of *S. pachycephalus nigricans* which had been extruded spontaneously by a captive pregnant female. The larvae were fed brine shrimp nauplii and kept at 16.4° to 18.8°C for 1 mo. The larval series was described and illustrated.

Fujita (1958) obtained a series of developing embryos of *S. oblongus* from two pregnant females maintained in an aquarium at 13.5° to 18.0°C. Larvae from one female were reared at 16° to 18°C on a diet of brine shrimp nauplii for 30 days until fin formation was completed. The series of developing embryos and larvae was described and illustrated.

Uchida et al. (1958) described and illustrated three specimens of *S. hubbsi* taken from plankton hauls.

Shiokawa and Tsukahara (1961) obtained a series of embryos of *S. pachycephalus pachycephalus* from captive females and then reared the larvae for 25 days at 15°C on a diet of brine shrimp nauplii. The embryos and larvae were described and illustrated as were demersal juveniles up to about 25-mm length netted from shallow water.

Harada (1962) described and illustrated a series of *S. inermis* that included late preextrusion larvae taken from pregnant females, larvae collected by plankton net, and juveniles up to about 60 mm in length.

Takai and Fukunaga (1971) followed development of embryos in a captive female of *S. longispinus* and reared the larvae for 30 days on a diet of brine shrimp and *Tigriopus* nauplii. The embryos and larvae were described and illustrated.

Sasaki (1974) removed late preextrusion larvae from freshly killed females of *S. schlegeli*, *S. steindachneri*, and *S. taczanowskii*. He summarized morphological and pigmentary characters of 20 specimens of each species and illustrated a specimen of each.

Distinguishing features.—Larvae of *S. oblongus* hatch at a total length of 7.25 mm or 6.5 mm notochordal length.[4] This is 1 mm larger than any eastern Pacific species described and slightly less than the range of *S. marinus* of the Atlantic. The most outstanding feature of *S. oblongus* larvae is the pattern of melanistic pigment, which begins to form well before hatching. Melanophores first appear as a shield over the dorsal surface of the gut, then patches form on the dorsal surface of the head, on the trunk above the gut, and as a band on the tail. At hatching, melanophores are continuous from the head to the broad tail band and they also appear on the ventral surface of the gut. The pectoral fins are unpigmented. With further development, pigment forms on the preopercular region of the head, along the jaws, the bases of the pectoral fins, and the tail band extends anteriorly and posteriorly. At notochord flexion the larvae are covered with melanophores except for the distal half of the pectoral fin blade and the caudal region (Fig. 22A). Larvae of *S. oblongus* differ from eastern Pacific and Atlantic species in their extraordinarily heavy pigmentation and in not developing the series of ventral midline melanophores on the tail.

Larvae of *S. longispinis* are spawned at about 5.3 to 5.5 mm notochordal length which is equivalent to *S. jordani*, the largest eastern Pacific species at hatching. Interestingly, the brood of *S. longispinis* studied by Takai and Fukunaga (1971) hatched as embryos within the ovary at about 3.1 mm notochordal length. Although this may have resulted from stress during captivity, it further strengthens the view that hatching occurs within the ovary in *Sebastes* and not after extrusion as stated by some authors (e.g., Morris 1956; Waldron 1968). The development of the pattern of melanistic pigmentation is almost identical to that in *S. oblongus* (Fig. 22B). The only difference appears to be in the absence of pigment on the distal portion of the pectoral fin base and on the blade of the fin.

Larvae of *S. hubbsi* represent a third member of this heavily pigmented group of Japanese *Sebastes*. The smallest of the three planktonic specimens described by Uchida et al. (1958) was a newborn larva 4.2 mm in notochordal length, indicating that larvae of this species are born at a length 1 mm smaller than larvae of *S. longispinis* and about 3 mm smaller than *S. oblongus*. The pigment pattern develops almost identically to that in the other two species, but differs chiefly in the sparse pigmentation of the pectoral fin base and in the development of evenly distributed minute melanophores on the blade of the pectoral fin (Fig. 22C).

[4]It is customary in Japanese descriptions of fish larvae to give body length as total length, including the finfold. Since we use notochordal length in preflexion larvae, the total lengths were converted to notochordal length by measuring notochordal and total lengths on the illustrations and multiplying the resultant conversion factor by the actual total length given for the specimen.

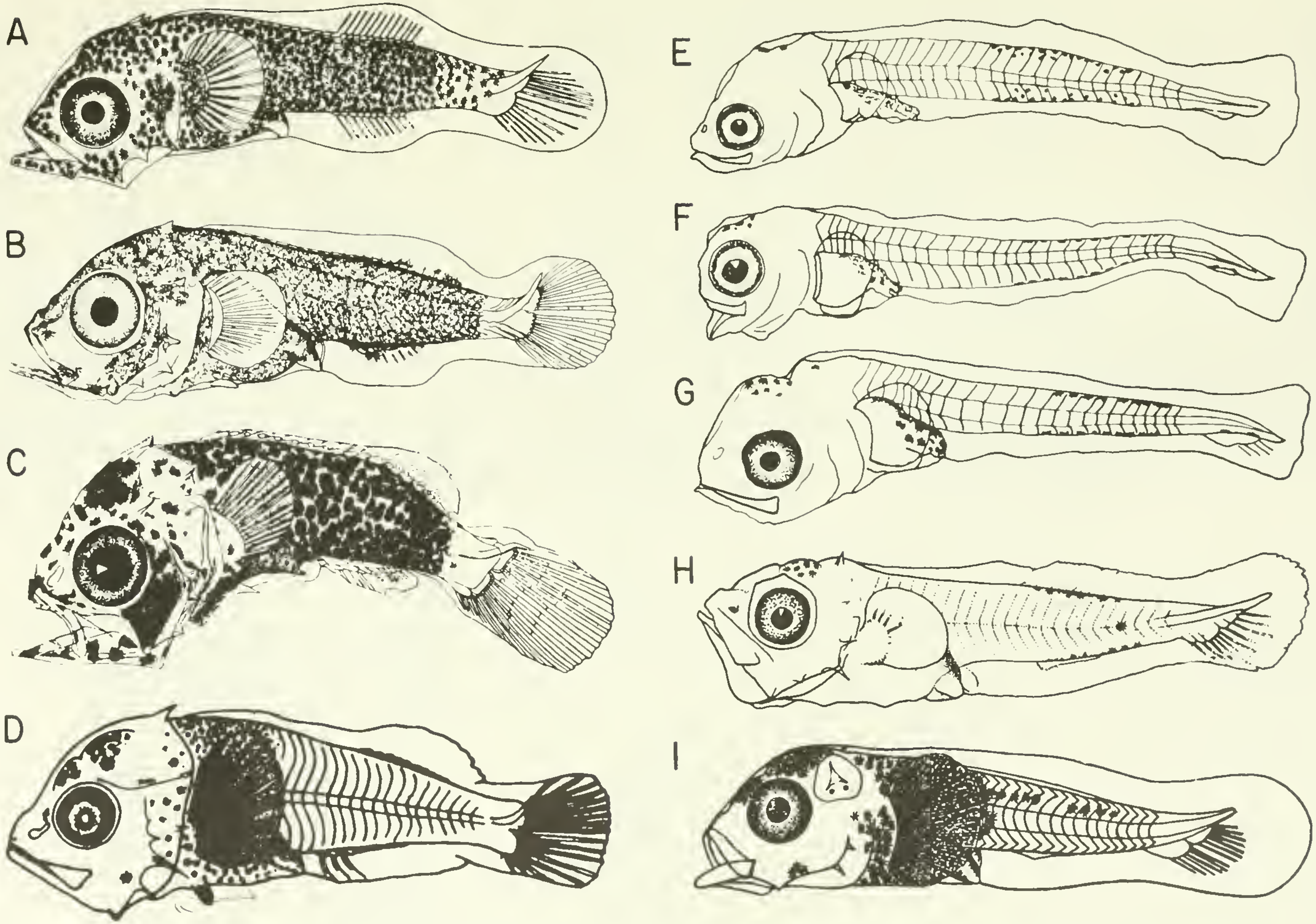

Figure 22.—Larvae of Japanese species of *Sebastes*. Measurements are total length. A. *S. oblongus*, 8.50 mm (from Fujita 1958); B. *S. longispinis*, 7.06 mm (from Takai and Fukunaga 1971); C. *S. hubbsi*, 6.03 mm (from Uchida et al. 1958); D. *S. pachycephalus pachycephalus*, 8 mm (from Shiokawa and Tsukahara 1961); E. *S. steindachneri*, 3.76 mm (from Sasaki 1974); F. *S. taczanowskii*, 4.50 mm (from Sasaki 1974); G. *S. schlegeli*, 5.69 mm (from Sasaki 1974); H. *S. inermis*, 7.1 mm (from Harada 1962); I. *S. pachycephalus nigricans*, 7.15 mm (from Fujita 1957).

A second type of *Sebastes* larva is represented by the subspecies *S. p. pachycephalus* and *S. p. nigricans*. Larvae of the two subspecies are extruded at lengths of 5.5 to 6.4 mm and 6.2 to 6.3 mm notochordal length, respectively, slightly larger than in eastern Pacific species. They also develop a striking pattern of melanophores. The first pigment to appear in embryos is a patch over the dorsal surface of the gut and a patch directly above this over the trunk. With further embryonic development, a large patch forms on the dorsal surface of the head and the base and blade of the pectoral fin is covered solidly with melanophores. As in the *S. oblongus* group, larvae of *S. pachycephalus* do not develop the series of ventral midline melanophores that is present in eastern Pacific and Atlantic *Sebastes*. At hatching, the heavy trunk band is augmented and melanophores have spread to the lateral and ventral surfaces of the gut. With further development, melanophores are added to the opercular region and the pectorals become solidly black.

The two subspecies differ in the pigmentation of the trunk and tail. Larvae of *S. p. pachycephalus* augment the anterior trunk band throughout larval development but develop no pigmentation on the posterior trunk and tail (Fig. 22D). Late in the larval period, two wide bands develop on the tail, one below the soft dorsal fin and one at the caudal peduncle. In preflexion larvae of *S. p. nigricans*, a line of melanophores extends posteriorly from the heavy trunk band to the caudal region (Fig. 22I). In later larval stages, melanophores are added to the lateral trunk and tail to form a continuous mass of pigment along the lateral body surface. The pelvic fins are solidly pigmented in both subspecies.

A third type of pigment pattern in Japanese *Sebastes* larvae is similar to that found in some species of the eastern Pacific and Atlantic. Late intraovarian larvae of *S. steindachneri* (Fig. 22E), *S. taczanowskii* (Fig. 22F), and *S. schlegeli* (Fig. 22G) all have a row of melanophores on the ventral midline of the tail, an opposing row along the dorsal midline, a patch on the dorsal surface of the brain, and a solid shield over the gut. They differ in the number of melanophores in each of the rows. Mean values for the number in the vental row of *S. steindachneri*, *S. taczanowskii*, and *S. schlegeli* are 16.3, 9.9, and 9.5, respectively, and for the dorsal row 18.7, 9.3, and 10.3, respectively. Size ranges in notochordal length for full-term larvae of the three species are 3.4 to 4.6 mm, 4.2 to 5.2 mm, and 4.8 to 6.8 mm, respectively.

A fourth species that falls into this group is *S. inermis*. Larvae are born at about 4 to 5 mm in length and Harada (1962) shows only dorsal head and gut pigment at this stage. His illustrations of 6- to 10-mm larvae show a short row of ventral and dorsal midline melanophores, but no numbers are given (Fig. 22H). No pectoral fin pigment is present on this species nor on the preceding three.

Helicolenus Goode and Bean

Literature.—Larvae of *Helicolenus dactylopterus* have been described and illustrated by a number of workers. Fage (1918) described a series of larvae 5.5 to 14 mm long from the Mediterranean Sea and illustrated the largest and smallest individuals of the series. Sparta (1942, 1956) described more completely the larval and early juvenile stages of *H. dactylopterus* from the Mediterranean and illustrated numerous larval stages and some juveniles. Haigh (1972) described the osteological development of a larval series from off South Africa. A series of excellent illustrations of *H. dactylopterus* are included with Tåning's (1961) description of redfish larvae from the North Atlantic.

Distinguishing features.—Larvae of *Helicolenus* can be differentiated from those of other scorpaenid genera by a combination of characters. Like *Sebastes*, larvae of *H. dactylopterus* have a small pectoral fin base (Table 3). Depth of the fin base averages 11% of the body length in larvae before notochord flexion, 12.5% during flexion, and 12% after flexion is completed. The range for the entire larval period is 9 to 14%. The blade of the fin is short and rounded. Fin length averages 11% of the body length in preflexion larvae, 15% during flexion, and 18% following flexion. Another distinctive feature is the mass of spongy tissue which forms at the dorsal midline of the trunk. It appears within the dorsal finfold in 4-mm larvae in the region to be occupied by the spinous dorsal fin. In later stages the spinous dorsal rays form within the mass and erupt from it. Such tissue has not been described for larvae of any other scorpaenid genus.

Larvae of the species of *Helicolenus* from the eastern Pacific off Chile, *H. lengerichi*, were not available for study. For comparative purposes, a brief description of a series of the North Atlantic species, *H. dactylopterus*, is given below and accompanied by the illustrations of Poul Winther (Tåning 1961).

Helicolenus dactylopterus (Delaroche), Figure 23

Literature.—See above.

Distinguishing features.—Planktonic eggs of *H. dactylopterus* have not been described, and there is uncertainty about the mode of reproduction of this species. Krefft (1961) reported that ovaries of reproductively mature females contained developing embryos embedded in a gelatinous matrix. Thus, *Helicolenus* may be ovoviviparous as in the subfamily Sebastinae or may produce a gelatinous egg balloon as in many genera of the Scorpaeninae. Krefft (pers. commun.) has suggested that the ovoviviparity may be facultative. Larvae are small at hatching as in the Scorpaeninae; Sparta (1942) illustrated a 2.8-mm larva that has already utilized its yolk and is morphologically similar to *Scorpaena* larvae of that size.

Body depth is moderate and increases throughout the larval period, from an average of 29% of the body length in preflexion larvae, to 33% in larvae undergoing flexion, to 37% in postflexion larvae (Table 25). The gut is compact. Snout-anus distance averages 49% of the body

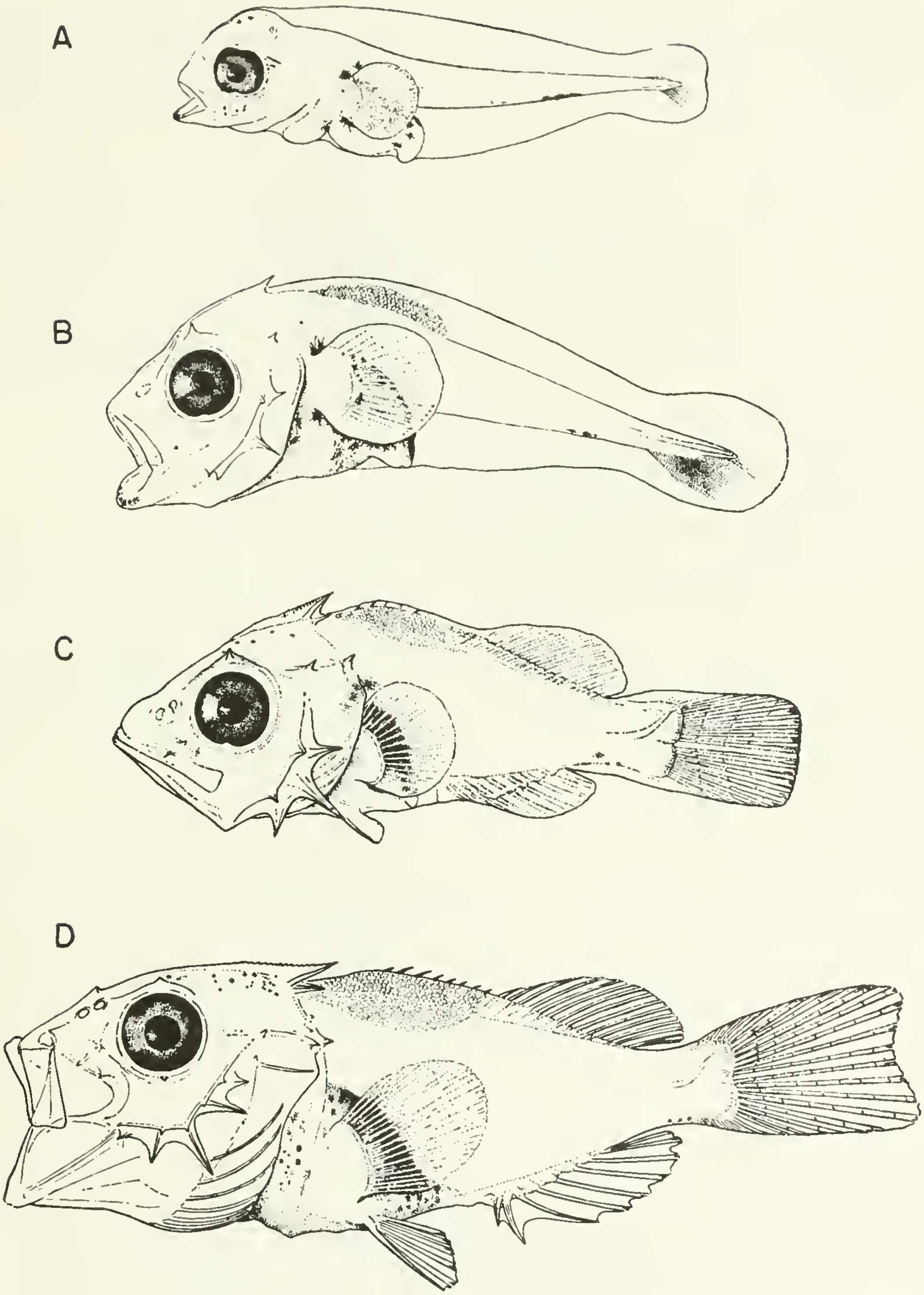

Figure 23.—Larvae of *Helicolenus dactylopterus* from Táning (1961). A. 3.6 mm; B. 5.6 mm; C. 10.0 mm; D. 19.0 mm.

Table 25. Measurements (mm) of larvae of *Helicolenus dactylopterus*. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
3.2	1.5	0.95	0.28	0.29	0.81	0.34	0.35	---	---
3.8	1.8	1.2	0.45	0.35	1.2	0.40	0.35	---	---
4.6	2.3	1.6	0.53	0.43	1.3	0.52	0.55	---	---
5.0	2.6	1.7	0.63	0.47	1.4	0.60	0.60	---	---
5.9	2.8	1.9	0.62	0.58	1.8	0.71	0.65	0.04	3.5
6.0	3.0	2.2	0.82	0.63	2.0	0.80	0.69	0.08	3.6
6.2	3.0	2.1	0.82	0.62	1.9	0.90	0.74	0.10	3.6
6.6	3.1	2.3	0.80	0.65	2.2	0.92	0.79	0.14	3.8
6.8	3.4	2.4	0.96	0.74	2.3	1.1	0.90	0.15	4.0
6.9	3.3	2.4	0.92	0.77	2.3	1.1	0.92	0.15	4.0
7.9	4.3	3.0	1.1	0.78	2.7	1.2	1.0	0.32	5.2
8.1	4.7	3.1	1.2	1.0	2.8	1.3	1.1	0.50	5.0
8.6	4.8	3.5	1.2	1.0	3.2	1.5	1.2	0.70	5.4
9.8	5.8	3.9	1.2	1.2	3.6	1.7	1.2	1.1	6.2
10.7	6.2	4.1	1.3	1.3	4.1	2.1	1.3	1.2	6.7
15.4	9.1	6.2	2.2	1.7	5.6	3.1	1.6	2.1	9.6

length in larvae up to notochord flexion and thereafter increases to an average of 58%. Head length also increases during the larval period from an average of 35% of body length in preflexion larvae, to 36% in larvae undergoing flexion, to 37% in postflexion larvae. The eye is moderate in size and averages 30% of the head length during the larval period with no trend of relative increase. Snout length averages 35% of the head length over the larval period.

The bases and blades of the pectoral fins are well differentiated in the 2.8-mm specimen of Sparta (1942). The short round blade portion of the pectoral fin is another feature held in common with many species of *Sebastes*. The paucity of specimens of *H. dactylopterus* precluded staining for osteological study; however, the size at formation of pectoral fin rays can be observed in unstained specimens. Pectoral rays begin to appear when the larvae are about 4.0 mm long and the last (lowermost) rays have differentiated at about 8.0 mm. The usual number of rays is 19. The pelvic fin buds appear in larvae about 6.0 mm long. The rays begin differentiating in 7-mm larvae, and the full complement of one spine and five rays is present in the 8.6-mm specimen.

The hypural anlage of the caudal fin is apparent in 3-mm larvae and the elements and principal caudal rays begin to differentiate in 4-mm larvae. The full complement of principal rays (8 + 7) is present in 7-mm larvae. Notochord flexion occurs at a relatively large size (6.0 to 8.0 mm) as in *Sebastes* and is another character held in common by the two genera. The dorsal and anal fins begin to form simultaneously in larvae about 6.0 mm long, but the full complements of XII, 11 or 12 dorsal rays and III, 5 anal rays are not present until 8.6 mm.

Larvae of *H. dactylopterus* have a distinctive pigment pattern that is established in larvae less than 3.0 mm long. On the head, a group of melanophores is present on the lower jaw and above the brain. The dorsolateral surfaces of the gut are covered with a solid shield of pigment which enlarges ventrally with continued development. Several superficial melanophores are present on the trunk just above the axillary region. The medial surface of the pectoral fin base is solidly pigmented and fine melanophores are located at two regions on the blade of the fin, some near the distal margin and another group at the basal region of the fin blade. A group of melanophores is present at the ventral midline of the tail just anterior to where the caudal fin will form. This unique pattern of pigmentation remains essentially unchanged throughout the entire larval period.

Distribution.—Adults of *H. dactylopterus* have a complex distribution. Eschmeyer (1969) recognized two Atlantic subspecies, *H. d. dactylopterus* and *H. d. lahillei*, with the former composed of four separate populations (northeastern Atlantic and Mediterranean, Gulf of Guinea, South Africa, and northwestern Atlantic). The subspecies *H. d. lahillei* is found off Uruguay and Argentina. The 6.0- and 6.2-mm specimens in the series are from *Discovery* station 714, off Uruguay, and thus are larvae of *H. d. lahillei*. They are not distinguishable from larvae of *H. d. dactylopterus*.

Sebastolobus Gill

Literature.—Pearcy (1962) described the floating egg masses, the developing embryos, and the newly hatched larvae of *Sebastolobus*. The larvae, pelagic juveniles, and early demersal juveniles of *S. altivelis* and *S. alascanus* are described and illustrated in Moser (1974). Larvae of the other species in the genus, *S. macrochir*, of the northwestern Pacific, have not been described; however, pelagic juveniles of this species are described and illustrated in Moser (1974).

Distinguishing features.—Early *Sebastolobus* larvae (up to 6 mm) can be distinguished from those of all other genera of eastern Pacific Scorpaenidae on the basis of pigmentation. *Sebastolobus* larvae of this size range are unique in having two large melanistic blotches about midway along the tail, one at the dorsal midline and one at the ventral midline. These are sometimes expanded to form a solid band on the tail (Fig. 24). Early larvae of all other eastern Pacific scorpaenid genera have a series of melanophores along the ventral midline of the tail, and in some species of *Sebastes*, an opposing row is present at the dorsal midline. The large tail blotches of *Sebastolobus* disappear in larvae between 4.2 and 6.4 mm. Soon after the loss of these large tail blotches the larvae develop prominent crestlike parietal ridges that terminate in double spines, the posterior (nuchal) spine being longer and more prominent than the anterior (parietal) spine (Fig. 24). Of the other eastern Pacific scorpaenid genera, only the larvae of *Scorpaenodes* have parietal ridges and spines like *Sebastolobus*. If two spines are present on the parietal ridges of other genera, the anterior spine is always longer and more prominent than the posterior. *Sebastolobus* larvae may be distinguished from those of *Scorpaenodes* on the basis of a melanistic shield, which covers the dorsolateral surface of the gut in the former and is absent in the latter. Larvae of *Sebastolobus* smaller than 10.0 mm could not be identified to species. Larvae larger than this can be identified to species by a combination of characters that are

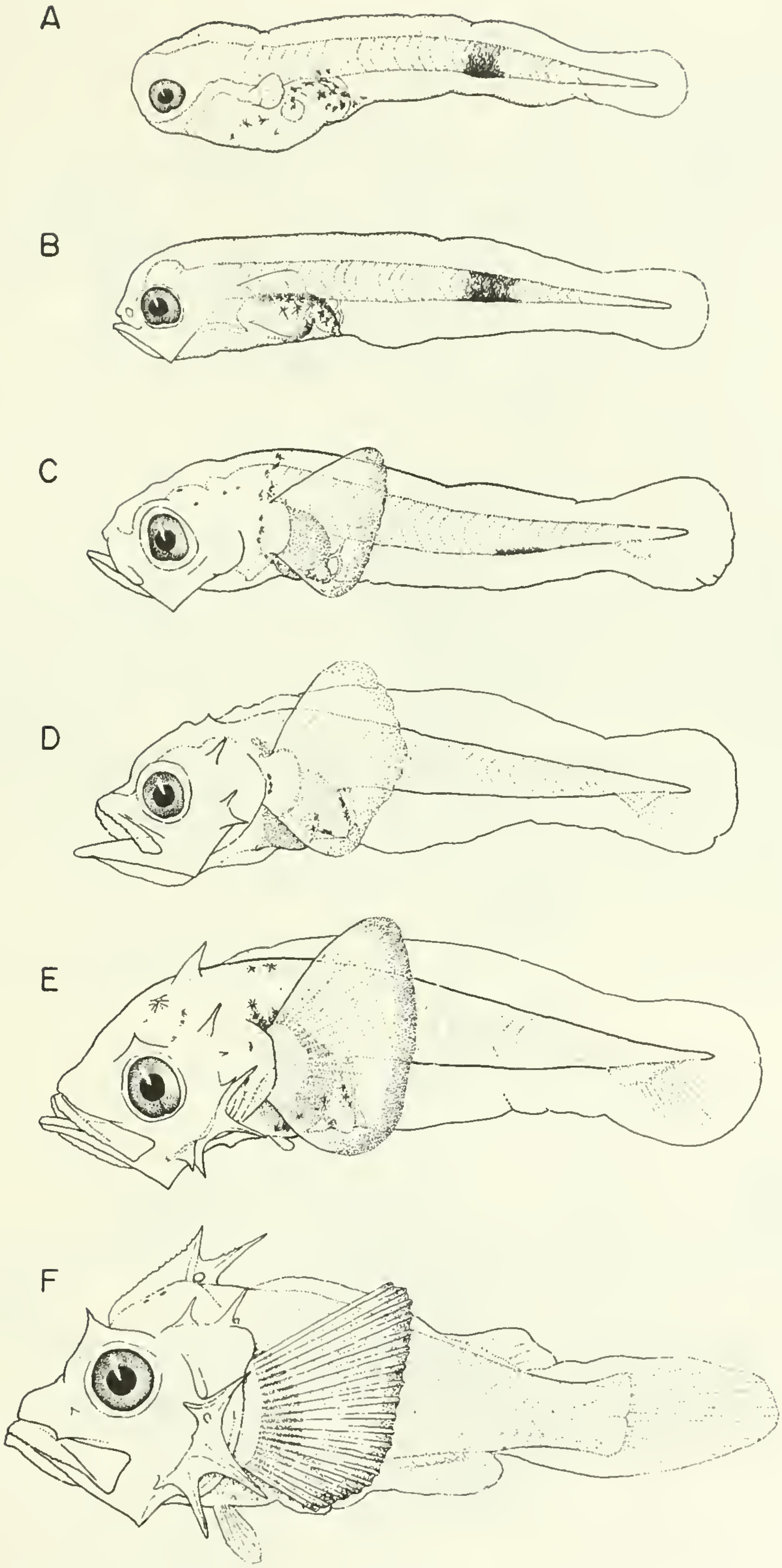

Figure 24.—Larvae of *Sebastolobus* spp. A. 3.0 mm; B. 3.5 mm; C. 5.2 mm; D. 5.7 mm; E. 6.2 mm; F. 7.7 mm.

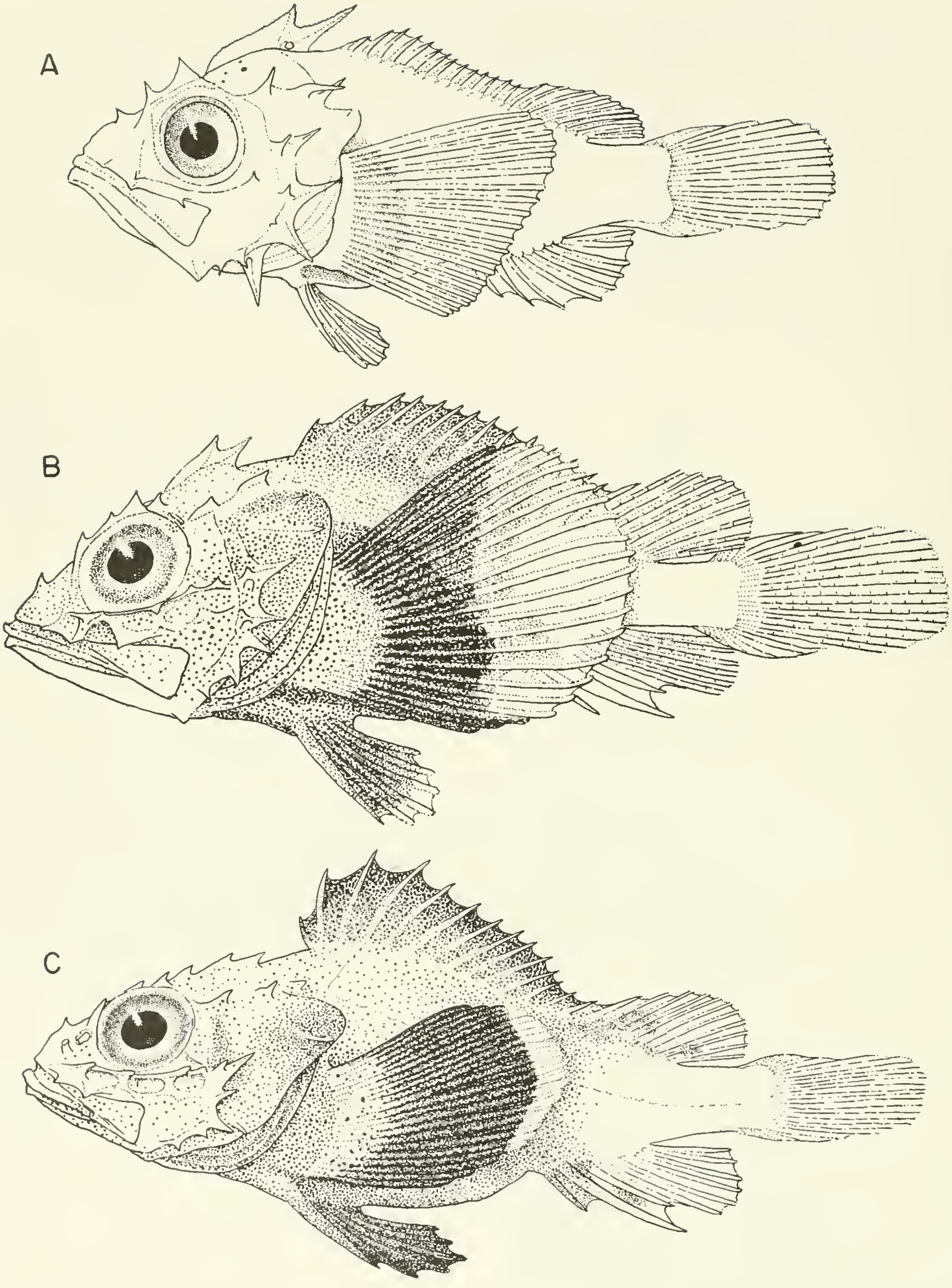

Figure 25.—Developmental series of *Sebastolobus altivelis*. A. 11.2-mm larva; B. 26.8-mm pelagic juvenile; C. 53.5-mm pelagic juvenile.

given in the following species descriptions of *S. altivelis* and *S. alascanus*.

Sebastolobus altivelis Gilbert, Figure 25

Literature.—Larvae, pelagic juveniles, and early demersal juveniles are described in Moser (1974).

Distinguishing features.—Larvae of *Sebastolobus* hatch and are freed from their floating egg mass at about 2.6 mm in length. They have an elliptical yolk sac with a posteriorly positioned oil droplet. When the larvae reach approximately 3.5 mm, the yolk sac has been resorbed and the jaws and feeding apparatus are well formed. Flexion of the notochord begins in larvae about 6.0 mm long and is completed in larvae about 7.5 mm (Table 26). Transformation into the pelagic juvenile stage is initiated within the size range of 14.0 to 20.0 mm (Table 27). All specimens larger than 20.0 mm have some juvenile pigmentation. The pelagic juvenile stage of *S. altivelis* is highly protracted and may last as long as 20 mo. Transformation into demersal juveniles occurs within the size range of about 42 to 56 mm.

Larvae larger than 10 mm may be differentiated to species on the basis of body depth and pectoral fin shape. Larvae and transforming specimens of *S. altivelis* are more robust and deeper-bodied than those of *S. alascanus*. Body depth of specimens of *S. altivelis* in the 10- to 20-mm size range is 36 to 45% of the body length (mean of 41%), whereas in specimens of *S. alascanus* of comparable size the range is 33 to 39% with a mean of 35%. The pelagic juveniles of *S. altivelis* are equally robust; body depth averages 41% of body length in the 20- to 40-mm size range but then decreases gradually to 34% in the largest pelagic juveniles. Pelagic juveniles of *S. alascanus* are less robust; body depth averages 34% with a range of 31 to 36%.

As in other scorpaenid genera, the pectoral fins provide excellent characters for species separation. The pectorals are longer and have a deeper base in larvae and pelagic juveniles of *S. altivelis* compared with *S. alascanus*. In specimens of *S. altivelis* in the 10- to 20-mm size range, the pectoral fin length averages 34% of the body length (range of 29 to 39%). The pectorals reach their maximum relative length in 20- to 40-mm pelagic juveniles where they average 39% of the body length (range of 35 to 41%). In pelagic juveniles 40 to 50 mm long the average is 35% (range of 32 to 37%). In 10- to 27-mm specimens of *S. alascanus* fin length averages 29% of body length (range of 26 to 31%).

The two species can be separated by a combination of meristic characters. *Sebastolobus altivelis* usually has one or two more pectoral fin rays and one or two less vertebrae than *S. alascanus* (Table 28).

The melanophore pattern of larvae of *S. altivelis* is indistinguishable from that of *S. alascanus*. At the beginning of the larval stage (3.5 mm) there are large median blotches opposite each other about midway back on the tail. In some specimens, the blotches are expanded to form a band. Also, melanophores cover the dorsolateral surfaces of the posterior region of the gut. The melanistic tail blotches are transitory; they are lost in some larvae as small as 4.2 mm and one or both are absent in most larvae between 5.0 and 6.0 mm in length. The dorsal blotch was absent in all larvae larger than 6.0 mm and the ventral one was absent in all larger than 6.4 mm. In contrast, the gut pigment is augmented throughout the larval period, extending forward to the axillary region and internally anterior to the cleithrum in larvae about 5.0 mm long. When the larvae reach 6.0 mm, the pigment extends onto the ventral surface of the gut and dor-

Table 26. Measurements (mm) of Sebastolobus spp. larvae. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-dorsal fin	Snout-anal fin
3.0	1.3	0.50	0.08	0.20	0.60	0.3	0.14			
3.5	1.4	0.80	0.18	0.25	0.52	0.23	0.20			
3.8	1.6	1.0	0.22	0.27	0.68	0.40	0.38			
4.2	1.8	1.2	0.25	0.30	0.86	0.45	0.40			
4.7	1.9	1.2	0.31	0.30	0.80	0.46	-			
5.0	2.0	1.4	0.35	0.33	0.90	0.65	0.50			
5.2	2.1	1.4	0.43	0.40	1.0	0.62	0.55			
5.5	2.3	1.6	0.42	0.35	1.1	0.65	0.58			
5.7	2.3	1.7	0.56	0.40	1.2	0.95	0.85			
5.8	2.4	1.7	0.51	0.39	1.2	1.0	0.78			
5.9	2.6	1.8	0.62	0.47	1.6	1.0	0.75			
6.0	2.7	1.8	0.55	0.51	1.8	1.3	0.85	0.22	2.3	3.4
6.2	2.7	1.9	0.70	0.48	1.6	1.4	0.90	0.20	-	-
6.4	2.7	1.8	0.60	0.45	1.5	1.2	0.85	0.13	-	-
6.7	3.1	1.9	0.82	0.55	1.8	1.4	1.0	0.15	3.9	3.9
6.8	2.8	2.0	0.82	0.52	1.8	1.4	1.1	0.17	-	3.2
6.9	3.3	2.2	0.80	0.58	2.0	1.5	1.2	0.25	2.7	4.1
7.1	3.5	2.5	0.82	0.71	2.4	1.8	1.2	0.80	2.5	4.2
7.3	3.8	2.5	0.95	0.76	2.4	1.8	1.4	0.85	2.7	4.4
7.7	4.2	2.7	1.1	0.75	2.8	2.1	1.5	0.85	2.9	4.5
7.8	4.3	3.1	1.1	0.82	2.6	2.1	1.4	1.2	3.2	4.8
8.3	4.4	3.1	1.1	0.79	2.6	2.0	1.4	1.0	3.1	4.9
8.6	4.8	3.2	1.2	0.92	3.1	2.4	1.7	1.4	3.5	5.3
8.9	5.2	3.3	1.2	1.0	3.1	2.5	1.7	1.4	3.8	5.4
9.2	5.2	3.5	1.2	1.0	3.2	2.7	1.5	1.5	3.8	5.6
9.6	5.4	3.5	1.2	1.1	3.7	2.8	1.8	1.7	4.1	5.8

Table 27. Measurements (mm) of Sebastolobus altivelis. (Specimens below dashed line have completed transformation into pelagic juvenile stage.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-dorsal fin	Snout-anal fin
10.1	6.2	3.8	1.2	1.2	3.8	2.8	1.8	1.7	4.2	6.4
10.5	6.5	4.2	-	1.2	3.9	3.0	1.9	1.8	4.4	6.7
11.2	6.9	4.5	1.3	1.4	4.2	3.5	2.1	2.4	5.2	7.3
12.7	7.3	4.6	1.3	1.5	4.7	3.8	2.0	2.5	5.4	7.9
13.4	8.0	5.0	1.5	1.6	4.8	3.7	2.0	2.5	5.4	8.3
14.4	8.8	6.2	1.7	2.1	5.7	5.0	2.7	3.1	6.0	9.6
15.2	10.1	6.1	1.8	1.9	6.3	5.2	2.8	2.9	6.7	10.6
15.4	9.8	6.0	1.7	2.2	6.4	4.7	2.8	2.9	6.9	10.1
15.4	9.9	6.5	1.9	2.2	6.3	5.8	2.9	3.8	6.8	11.0
15.7	10.3	6.8	2.1	2.1	6.9	5.8	2.9	3.8	6.7	10.8
16.0	10.3	6.2	1.8	2.0	7.1	5.4	3.1	3.3	7.0	10.6
16.3	10.3	7.2	2.1	2.2	6.6	6.2	3.0	4.0	6.8	11.2
16.6	10.8	7.4	1.8	2.4	6.6	6.4	3.0	3.4	7.6	11.8
16.7	11.2	6.7	1.9	2.2	7.5	5.8	3.2	3.3	7.1	11.3
17.6	11.5	7.6	2.0	2.5	7.2	6.8	3.2	4.2	7.1	12.2
17.6	11.7	7.0	1.9	2.4	7.3	5.9	3.1	3.8	7.7	12.0
18.2	12.0	7.7	2.1	2.6	7.3	6.3	3.1	4.2	7.8	12.7
18.4	12.5	7.1	2.0	2.5	8.3	6.2	3.6	4.2	7.5	12.8
19.3	13.2	7.9	2.1	2.5	8.5	6.7	3.8	3.8	8.3	13.4
19.4	13.0	8.5	2.3	2.5	8.7	7.6	3.8	4.7	8.4	14.0
20.7	13.8	8.5	2.6	2.3	8.4	7.6	3.7	4.8	8.6	14.7
21.3	14.9	9.2	2.8	2.8	9.0	8.1	3.8	4.8	9.5	15.2
22.6	15.9	9.6	2.5	3.1	9.2	8.8	4.2	5.6	9.5	16.7
23.4	16.6	9.8	2.5	2.7	10.1	9.0	4.4	5.6	9.5	17.4
24.5	17.7	10.8	2.9	3.4	11.0	10.0	4.5	5.8	10.1	18.1
25.8	18.6	10.6	2.9	2.9	11.3	9.3	4.4	5.9	10.1	18.9
26.8	17.7	10.6	2.8	3.8	10.6	11.0	4.8	6.5	10.1	18.8
27.7	20.3	11.5	2.9	3.6	12.2	11.0	5.4	7.1	11.7	22.0
28.3	20.3	12.0	3.2	3.7	12.2	11.5	5.0	7.1	11.5	21.8
29.4	20.4	12.3	3.3	3.8	11.5	11.5	5.2	7.2	12.3	21.1
30.5	21.1	13.0	3.8	3.6	11.7	11.7	5.4	7.6	12.3	23.0
31.4	21.1	12.3	3.2	3.5	13.7	12.2	5.8	7.5	12.3	22.9
32.4	21.1	12.5	3.5	3.6	13.0	12.8	5.8	8.3	12.5	22.2
33.6	23.1	14.0	4.2	4.2	13.5	11.7	5.8	7.5	12.8	25.1
34.6	23.5	13.4	3.8	3.8	14.2	13.5	6.0	8.2	13.7	25.5
36.5	25.0	15.2	4.2	4.8	15.5	14.7	6.7	9.2	14.9	27.5
37.5	25.8	15.0	4.2	4.6	15.9	14.4	6.7	8.3	14.7	27.6
38.5	25.6	15.2	4.0	4.8	16.0	15.7	6.6	9.8	15.2	27.5
39.5	27.9	16.2	5.0	4.8	16.0	15.0	6.7	8.9	16.0	29.9
40.4	27.1	16.4	5.0	4.8	15.2	15.0	6.8	10.8	16.0	30.0
41.6	27.9	16.4	4.3	5.8	15.9	15.2	7.1	10.1	16.2	29.6
42.3	28.1	16.9	4.6	5.2	17.4	15.2	7.2	10.0	15.9	29.4
43.5	30.1	16.9	5.2	5.4	16.0	14.7	6.7	9.5	17.4	32.4
44.4	30.0	17.9	-	4.8	16.4	16.4	7.1	9.5	17.2	32.2
45.1	29.5	18.2	4.8	5.4	17.6	16.0	7.8	10.1	17.2	32.0
46.2	30.7	17.9	5.0	4.9	17.7	17.1	8.1	11.5	17.1	33.5
47.1	30.2	18.1	5.0	5.6	17.1	15.2	7.0	10.3	17.7	33.0
48.5	32.0	18.6	5.4	5.8	18.6	16.9	7.8	10.5	17.7	34.7
49.5	32.2	19.8	5.0	5.8	18.6	18.1	8.3	11.8	16.4	36.2
51.3	37.0	20.6	6.7	5.8	18.8	17.4	8.0	11.3	18.9	40.0
53.5	35.7	20.6	6.2	7.5	18.6	16.9	8.2	11.0	18.7	37.8
56.0	37.6	21.4	5.8	7.7	19.2	19.8	8.3	12.3	20.3	40.6
*42.0	26.8	16.6	4.6	5.6	12.0	12.7	6.0	9.3	16.4	29.0
*47.4	29.6	17.7	4.7	6.9	13.9	13.5	6.8	10.1	18.1	31.7
*48.1	31.4	19.1	5.2	7.3	14.4	15.2	7.0	11.5	17.9	33.5
*50.3	33.0	19.2	5.4	7.3	14.0	13.8	7.1	11.8	18.8	35.3
*51.0	33.0	19.5	4.7	7.2	15.0	16.2	7.5	11.2	18.7	35.2
*53.0	33.4	20.5	5.4	8.6	14.6	15.5	7.0	12.1	19.9	37.7
*54.0	35.4	19.7	5.9	7.3	15.5	17.7	7.8	12.6	20.6	38.4
*56.0	35.2	21.1	5.6	7.7	15.5	16.4	7.4	12.6	20.8	38.1
*57.5	37.2	21.4	5.6	8.0	15.3	16.7	8.1	12.5	21.1	40.3
*58.6	37.9	22.6	6.0	8.7	16.5	16.9	8.2	12.7	21.8	40.6
*60.0	38.0	22.0	6.0	8.4	16.2	15.1	8.1	12.8	21.5	41.6

*Benthic juvenile.

Table 28. **Meristics from cleared and stained larvae and juveniles of _Sebastolobus_ spp. (above dashed line) and _Sebastolobus altivelis_ (below dashed line).**

Length (mm)	Primary caudal fin rays		Secondary caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	Superior	Inferior	Superior	Inferior	Left	Right	Left	Right	Superior	Inferior	Upper limb	Lower limb			Left	Right	
6.2	-	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-
6.8	-	-	-	-	3	3	14	2	-	-	-	3	-	-	-	-	-
7.0	8	7	-	-	5	5	14	12	-	-	-	2	-	-	-	-	-
7.7	8	7	4	4	7	7	23	24	2	1	3	9	III-5	XV-9	I-5	I-5	28
8.1	8	7	-	2	7	7	23	23	-	-	3	9	III-3	XV-9	I-5	I-5	28
8.3	8	7	3	4	7	7	23	23	2	1	2	8	III-5	XV-9	I-5	I-5	27
8.8	8	7	4	6	7	7	23	24	2	2	3	10	III-5	XV-9	I-5	I-5	29
9.3	8	7	3	4	7	7	24	24	2	1	3	10	III-5	XV-9	I-5	I-5	29
10.1	8	7	6	8	7	7	23	23	1	2	6	12	III-5	XV-9	I-5	I-5	29
10.6	7	7	6	7	7	7	23	23	1	2	5	13	III-6	XV-10	I-5	I-5	29
11.2	8	7	6	7	7	7	23	23	1	2	5	13	III-5	XV-9	I-5	I-5	28
11.5	8	7	7	7	7	7	23	23	1	2	5	13	III-5	XV-9	I-5	I-5	29
12.0	8	7	6	7	7	7	23	23	2	2	5	13	III-5	XV-8	I-5	I-5	28
13.0	8	7	8	7	7	7	23	24	2	2	6	13	III-5	XV-10	I-5	I-5	29
13.7	8	7	6	7	7	7	23	23	2	2	5	13	III-5	XV-9	I-5	I-5	29
14.4	8	7	7	7	7	7	23	24	2	2	6	14	III-5	XV-9	I-5	I-5	29
15.0	8	7	7	7	7	7	23	23	2	2	6	13	III-5	XV-9	I-5	I-5	29
16.6	8	7	7	7	7	7	23	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
17.6	8	7	8	7	7	7	23	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
18.1	8	7	7	7	7	7	24	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
19.4	8	7	7	7	7	7	22	22	2	2	6	14	III-5	XV-9	I-5	I-5	29
20.6	8	7	8	8	7	7	23	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
25.8	8	7	8	9	7	7	24	23	2	2	6	15	III-5	XV-9	I-5	I-5	29
30.5	8	7	6	7	7	7	24	24	2	2	7	15	III-5	XVI-9	I-5	I-5	29
40.4	8	7	7	7	7	7	23	23	2	2	7	15	III-5	XV-9	I-5	I-5	29
50.0	8	7	7	7	7	7	23	23	2	2	7	14	III-5	XV-8	I-5	I-5	29

sally as deeply embedded pigment at the nape. With continued development the melanophores form a solid sheath on the peritoneum surrounding the gut.

Melanophores appear at the posterior margin of each pectoral fin in some larvae as small as 4.0 mm. About half the larvae examined between 4.0 and 5.0 mm have this posterior margin of fine melanophores and the pigment is present in all larvae in the 5.0- to 11.0-mm range. The melanophores are then lost, and almost all larvae larger than 11.0 mm have unpigmented fins.

Melanophores appear on the posterior lobes of the brain in 5.2- to 7.0-mm larvae and are present in all larvae larger than this. They also appear above the anterior lobes of the brain in larvae between 7.0 and 9.0 mm in length and in most larvae larger than 9.0 mm.

Pigmentation of the pelagic juveniles of the two species is markedly different. It begins to appear in some specimens of *S. altivelis* of the 14- to 20-mm size range. On the head, patches of melanophores appear on the opercle, cheek, snout, and jaws. In most specimens larger than 22 mm, the patches are confluent, and the head is generally dusky with darker areas at the opercle and along the upper jaw.

A patch of melanophores appears superficially over each side of the gut in specimens as small as 14 mm. These patches expand to form a solid melanistic sheath in some specimens of the 14- to 20-mm size range. The posterior margin of the sheath is an arc running from the vent to the nape and stands out sharply against the pigmentless region of the trunk posterior to the sheath. With continued development the pigment sheath expands posteriad and is a striking feature of the pelagic juveniles. In the 20- to 30-mm size range the sheath extends posteriad to a vertical from the first or second anal fin spines. In the 30- to 40-mm size range the sheath extends posteriad to the 2nd or 3rd anal spine in most specimens and to the soft dorsal fin in some. In most pelagic juveniles of the 40- to 50-mm size range, the dusky sheath extends back to the soft dorsal and it does so in all specimens of the 50- to 60-mm size range. When the juveniles become benthic, the dusky sheath extends posteriad to the caudal fin.

The fins become deeply and characteristically pigmented in juveniles of *S. altivelis*. The anterior portion of the spinous dorsal fin becomes melanistic in specimens as small as 18 mm. In juveniles of the 20- to 25-mm size range, the anterior one-half to two-thirds of the fin is melanistic. In the 25- to 30-mm range, three-fourths or more of the fin is black. In pelagic juveniles larger than this the pigment has spread onto the soft dorsal fin, and covers both the soft dorsal and soft anal fins in benthic juveniles.

The base of the pectoral fins begins to be covered with melanophores in specimens as small as 14 mm. In specimens as small as 18 mm the melanophores extend onto the basal region of the rays. With further growth the black basal zone enlarges posteriad and becomes a highly characteristic feature of the pelagic juveniles. The posterior margin of this zone contrasts sharply with the distal clear region of the fin. In juveniles of the 19- to 25-mm size range, the width of the black basal zone averaged 20% of the fin length. Enlargement of this zone is shown by the average relative widths for successive size ranges (25 to 30 mm, 38%; 30 to 35 mm, 46%; 35 to 40 mm, 54%; 40 to 45 mm, 65%; 45 to 50 mm, 72%; 50 to 55 mm, 76%). Towards the end of the pelagic juvenile stage a pale translucent layer covers the basal region of the pectoral fin and gives the black zone the appearance of a band.

Distribution.—An extensive discussion of the distribution and abundance of larvae, juveniles, and adults of *S. altivelis* is given in Moser (1974).

Sebastolobus alascanus Bean, Figure 26

Literature.—Larvae, pelagic juveniles, and early demersal juveniles are described in Moser (1974).

Distinguishing features.—Larvae of *Sebastolobus* smaller than 10 mm are not separable to species. Distinguishing features of *Sebastolobus* larvae up to this size are given in the generic account and in the section describing *S. altivelis*. *Sebastolobus alascanus* larvae longer than 10 mm differ from those of *S. altivelis* in being less robust and in having shorter pectoral fins with a narrower base and fewer pectoral rays (Tables 29, 30). These characters carry through into the pelagic juveniles of the two species. The descriptive details for larvae and pelagic juveniles of both species are given in the section on *S. altivelis*.

In transforming species of *S. alascanus*, the first head pigment to appear is a melanistic blotch on the posterior region of the opercle. This gradually spreads anteriorally onto the cheek and in late-stage pelagic juveniles the entire head is speckled with melanophores. A blotch begins to form over each side of the gut in larvae as small as 15 mm. These enlarge dorsad onto the spinous dorsal fin and posteriad as an irregular mottled sheath that contrasts markedly with the solidly pigmented sheath of *S. altivelis* juveniles. In the largest pelagic juveniles the mottling on the dorsal fin and trunk extends posteriad to a vertical from the vent. When the juveniles become benthic the mottling spreads onto the remainder of the body and median fins. Melanophores appear on the bases of the pectoral fins in specimens of the 14- to 20-mm size range. A faint band of melanophores appears on the rays in some specimens of this size range but never becomes highly developed and covers only the basal one-third of the fin in the largest pelagic juveniles.

Distribution.—An extensive discussion of the distribution and abundance of *S. alascanus* larvae, juveniles, and adults is given in Moser (1974).

Trachyscorpia Ginsburg

Literature.—None.

Distinguishing features.—No larvae are known and the genus is known in the eastern Pacific from one adult

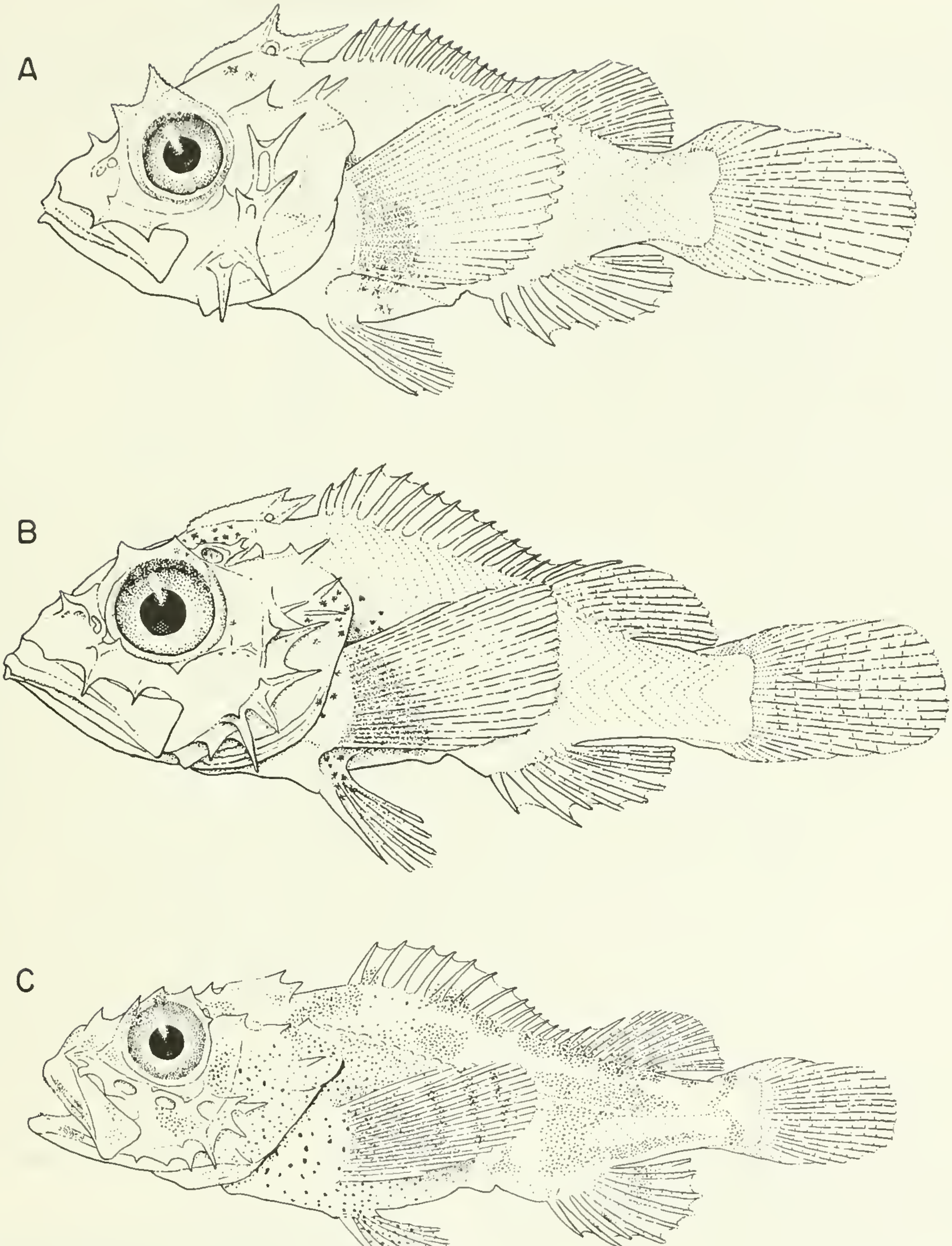

Figure 26.—Developmental series of *Sebastolobus alascanus*. A. 10.3-mm larva; B. 16.0-mm transforming specimen; C. 25.3-mm pelagic juvenile.

Table 29. Measurements (mm) of larvae and juvenilea of *Sebastolobus alascanus*.

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-dorsal fin	Snout anal fin
10.3	6.2	4.2	1.5	1.2	4.0	3.2	1.6	1.9	4.3	6.8
11.2	7.4	5.0	1.8	1.3	4.1	3.2	1.7	2.1	5.0	7.7
11.7	7.2	5.0	-	1.3	3.9	3.1	1.8	2.1	5.1	7.7
12.5	7.7	4.7	1.7	1.5	4.5	3.6	1.8	2.4	5.4	8.3
13.2	7.3	5.0	1.6	1.8	4.6	3.9	1.9	2.7	5.8	8.2
14.0	8.1	5.7	1.8	2.1	4.9	4.1	1.9	2.5	6.2	8.8
14.4	8.4	5.6	1.4	1.8	5.2	4.2	2.1	2.6	5.7	9.1
15.2	9.2	6.2	1.8	2.0	5.2	4.4	2.1	2.9	6.3	10.0
16.0	9.3	6.2	2.0	2.0	5.2	4.8	2.2	2.9	7.1	10.0
16.4	9.8	6.7	1.8	2.5	5.7	4.7	2.3	3.2	7.1	10.5
16.9	10.0	6.8	1.9	2.3	5.9	4.8	2.4	3.1	7.3	10.8
17.6	10.6	6.7	2.1	2.2	6.1	4.9	2.3	3.5	7.1	11.3
18.6	12.7	-	-	2.8	6.8	5.4	2.8	3.8	8.5	13.2
19.8	12.0	7.7	2.0	2.8	7.1	5.9	2.9	4.0	8.3	13.0
20.0	12.0	8.1	2.2	2.9	7.1	6.4	2.8	4.2	8.4	13.0
20.3	12.8	8.2	1.8	3.1	7.2	6.2	7.8	4.0	8.1	13.5
21.0	13.5	8.6	1.9	3.1	7.5	6.5	3.0	4.6	8.1	14.4
21.4	12.8	8.3	2.4	2.9	7.1	6.2	2.8	3.8	8.6	14.4
21.9	12.8	8.5	2.1	3.1	7.1	6.2	2.8	4.2	8.8	14.9
22.3	14.2	9.6	-	2.8	7.9	6.5	3.2	4.4	9.1	15.4
22.9	14.4	9.8	2.6	3.2	7.5	6.7	3.1	4.6	9.3	15.5
23.2	14.7	9.5	2.5	2.9	7.9	7.2	3.0	5.0	9.6	16.0
23.4	14.9	9.0	2.2	3.3	8.0	7.1	3.2	5.0	9.3	16.4
24.0	14.4	9.8	2.2	3.2	8.0	6.8	3.3	5.0	9.8	15.9
24.3	15.5	10.0	2.8	3.2	8.6	7.3	3.3	5.0	9.8	16.9
25.1	15.9	10.0	3.0	3.3	8.4	7.0	3.4	5.0	10.1	17.2
25.5	16.0	10.1	2.8	3.5	8.8	8.2	3.7	5.5	10.1	17.6
26.4	17.9	10.6	3.2	3.5	9.0	8.0	3.7	5.7	11.3	19.1
27.2	17.9	11.2	3.0	-	8.3	8.1	3.3	5.4	10.8	19.3
*22.5	13.0	8.7	2.1	3.2	7.2	6.3	2.9	4.6	9.6	14.7
*25.3	16.9	10.3	3.5	3.2	8.1	6.8	3.3	5.0	11.2	18.9
*37.8	22.0	12.7	2.9	5.0	10.1	9.6	4.2	8.2	13.5	24.3
*39.0	24.0	14.1	4.0	5.1	9.9	9.8	4.0	8.8	15.0	26.7
*40.8	25.1	14.8	3.8	5.3	10.0	9.7	3.8	8.8	15.3	27.3
*42.3	27.7	15.4	4.3	5.8	10.1	10.0	4.2	9.0	16.3	29.6
*43.6	26.3	15.4	4.1	5.8	9.5	10.6	4.4	9.4	16.1	29.5
*44.7	26.2	15.9	4.3	5.8	11.2	10.5	4.8	8.1	16.9	29.7
*46.2	28.1	16.2	4.4	6.4	10.8	10.8	4.7	9.9	16.7	31.2
*48.8	29.1	16.8	4.7	6.5	11.4	11.4	4.7	10.5	18.0	32.9
*50.3	29.4	17.4	4.8	7.0	12.4	12.2	5.0	10.6	18.0	33.0
*51.0	30.6	17.5	5.0	6.8	11.8	11.5	5.2	10.5	17.5	33.6
*59.2	36.6	20.6	5.4	8.4	13.0	13.5	5.6	12.1	20.8	40.0
*60.0	36.8	21.6	5.7	9.0	14.3	14.3	5.9	13.0	21.5	39.7

* Benthic juvenile.

specimen reported as *Trachyscorpia* sp. (Chirichigno 1974). The specimen was collected off Peru at lat. 13°57.2′S and long. 76°42′W in 580 to 600 m. Eschmeyer (pers. commun.), who has examined the specimen, finds no obvious difference between it and *T. cristulata* from the Atlantic. If Eschmeyer (1969) is correct in the placement of *Trachyscorpia* near *Sebastolobus* in the subfamily Sebastolobinae, its larvae can be expected to share some of the features of *Sebastolobus* larvae.

Scorpaenodes Bleeker

Literature.—The literature contains no descriptions or illustrations of the developmental stages of *Scorpaenodes*.

Distinguishing features.—*Scorpaenodes* larvae differ from all other known Scorpaenidae except *Sebastolobus*, in having prominent crestlike parietal ridges that terminate in double spines, the posterior (nuchal) spines being more prominent than the anterior (parietal) spine; in larvae of other known scorpaenid genera, if two spines are present on the parietal ridge, the second is smaller and subjacent to the first. *Scorpaenodes* differs markedly from *Sebastolobus* in melanophore pattern and in degree of development at comparable sizes. Newly hatched *Scorpaenodes* larvae have a series of about a

Table 30. **Meristics from cleared and stained larvae and juveniles of *Sebastolobus alascanus*.**

Length (mm)	Primary caudal fin rays		Secondary caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	Superior	Inferior	Superior	Inferior	Left	Right	Left	Right	Superior	Inferior	Upper limb	Lower limb			Left	Right	
7.5	8	7	3	4	7	7	21	21	2	2	3	9	III-5	XVI-8	I-5	I-5	30
11.0	8	7	3	5	7	7	22	22	1	2	4	9	III-5	XVI-9	I-5	I-5	30
11.7	8	7	6	6	7	7	22	22	2	2	4	10	III-5	XVI-8	I-5	I-5	30
12.5	8	7	7	8	7	7	21	21	2	2	5	12	III-5	XVI-10	I-5	I-5	30
13.2	8	7	8	7	7	7	21	22	2	2	5	12	III-5	XVI-9	I-5	I-5	30
14.4	8	7	9	9	7	7	22	22	2	2	5	13	III-5	XVI-9	I-5	I-5	30
15.2	8	7	8	8	7	7	22	22	2	2	5	12	III-5	XVI-9	I-5	I-5	30
16.4	8	7	9	9	7	7	21	21	2	2	7	13	III-5	XVII-9	I-5	I-5	30
17.6	8	7	9	9	7	7	21	21	2	2	6	13	III-5	XVI-9	I-5	I-5	30
18.6	8	7	9	9	7	7	22	22	2	2	6	13	III-5	XVI-9	I-5	I-5	30
19.8	8	7	8	8	7	7	22	22	2	2	8	13	III-5	XVI-9	I-5	I-5	30
20.3	8	7	9	8	7	7	22	22	2	2	5	13	III-5	XVI-9	I-5	I-5	31
21.4	8	7	8	8	7	7	22	22	2	2	6	13	III-5	XVI-9	I-5	I-5	30
22.3	8	7	8	8	7	7	22	22	2	2	6	12	III-5	XVI-9	I-5	I-5	30
24.3	8	7	9	8	7	7	21	21	2	2	7	14	III-4	XVI-9	I-5	I-5	30
25.5	8	7	9	9	7	7	22	22	2	2	6	14	III-5	XV-10	I-5	I-5	30
26.4	8	7	9	9	7	7	21	21	2	2	7	12	III-5	XV-9	I-5	I-5	30
27.2	8	7	10	10	7	7	21	21	2	2	7	13	III-5	XVI-10	I-5	I-5	30

dozen melanophores along the ventral midline of the tail. These soon become embedded and are not visible in larvae larger than 4.0 mm. Newly hatched *Sebastolobus* larvae lack this series of melanophores, but have two large melanistic blotches about midway along the tail. *Scorpaenodes* larvae lack the melanistic shield that covers the dorsolateral surfaces of the gut in larvae of *Sebastolobus, Scorpaena*, and *Sebastes*. In place of this, small *Scorpaenodes* larvae have a deeply embedded blotch just dorsal to the axilla. This later enlarges to cover the dorsal surface of the gas bladder. Head spine and caudal fin formation occur at smaller sizes in *Scorpaenodes* compared with *Sebastolobus*. In *Scorpaenodes*, numerous head spines are present in larvae less than 3.0 mm long, while *Sebastolobus* of that size still have their yolk and do not obtain a comparative degree of spine development until they are twice that size. In *Scorpaenodes*, notochord flexion occurs within the size range of 4.0 to 5.5 mm whereas in *Sebastolobus* it occurs in the range of 6.0 to 7.5 mm.

***Scorpaenodes xyris* (Jordan and Gilbert), Figures 27-29**

Literature.—There are no previous descriptions or illustrations of *Scorpaenodes* larvae.

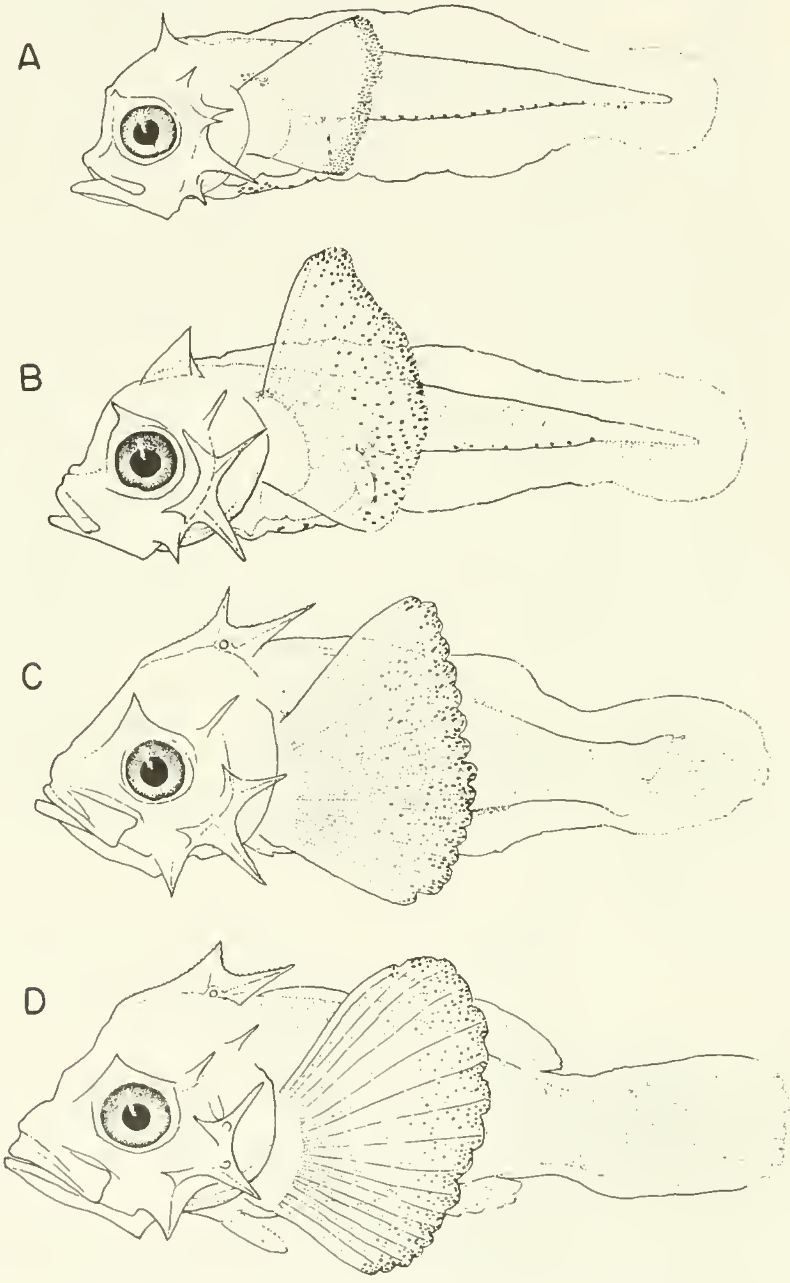

Figure 27.—Larvae of *Scorpaenodes xyris*. A. 2.7 mm; B. 3.2 mm; C. 4.0 mm; D. 4.8 mm.

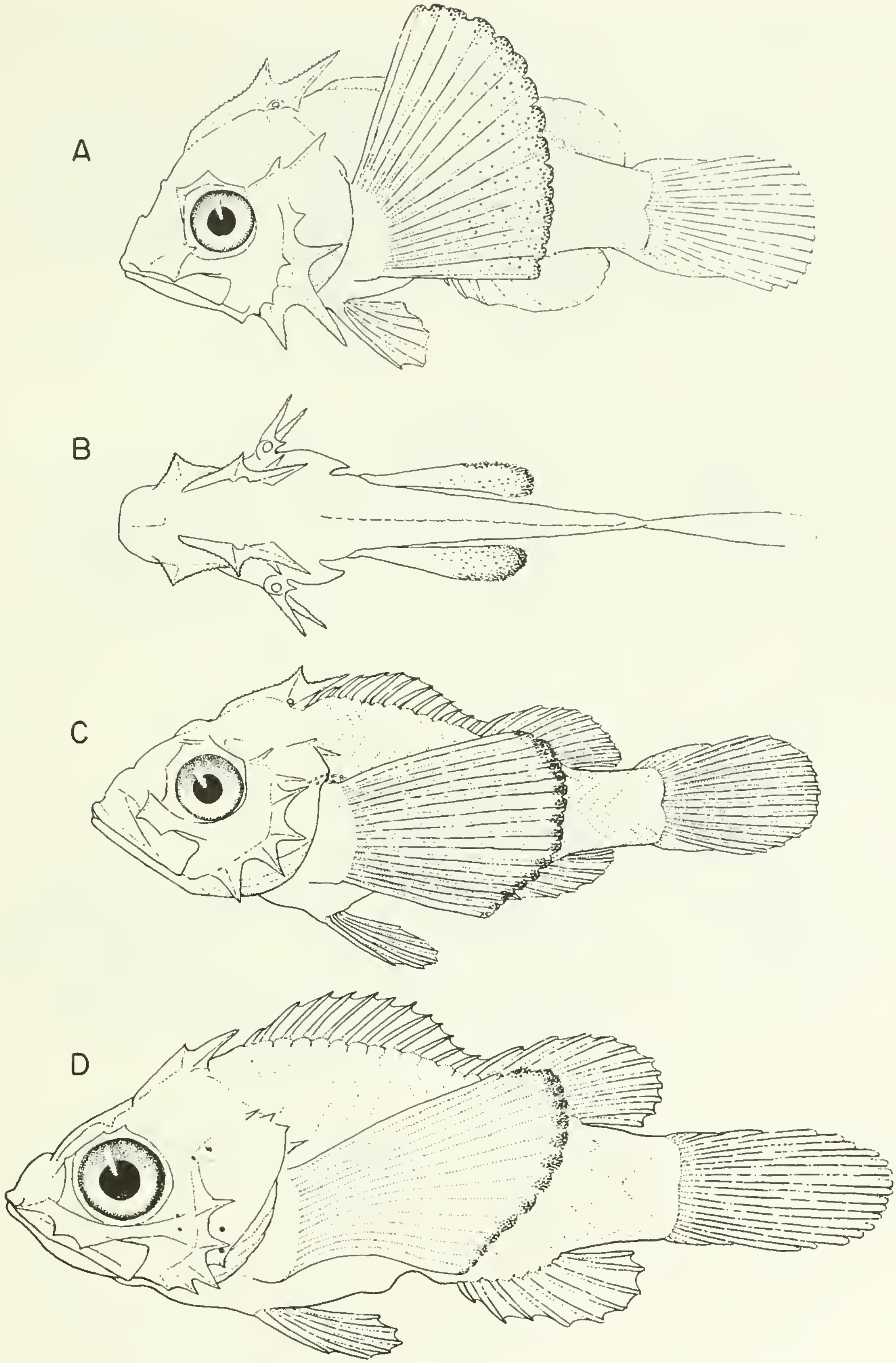

Figure 28.—Larvae of *Scorpaenodes xyris*. A. 6.2 mm; B. 6.2 mm, dorsal view; C. 9.2 mm; D. 13.0 mm.

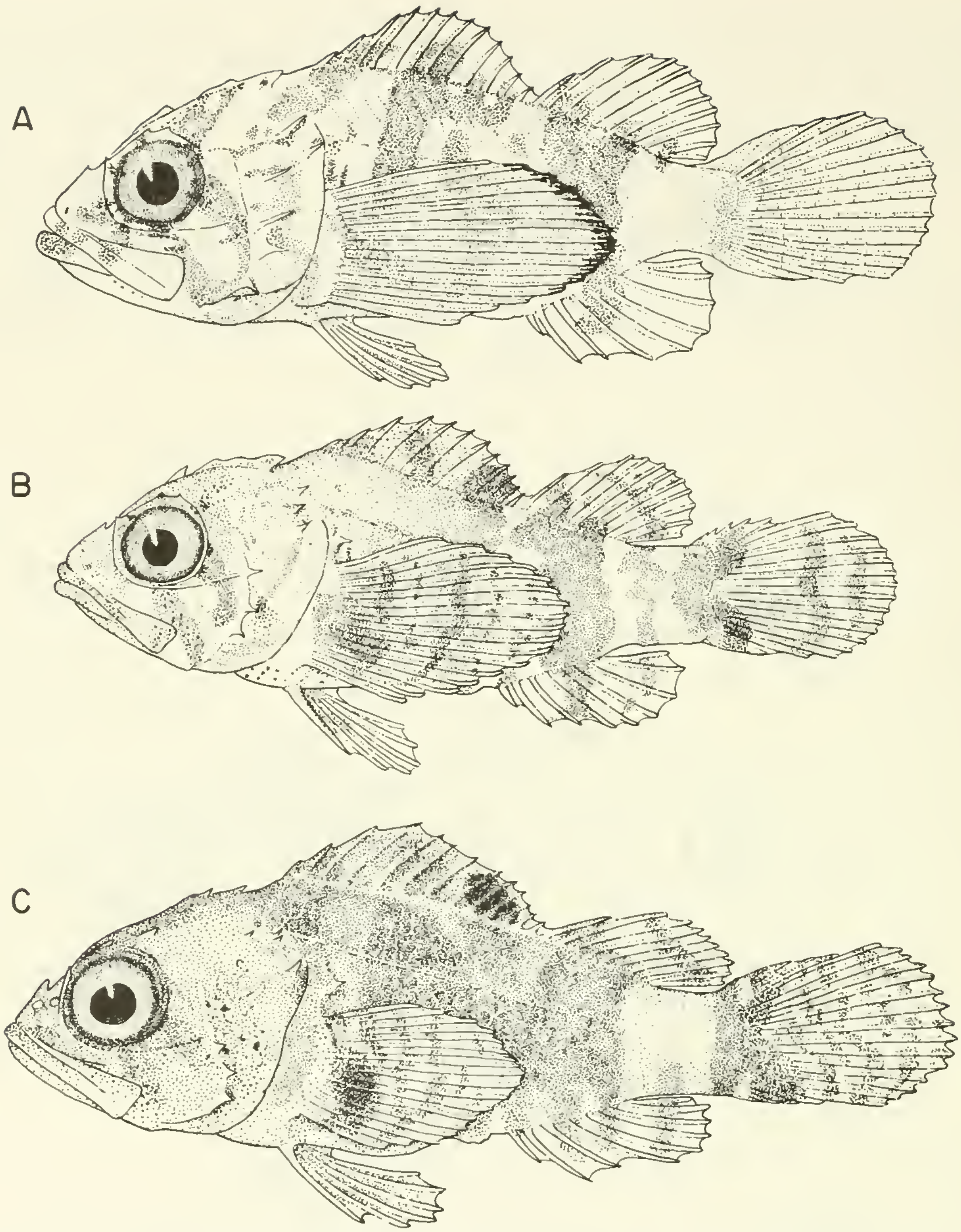

Figure 29.—Developmental series of *Scorpaenodes xyris*. A. 12.5-mm transforming specimen; B. 11.8-mm benthic juvenile; C. 12.7-mm benthic juvenile.

Distinguishing features.—A single species of *Scorpaenodes, S. xyris*, is known from the eastern Pacific. Comparison of *S. xyris* larvae with those of congeners is not possible since we have only *S. xyris* larvae in our collections.

The smallest larvae of *S. xyris* in our collections are 1.8 mm in length. These specimens have already exhausted their yolk supply, so it is likely that newly hatched larvae of *S. xyris* are slightly smaller than 1.8 mm. Larvae reach a maximum length of 14.0 mm and transformation into benthic juveniles occurs within a size range of 11.0 to 14.0 mm.

Scorpaenodes xyris larvae are deep-bodied; body depth increases gradually during the larval period. It averages 28% of body length before notochord flexion, 33% during flexion, and 39% after the completion of flexion (Table 31). In the slightly more elongate transforming specimens and newly transformed juveniles, body depth is 36% of body length.

Table 31. Measurements (mm) of larvae of Scorpaenodes xyris. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
2.7	1.2	0.80	0.20	0.28	0.78	0.27	0.21	-	-
3.2	1.5	1.0	0.25	0.32	0.84	0.84	0.54	-	-
3.8	1.8	1.1	0.37	0.32	1.0	0.97	0.67	-	-
3.9	1.8	1.2	0.48	0.37	1.2	1.1	0.68	-	-
4.0	1.9	1.4	0.49	0.35	1.2	1.2	0.76	-	-
4.2	2.0	1.2	0.50	0.38	1.2	1.2	0.71	0.03	-
4.2	2.0	1.3	0.46	0.35	1.2	1.3	0.75	0.03	2.4
4.3	2.0	1.3	0.50	0.39	1.2	1.5	0.83	0.12	2.4
4.4	2.3	1.5	0.48	0.35	1.4	1.4	0.85	0.15	2.8
4.6	2.4	1.5	0.55	0.51	1.6	1.6	0.83	0.21	2.5
4.9	2.8	2.0	0.72	0.54	1.8	1.8	0.91	0.40	2.9
5.2	2.8	1.9	0.68	0.60	1.9	1.9	1.0	0.50	2.5
5.4	3.2	2.1	0.76	0.55	2.0	2.2	1.1	0.70	3.2
5.6	3.2	2.0	0.70	0.58	2.1	2.1	1.2	0.60	3.2
5.8	3.6	2.4	0.75	0.65	2.3	2.2	1.1	0.80	3.6
6.2	3.6	2.3	0.78	0.70	2.4	2.3	1.2	1.0	3.7
6.5	3.8	2.4	0.83	0.75	2.4	2.8	1.2	1.4	3.9
6.8	4.2	2.6	0.92	0.77	2.7	2.5	1.2	1.1	4.2
7.0	4.3	2.8	0.90	0.88	2.7	2.9	1.3	1.2	4.5
7.2	4.5	2.8	0.80	0.82	2.9	2.8	1.3	1.2	4.7
7.5	4.2	2.5	0.84	0.88	3.0	2.8	1.4	1.3	4.3
7.7	4.8	3.1	1.1	0.90	2.8	2.8	1.5	1.4	4.8
7.9	4.4	3.1	1.0	0.86	2.8	2.9	1.4	1.2	4.8
8.2	5.1	2.9	0.92	0.93	3.2	3.3	1.5	1.8	5.3
8.6	5.2	3.2	1.0	1.0	3.3	3.2	1.4	1.7	5.3
9.0	5.4	3.3	1.0	1.0	3.5	3.9	1.7	1.7	5.5
9.2	5.0	3.5	1.2	1.0	3.4	3.6	1.6	1.5	5.3
9.5	6.3	3.9	1.2	1.2	3.8	3.5	1.6	1.8	6.4
9.8	5.8	3.6	1.1	1.1	3.6	4.3	1.7	1.7	6.1
10.0	6.1	3.6	1.1	1.2	4.1	4.5	1.8	1.9	6.2
10.3	6.8	4.1	1.2	1.3	4.1	3.8	1.8	1.7	6.8
10.6	6.9	4.1	1.2	1.3	3.8	3.8	1.8	1.7	7.0
11.0	6.4	4.2	1.3	1.4	4.2	4.2	1.8	2.0	6.5
11.7	7.7	4.6	1.3	1.4	4.3	4.2	2.2	2.4	7.9
12.2	7.3	4.3	1.4	1.5	5.0	5.2	2.2	2.6	7.8
13.0	8.6	4.3	1.2	1.6	5.2	5.2	2.1	2.2	8.8
*11.0	6.8	3.9	1.0	1.3	3.8	3.9	1.9	2.1	7.3
*11.8	7.6	4.6	1.2	1.4	4.2	4.1	2.0	2.3	8.1
*12.5	8.1	4.8	1.2	1.7	4.6	4.9	2.2	2.4	8.7
**12.5	8.2	4.8	1.1	1.8	4.4	4.2	2.1	2.7	8.8

*Transforming specimen.

**Benthic juvenile.

The gut is compact in small larvae of *S. xyris*. Snout-anus distance undergoes a relative increase throughout the larval period. It averages 46% of body length prior to notochord flexion, 52% during flexion, 61% in postflexion larvae, and 64% in transforming specimens.

The large spiny head is a prominent feature of *S. xyris* larvae. Head length increases from a mean of 30% of body length in preflexion larvae to 34% in larvae undergoing notochord flexion, to 38% in postflexion larvae and transforming specimens. The eyes are relatively small; eye diameter averages 30% of the head length for the entire larval period with no obvious trend of relative increase or decrease. The snout length is relatively short in newly hatched larvae (25% of head length), increases to a relative maximum length during notochord flexion (average of 36% of head length), and then gradually decreases during the remainder of the larval period to 25% of head length.

The smallest larvae (1.8 mm) in our collection have pectoral fins with the base and blade well differentiated. The fins enlarge rapidly and are prominent fan-shaped structures in larvae larger than 3.0 mm. Fin length averages 22% of body length prior to notochord flexion, 34% during flexion, and 39% during the remainder of the larval period. They shorten during transformation (average of 36%) and are about 35% in newly transformed juveniles. The base of the pectoral fin is wide as in other scorpaenine genera. It averages 18% of the body length for the entire larval period. Ossification of the rays begins in 4-mm larvae (Table 32). The full complement of 16 to 19 rays is present in larvae longer than 4.7 mm.

The anlage of the caudal fin is present in 2-mm larvae. The hypurals begin to ossify in 5-mm larvae and the full complements of 3 superior and 2 inferior elements are ossified in 8-mm larvae. The principal caudal rays begin to ossify in 4-mm larvae and the full complement of 8

Table 32. Meristics from cleared and stained larvae of Scorpaenodes xyris.

Length (Mm)	Principal caudal fin rays		Procurrent caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	superior	inferior	superior	inferior	left	right	left	right	superior	inferior	upper limb	lower limb			left	right	
4.2	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-	-
4.6	8	7	-	-	7	7	17	17	-	-	0	5	-	-	I-2	I-2	18
5.2	8	7	2	2	7	7	16	16	2	1	1	6	III-5	XIII-7	I-5	I-5	24
5.8	8	7	3	3	7	7	17	17	2	2	2	7	III-5	XIII-9	I-5	I-5	24
6.0	8	7	4	4	7	7	17	17	2	2	2	7	III-5	XIII-9	I-5	I-5	25
6.7	8	7	4	4	7	7	17	16	2	2	3	7	III-5	XIII-9	I-5	I-5	24
7.2	8	7	4	4	7	7	17	17	2	2	3	7	III-5	XIII-9	I-5	I-5	24
7.9	8	7	4	4	7	7	18	18	2	2	2	8	III-5	XIII-9	I-5	I-5	24
8.2	8	7	4	4	7	7	17	17	3	2	3	9	III-5	XIII-9	I-5	I-5	24
9.5	8	7	4	4	7	7	17	18	3	2	4	10	III-5	XIII-9	I-5	I-5	24
10.3	8	7	4	4	7	7	17	17	3	2	3	10	III-5	XIII-9	I-5	I-5	24
11.7	8	7	4	4	7	7	19	19	3	2	3	9	III-5	XIII-9	I-5	I-5	24

superior and 7 inferior rays is present in a 4.6-mm larva. The procurrent caudal rays begin to ossify in 5-mm larvae and the full complements of 4 superior and 4 inferior rays are present in 6-mm larvae.

The pelvic fin appears in 4-mm larvae and increases in length to 13% of body length at the completion of notochord flexion. Fin length averages 18% of body length for the remainder of the larval period. The rays begin to ossify in 4-mm larvae, and the full complement of 1 spinous ray and 5 soft rays is present at 4.6 mm in length.

The dorsal and anal fins begin to develop simultaneously in 4-mm larvae. Ossification of the rays begins in 5-mm larvae and the full complements of XIII, 9 (10) dorsal rays and III, 5 anal rays are present before the larvae reach 6.0 mm.

Pigmentation is sparse in *S. xyris* larvae. The smallest larvae in the collection have a series of 12 to 18 melanophores along the ventral midline of the tail, from the junction of the gut to the hypural anlage. They also have a patch of melanophores along the ventral midline of the gut and several melanophores on the terminal section of the gut. Also, there is an embedded blotch just dorsal to the axilla and the distal region of each pectoral fin is covered with fine melanophores.

As development proceeds some of this original pigment pattern is lost. The series on the ventral midline of the tail is lost before the larvae reach 4.0 mm. The melanophores at the ventral midline of the gut are lost in larvae between 4.0 and 4.5 mm. The patch median to the axillary region enlarges to form a shield over the gas bladder and is visible throughout the larval period.

Just before transformation, a group of melanophores appears on the opercle and preopercle. Transforming specimens from bottom collections have a striking mottled pattern on the head and body. In some, the distal margin of the pectoral fin is still melanistic.

Distribution.—*Scorpaenodes xyris* is a coastal warm-water species. Adults have a latitudinal range from Peru northward to San Clemente Island, Calif., and occur off islands such as Guadalupe and the Galapagos (Miller and Lea 1972). CalCOFI surveys show that the larvae occur throughout the lower two-thirds of the Gulf of California. On the outer coast, *S. xyris* larvae were found only as far north as line 117 (about lat. 28°N) off Punta Eugenia. The planktonic collections of the EASTROPAC expedition show that *S. xyris* larvae occur from lat. 20°N to lat. 20°S along a coastal band (Fig. 30). Larvae occurred in small numbers in both CalCOFI and the eastern tropical Pacific hauls. The largest number taken on any haul was seven, and three-fourths of the positive hauls had a single larva of *S. xyris*.

Larvae were taken on all CalCOFI cruises in the Gulf of California (Fig. 30). More larvae were taken in June than in the other months (February, April, December), thus suggesting a summer spawning peak in this region. On EASTROPAC expeditions, the number of occurrences was about equal on the winter cruises (February-April) and the summer cruises (July-September).

Figure 30.—Stations at which larvae of *Scorpaenodes xyris* were taken on CalCOFI cruises (triangles) during 1956 and 1957 and EASTROPAC expeditions (dots) during 1967 and 1968.

Scorpaena Linnaeus

Literature.—The early stages of two North Atlantic-Mediterranean species of *Scorpaena*, *S. porcus* and *S. scrofa*, were described by Raffaelle (1888) and Fage (1918). More thorough descriptions of the egg, larval, and juvenile stages of these two species and of the eggs and larvae of *S. notatus* were given by Sparta (1941, 1942, 1956). The latter paper includes a color plate. The early developmental stages of the sculpin, *Scorpaena guttata*, of California and Baja California were described from specimens cultured in aquaria (Barnhart 1932; David 1939; Orton 1955). These authors described the egg masses, developing eggs, and larvae up to the stage of yolk exhaustion (about 3.0 mm body length).

Distinguishing features.—*Scorpaena* larvae are easily distinguished from *Sebastes* and *Sebastolobus* by myomere count, *Scorpaena* having 24, *Sebastes* having 26 or more, and *Sebastolobus* having 28 or more. *Scorpaena* differs further from *Sebastolobus* in having a row of melanophores along the ventral midline of the tail, as opposed to a single dorsal and ventral blotch, and in having nonbifurcate parietal ridges. This latter character also separates *Scorpaena* from *Scorpaenodes*. *Scorpaena* larvae develop a moderately long pair of parietal spines that reach their greatest relative length at about the completion of caudal fin formation. A small nuchal spine forms subjacent to each parietal spine. *Scorpaena* may be separated from *Pontinus* on the basis of gut pigmentation. *Scorpaena* larvae develop a melanistic shield over the dorsolateral surface of the gut, whereas *Pontinus* larvae have a deeply embedded blotch above the axillary region which, as in *Scorpaenodes*, enlarges to cover the dorsal surface of the gas bladder. This character is particularly useful in separating small larvae of *Scorpaena*, *Pontinus*, and *Scorpaenodes* that have not yet formed head spines. Another melanistic character useful in separating *Scorpaena* larvae from those of *Scorpaenodes* and *Pontinus* is the presence of a ventral midline blotch just anterior to the juncture of the cleithra in *Scorpaena*. This is absent in the other five genera.

Scorpaena larvae have highly characteristic pectoral fins. They are moderate in length, as opposed to the extremely elongate fins of *Scorpaenodes*, and are fan-shaped in contrast to the aliform pectorals of *Pontinus*. Pigmentation varies among the species of *Scorpaena*, but the pectorals are usually heavily pigmented.

According to a recent revision, there are nine species of *Scorpaena* in the eastern Pacific (Greenfield 1974). *Scorpaena* larvae usually occur nearshore, thus are not common constituents of our plankton hauls. Our collections contain sufficient numbers of larvae for the following descriptions of *S. guttata* and another form which we designate as Type A.

Scorpaena guttata Girard, Figure 31

Literature.—The three publications on the early developmental stages of *S. guttata* listed in the preceding section describe stages up to 3.0 mm. Later larval stages of *S. guttata* have not been previously described.

Distinguishing features.—The early stages of *Scorpaena guttata* have been studied in detail (Barnhart 1932; David 1939; Orton 1955) and the following account is a summary of these studies. The egg masses are spawned at about midnight and float to the surface. They are bilobed gelatinous structures, each lobe measuring 16 to 26 cm in length. The matrix is about 2-mm thick and within it the eggs are evenly spaced in a single layer. The slightly elliptical eggs measure about 1.2 mm at the long axis. The yolk mass is colorless and contains no oil globule. The chorion is colorless, transparent, and unsculptured. There is no apparent perivitelline space. The eggs hatch when freed from the matrix at an average time of 3 days after fertilization in southern California waters. The newly hatched young are 1.9 to 2.0 mm long, have a large elliptical yolk sac, and have a voluminous dorsal finfold that is inflated in appearance. The pectoral fin buds are small and inconspicuous. A patch of dendritic melanophores covers the dorsal aspect of the gut and similar melanophores are also below the gut.

At about 4 days after fertilization, the larvae are 2.5 to 2.7 mm long, have 22 to 24 myomeres, and have a row of melanophores along the ventral midline of the tail. At about 5 days after fertilization, the yolk is half utilized, and at about 6 days the mouth is formed. At 7 to 8 days the yolk is depleted, the jaws are functional, and the pectorals are fan-shaped and have one to several rows of melanophores along their distal margins. The previously undescribed later larval stages of *S. guttata* are delineated below.

Early-stage larvae of *S. guttata* are deep-bodied, become comparatively more slender during notochord flexion, and thereafter become increasingly deep-bodied. Body depth averages 36% of body length prior to notochord flexion, 30% during flexion, and 40% following flexion (Table 33).

The compact gut increases gradually in relative length during the larval period. Snout-anus length averages 49% of body length prior to notochord flexion, 51% during flexion, and 60% following flexion.

At the completion of yolk utilization the head of *S. guttata* larvae is moderately large and increases in relative size during later larval development. Head length averages 30% of body length in preflexion larvae, 34% during flexion, and 38% following flexion. The eyes are moderately small; eye diameter averages 32% of the head length throughout the larval period with no obvious trend of relative increase or decrease. Snout length increases from an average of 31% of the head length in preflexion larvae to 33% in larvae undergoing flexion, then decreases gradually to 28% in our largest larva.

The pectoral fins are small and poorly differentiated in 2.0-mm larvae but growth and differentiation is rapid and, when the larvae have reached 3.0 mm, the fins have a well-differentiated base, a deep fan-shaped blade, and have doubled in length to 15% of the body length. Fin length increases to an average of 21% of the body length at notochord flexion. Following notochord flexion, fin length averages 22% of body length up to about 10 mm, and then there is a considerable jump in relative fin length to 29% in our largest larva (12.8 mm). The depth of the fin base is slightly smaller than in other scorpaenine genera. It averages 15% of the body length over the entire larval period. Fin rays begin to ossify in larvae about 4.0 mm long and the full complement of 17 to 19 rays is present in 5-mm larvae.

The hypural anlagen of the caudal fin are apparent in larvae as small as 2.5 mm. They begin to ossify in 5-mm larvae and in the largest stained specimen (6.5 mm) the large superior and inferior elements are well ossified. The

Table 33. Measurements (mm) of larvae of *Scorpaena guttata*. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
2.0	1.1	0.38	0.11	0.18	0.90	0.14	0.15	-	-
2.9	1.4	0.95	0.27	0.26	1.1	0.45	0.37	-	-
3.2	1.6	1.0	0.30	0.32	1.1	0.57	0.50	-	-
3.9	1.7	1.2	0.35	0.35	1.3	0.60	0.62	-	-
4.2	2.1	1.2	0.44	0.45	1.2	0.93	0.69	0.08	-
4.5	2.2	1.6	0.50	0.45	1.3	1.0	0.75	0.10	2.6
4.8	2.4	1.7	0.52	0.52	1.4	1.0	0.78	0.12	2.7
5.4	2.7	1.7	0.60	0.55	1.5	1.0	0.83	0.11	3.1
5.7	3.2	2.0	0.67	0.67	1.8	1.2	0.94	0.32	3.4
5.8	3.2	2.0	0.68	0.68	2.1	1.2	1.0	0.55	3.3
6.0	3.5	2.2	0.76	0.72	2.2	1.4	1.0	0.60	3.6
6.5	3.7	2.3	0.80	0.78	2.4	1.5	1.1	0.73	3.7
8.0	5.1	3.2	1.1	1.1	3.5	1.8	1.3	1.6	5.2
9.2	5.5	3.8	1.2	1.0	3.8	2.0	1.4	1.6	5.6
9.8	6.0	3.8	1.1	1.1	3.9	1.8	1.5	1.7	6.1
12.8	7.9	5.0	1.4	1.8	5.4	3.7	1.8	2.6	8.2

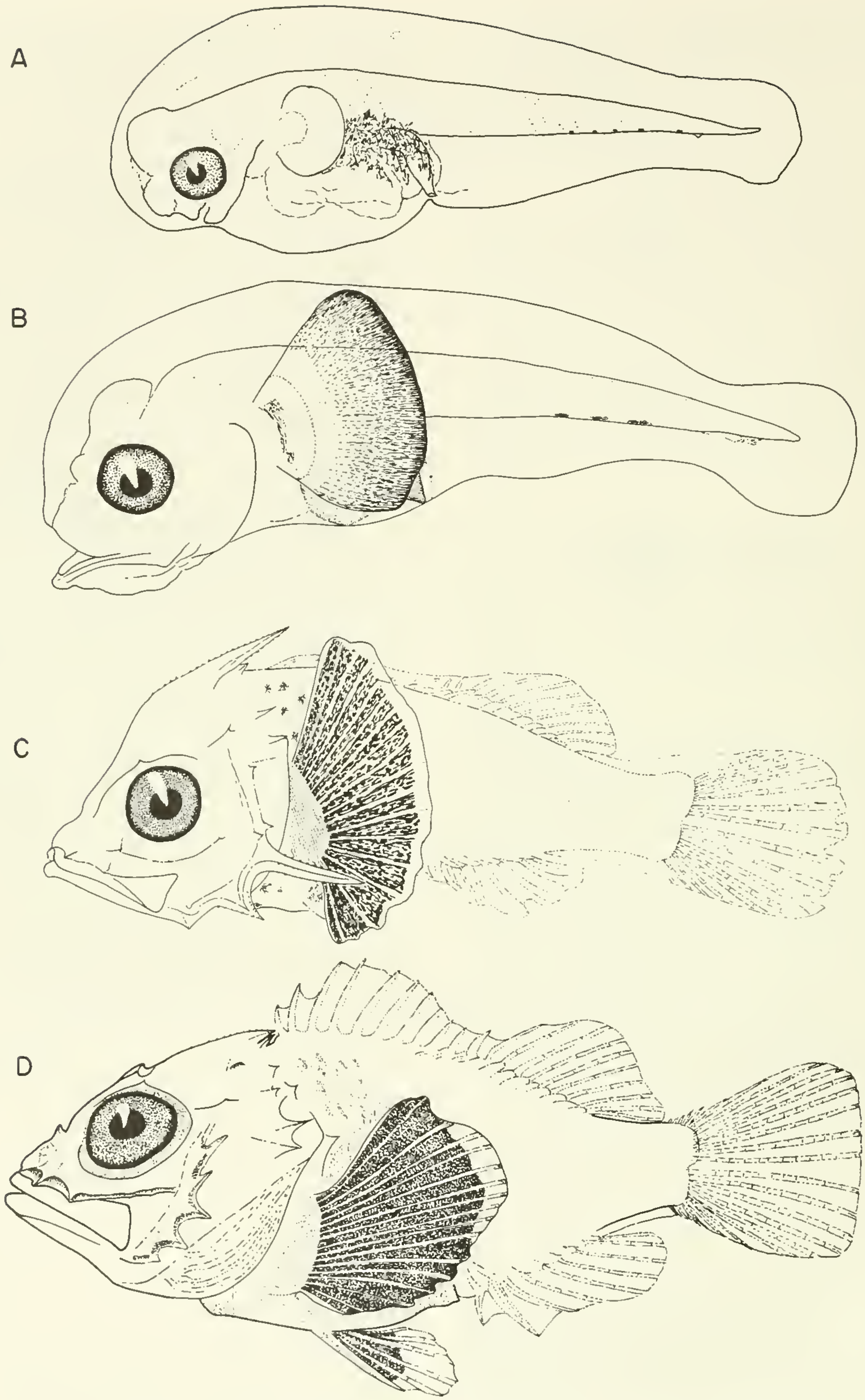

Figure 31.—Larvae of *Scorpaena guttata*. A. 2.1 mm; B. 3.1 mm; C. 6.2 mm; D. 12.8 mm.

full complement of 8 + 7 principal caudal rays is undergoing initial ossification in a larva 5.2 mm long. Secondary caudal rays begin ossifying in 5-mm larvae. In the largest stained specimen (6.5 mm) there are 4 superior and 4 inferior secondary elements ossifying.

The pelvic fins appear when the larvae are about 4.0 mm long and increase in relative length to 10% of the body length at the completion of notochord flexion. There is a gradual elongation of the fin during later larval stages to a maximum of 20% of the body length in our largest larva. Pelvic fin rays begin ossifying in 5-mm larvae and the full complement of 1 spinous ray and 5 soft rays is ossifying before the larvae reach 6.0 mm.

The dorsal and anal fins begin to form simultaneously in larvae about 4.5 mm long. Ossification begins in 5-mm larvae and the full complements of III, 5 or 6 anal rays and XII, 8 to 10 dorsal rays is present in 6-mm larvae.

Larvae of *S. guttata* are characteristically pigmented. Pigmentation of larvae less than 3.0 mm long has been described by other investigators and is summarized above. Notable changes occur in the initial pigment pattern in larvae larger than 3.0 mm. Melanophores first appear on the posterior margin of the pectoral fin in early larvae and when the larvae are 3.2 mm long, the distal half of the fin is covered. At 4.0-mm length, the entire fin is covered with melanophores as is the medial surface of the fin base. As the rays develop, the pigment becomes restricted to the membrane between the rays and becomes strikingly heavy. In 6-mm larvae the distal margin of each fin begins to lose pigment and this clear zone widens to about 20% of the length of the fin in the largest larva. Gut pigment was originally on the dorsolateral surface of the gut, but spreads ventrally to cover all surfaces of the gut when the larvae reach 4.0 mm. There is a gradual reduction in the number of pigment spots in the ventral tail series. In larvae about 3.0 mm long the number of melanophores in this series ranges from 2 to 7 with a mean of 4.15 ± 1.62 SD for 50 larvae. In larvae between 3.0 and 8.0 mm there is a general decline in this number but the average number for the whole size range is 2.64 ± 1.12 for 11 larvae. Larvae longer than 9.0 mm had no ventral tail melanophores.

When the larvae reach 4.0 mm, a small blotch of pigment develops just anterior to the cleithral symphysis. This remains throughout the larval period and is augmented by several more melanophores in larvae larger than 9.0 mm. Melanophores develop on the head region in larvae of about 4.5 mm in length. A single melanophore is embedded at the nape and persists through the remainder of the larval period. It is augmented by several more melanophores in larvae 8.0 mm and longer. A pair of melanophores appears above the optic lobes of the brain in 4.5-mm larvae and to these are added other melanophores until the optic lobes are covered in larvae larger than 9.0 mm. A pair of melanophores forms above the olfactory lobes in larvae about 6.0 mm long and persists throughout the remainder of the larval period. Several melanophores form around the base of the pelvic fins in larvae about 6.0 mm long, but the fins themselves remain unpigmented until late in the larval period. Melanophores begin to form in the epaxial myosepta above the pectoral fin in some larvae as small as 6.2 mm and cover an extensive area in larvae larger than 10.0 mm. Melanophores appear on the cheek and below the eye in 9-mm larvae and become more extensive in larger larvae.

Distribution.—Adults of *S. guttata* are known from Santa Cruz, Calif., southward to Uncle Sam Bank, Baja California (about lat. 24°35'N). This species also occurs at Guadalupe Island, Baja California, and in the northern part of the Gulf of California (Miller and Lea 1972). Distribution of *S. guttata* larvae was analyzed for the 1966 and 1969 CalCOFI cruises. Larvae were taken from June to November in 1966 and from July to September in 1969. Spawning appears to peak in August, as 44% of the total occurrences and 67% of the larvae for 1966 were taken during this month (Table 34).

Table 34. Numbers of occurrences and standardized numbers of larvae of *Scorpaena guttata* taken by CalCOFI in 1966.

CalCOFI line	Latitude[1] (N)	June		July		August		September		October		November	
		Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.
97	32°17.5'	-	-	-	-	1	3	-	-	-	-	-	-
100	31°42.2'	-	-	-	-	1	3	2	6	-	-	-	-
103	31°07.0'	1	3	1	2	-	-	1	12	-	-	-	-
107	30°27.9'	-	-	-	-	2	5	2	6	-	-	-	-
110	29°52.0'	-	-	-	-	2	9	-	-	-	-	-	-
113	29°24.2'	-	-	1	3	1	3	3	28	-	-	-	-
117	28°58.0'	-	-	3	16	6	104	2	15	1	6	-	-
118	28°18.5'	-	-	-	-	1	3	1	9	-	-	-	-
119	28°19.0'	-	-	-	-	1	3	-	-	-	-	-	-
120	28°25.0'	-	-	4	12	4	52	-	-	1	3	-	-
123	27°26.2'	-	-	1	2	2	28	-	-	1	3	-	-
127	26°57.5'	-	-	4	12	1	62	-	-	-	-	-	-
130	26°33.5'	-	-	1	2	1	5	-	-	-	-	-	-
133	26°08.5'	-	-	1	3	4	29	-	-	-	-	-	-
137	25°36.1'	-	-	2	5	-	-	-	-	1	2	1	8

[1]Latitude of most shoreward station.

Larvae of *S. guttata* occur in the southern portion of the CalCOFI pattern, from about the Mexican border south to line 137, just north of Magdalena Bay (Table 34). The greatest concentration of positive hauls was off central Baja California in the area around Punta Eugenia (Fig. 32).

Scorpaena Type A, Figure 33

Literature.—This larval form of *Scorpaena* has not been previously described or illustrated.

Distinguishing features.—Egg masses of *Scorpaena* species other than *S. guttata* have not been reported in the eastern Pacific and yolk-sac stages of Type A larvae are not present in our collection. Type A larvae are similar morphologically to those of *S. guttata*, but are comparatively more slender prior to notochord flexion. Body depth at this stage averages 27% of body length for Type A larvae (Table 35) and 36% for *S. guttata*. Body depth for Type A larvae undergoing notochord flexion averages 29% of body length, and for postflexion stages the mean is 38%. Comparative percentages for *S. guttata* larvae are 30% and 40%.

Figure 32.—Stations at which larvae of *Scorpaena guttata* were taken on CalCOFI cruises during 1966. Solid circles indicate stations where number of larvae exceeded mean (7.4) for all positive stations. Area of complete grid is outlined (see Ahlstrom 1961 for complete grid).

Table 35. Measurements (mm) of larvae of *Scorpaena* Type A. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
2.2	1.2	0.58	0.20	0.22	0.57	0.23	0.26	-	-
2.5	1.2	0.70	0.23	0.25	0.67	0.27	0.32	-	-
2.8	1 4	0.73	0.21	0.22	0.68	0.28	0.40	-	-
3.0	1.4	0.87	0.25	0.30	0.90	0.42	0.43	-	-
3.5	1.8	1.0	0.33	0.32	0.95	0.52	0.52	-	-
3.7	1.8	1.0	0.34	0.33	0.98	0.47	0.55	-	-
4.0	2.1	1.2	0.41	0.40	1.2	0.65	0.60	0.05	2.2
4.2	2.1	1.3	0.40	0.40	1.3	0.65	0.65	0.07	2.3
4.6	2.3	1.5	0.48	0.42	1.4	0.75	0.68	0.10	2.6
5.0	2.7	1.6	0.50	0.51	1.4	0.77	0.70	0.07	2.8
5.5	3.1	1.9	0.62	0.60	1.5	1.0	0.71	0.18	3.2
5.8	3.4	2.2	0.73	0.73	1.9	1.1	0.97	0.69	3.4
6.1	3.8	2.3	0.70	0.72	2.1	1.2	1.1	0.53	3.8
6.8	4.2	2.5	0.75	0.90	2.8	1.3	1.2	1.1	4.2
7.0	4.2	2.6	0.83	0.90	2.8	1.5	1.2	1.1	4.2
7.6	4.8	2.9	0.91	1.0	3.0	1.7	1.2	1.1	4.8
8.0	4.8	3.1	0.93	1.1	3.5	1.8	1.4	1.4	4.8
12.2	8.8	5.2	1.6	1.7	5.7	4.0	2.0	1.9	9.2

The gut is compact and increases in relative length during the larval period. Snout-anus length averages 50% of body length prior to notochord flexion, 53% during flexion, and 61% following flexion. Head size is moderate and increases relative to body length during development. Head length averages 28% up to the beginning of notochord flexion, 32% during flexion, and 38% following flexion. Snout length and eye diameter show no change relative to head size and average 32% and 33% of head length, respectively.

The fan-shaped pectoral fins are similar in size to those of *S. guttata*. They increase in relative length from an average of 12% of body length in preflexion larvae to 16% during flexion, and 21% following flexion. Depth of the fin base shows a more gradual relative increase of 14%, 15%, and 17% for the three stages. Pectoral fin rays begin to ossify in 3-mm larvae and the full complement of 19 to 20 rays is present in 4-mm larvae. The pelvic fins begin to form in 4-mm larvae and reach a maximum of 18% of the body length in our largest larva. Ossification is initiated in 4-mm larvae and the full complement of I, 5 rays is present at 6.0-mm length.

The hypural anlagen of the caudal fin appear in larvae about 2.5 mm long. They begin to ossify when the larvae reach 4.0 mm and the large superior and inferior elements are well ossified at a length of 6.0 mm. Primary caudal rays begin to ossify in 3-mm larvae and the full complement of 8 + 7 rays is present at about 4.0-mm length. Secondary caudal rays begin ossifying at about 4.0-mm length and there are 5 superior and 5 inferior rays present in our largest stained specimen (6.0 mm).

The dorsal and anal fins begin to develop simultaneously in larvae about 4.0 mm long. Ossification is initiated immediately thereafter and the larvae larger than 5.3 mm have III, 5 anal rays and XII, 8 dorsal rays.

The larvae of *Scorpaena* Type A differ from those of *S. guttata* chiefly in the pattern of melanophores. As in early larvae of *S. guttata*, those of *S.* Type A have melanophores along the dorsolateral surfaces of the gut, along the ventral midline of the tail, and on the pectoral fins. The particular arrangement of melanophores on the tail and pectoral fins is distinctly different in the two forms and is a useful means of separating them. In Type A larvae the ventral midline series extends along the entire length of the tail from above the anus posteriad to the hypural anlage of the caudal fin. In larvae of *S. guttata*, the series is confined to the posterior half of the tail. Accordingly, there are more melanophores in this series in Type A; the range for preflexion larvae is 8 to 14 and for larvae undergoing flexion is 4 to 8. Ventral tail melanophores are not present in postflexion larvae. The melanophore pattern of the pectoral fin is similar in larvae of *S.* Type A and *S. guttata* up to about 3.0 mm in length. At that size, a region of darker pigmentation develops at the ventral aspect of the fin in Type A. This area of darker pigment remains detectable from the surrounding pigment in larvae up to about 6.0 mm in length. This pigment does not develop in larvae of *S. guttata*. As in *S. guttata*, pigment begins to develop on the medial surface of the fin base at about 3.0 mm in length and intensifies during the remaining larval period. In Type A larvae of about 4.0-mm length the dorsal and upper posterior margins of the fin begin to lose melanophores. This clearing becomes more extensive with further development and in the largest larvae the membranes of the most dorsal three rays and the posterior one-third of the fin are clear. In *S. guttata* only a

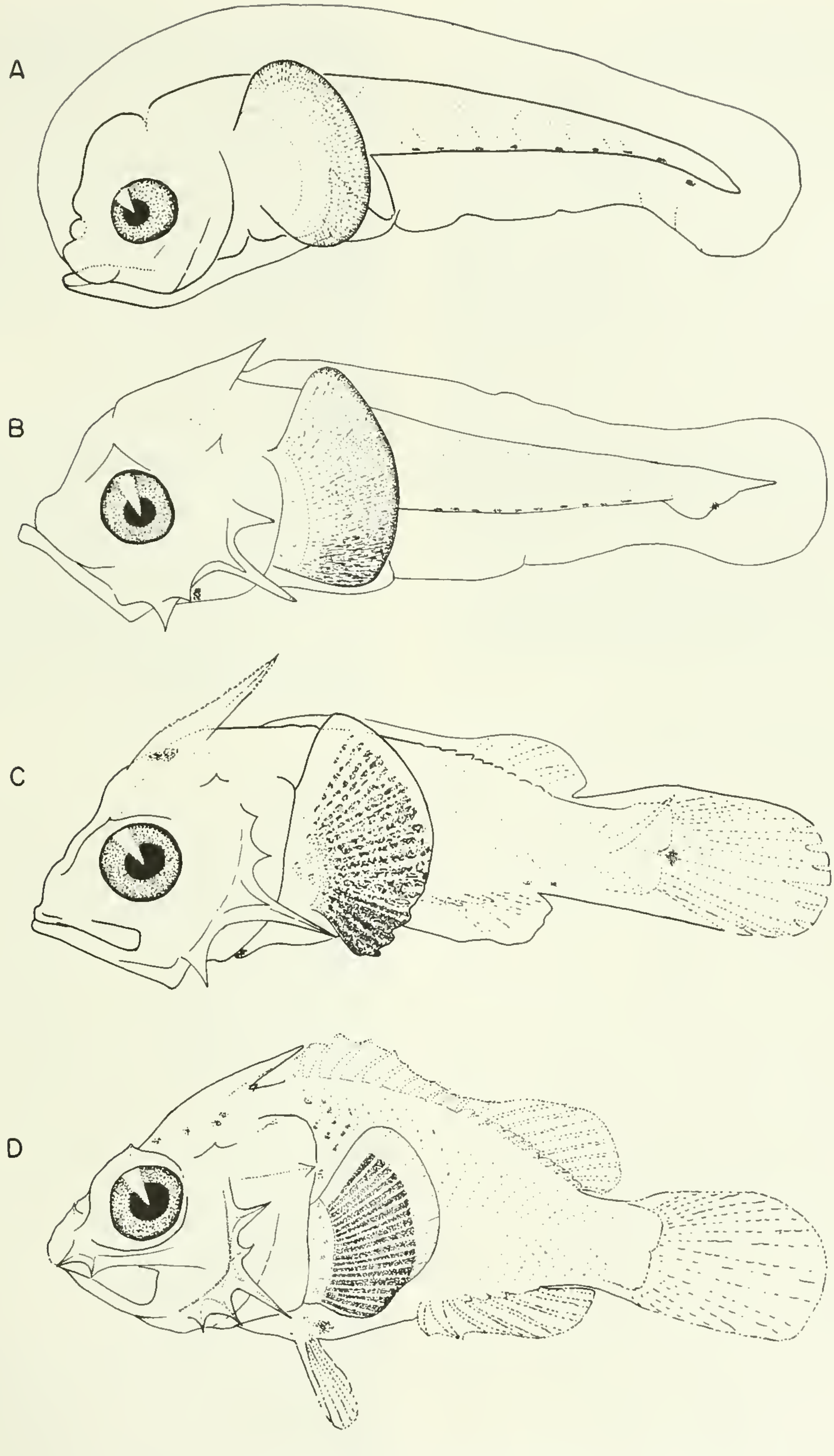

Figure 33.—Larvae of *Scorpaena* Type A. A. 2.5 mm; B. 3.5 mm; C. 4.6 mm; D. 8.0 mm.

narrow portion of the distal region of the fin becomes clear in mid- and late-stage larvae.

Other pigmentation is not substantially different from that of *S. guttata* and other known *Scorpaena* larvae. A melanistic blotch appears just anterior to the junction of the cleithra at about 3.0-mm length and remains throughout the larval period. Melanophores form posteriorly on the brain when the larvae are about 4.0 mm long. At about 5.5 mm, one or two melanophores appear above the olfactory lobes. In 7-mm larvae additional melanophores form above the optic lobes and at 8.0 mm the brain is covered. At 4.0-mm length an embedded melanophore forms at the nape and remains throughout the larval period. Myoseptal pigment is present in the epaxial musculature above the pectoral fin in the 8.0-mm larva.

Distribution.—Most of our larvae of *Scorpaena* Type A were collected on the CalCOFI cruise in the Gulf of California during June 1957. They occurred at 24 stations distributed throughout the entire Gulf (Fig. 34). They occurred at two stations of the CalCOFI cruise during August 1957, however, only a small portion of the plankton from that cruise was sorted and the larvae may have occurred more extensively on that cruise. Except for one station, where the standardized number of larvae was 143, the larvae occurred in small numbers. Eliminating that station the mean number of larvae for the other 25 stations in the Gulf was 12. The species that produces larvae of *Scorpaena* Type A is a summer spawner since no larvae were taken on the December, February, or April cruises in the Gulf during 1956 and 1957.

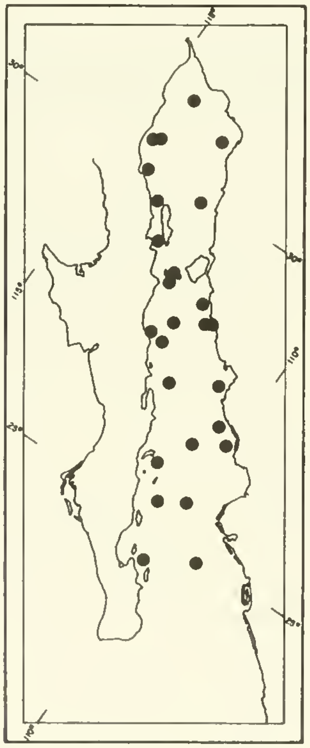

Figure 34.—Stations at which larvae of *Scorpaena* Type A were taken on CalCOFI cruises in the Gulf of California during 1956 and 1957.

Larvae of *Scorpaena* Type A occurred at two stations of the EASTROPAC expedition in the vicinity of Panama Bay and at two stations of the Scripps Tuna Oceanography Cruise 58-1, one near Panama Bay and one off the Tres Marias Islands (lat. 21°30′N, long. 106°30′W). The low incidence of these larvae on these wide-ranging expeditions probably reflects the near-shore nature of spawning in the species producing the larvae.

Pontinus Poey

Literature.—The literature contains no descriptions or illustrations of the developmental stages of *Pontinus*.

The taxonomy of *Pontinus* in the eastern Pacific is poorly known. At present there are five recognized and six nominal species, however, unpublished information of W. Eschmeyer (Calif. Acad. Sci.) indicates that the species complement of eastern Pacific *Pontinus* is more than double the presently recognized number. In fact, a previously undescribed but abundant species was discovered while examining museum specimens during the present study. Unfortunately, the characters that separate this host of species are mostly not the kind that may be traced backward into larval series.

Distinguishing features.—Larvae of *Pontinus* can be separated from those of other eastern Pacific genera by a combination of characters. As in larvae of *Scorpaenodes* and *Ectreposebastes, Pontinus* larvae lack the melanistic shield that covers the dorsolateral surfaces of the gut in *Sebastes, Sebastolobus*, and *Scorpaena*. In place of this, larvae of *Pontinus, Scorpaenodes*, and *Ectreposebastes* have a deeply embedded medial blotch just dorsal to the axilla. This blotch later enlarges to cover the dorsal surface of the gas bladder. *Pontinus* larvae differ from *Scorpaenodes* in several characters. In *Pontinus*, a single elongate spine develops at the terminus of each parietal ridge. In midstage larvae a small subjacent nuchal spine develops posterior to each parietal spine and remains inconspicuous throughout the larval period. This contrasts greatly with the bifurcate terminus of the parietal ridge in *Scorpaenodes*. The pectoral fins of the two genera differ in shape, relative length, and pigment pattern. They are aliform in *Pontinus* and fan-shaped in *Scorpaenodes*. The pectorals are shorter in *Pontinus*; pectoral fin length averages 31% of the body length in postflexion larvae of Type A and 27% in *Pontinus* Type B; mean length was 39% in postflexion larvae of *S. xyris*. The pectoral fin base is also narrower in *Pontinus*; the depth of the fin base averages 14% of the body length in postflexion larvae of Type A and 16% in *Pontinus* Type B. Fin base depth averaged 18% in postflexion *S. xyris* larvae. Pigmentation of the pectoral fins is limited to the distal margin of the pectoral fin in *Scor-*

paenodes whereas in *Pontinus* the pattern of pigmentation is more complex and develops through sequential stages. Larvae of *Ectreposebastes* are highly distinctive and may be separated from those of *Pontinus* on the basis of body depth and pectoral fin length. Body depth averages 46% of body length for postflexion larvae of *Ectreposebastes* and 39% for postflexion larvae of *Pontinus* Type A. The pectoral fin extends to the base of the caudal fin in *Ectreposebastes* and extends only to the midregion of the anal fin in *Pontinus*. Also, pigmentation of the pectoral fin is markedly different as evident in the illustrations of larvae of the two genera.

Despite the large species complement of *Pontinus*, we can distinguish only three larval forms in our collection. We have a complete larval series of the abundant form, here called *Pontinus* Type A. It ties in with the juveniles of a common but undescribed species of *Pontinus* discovered in this study. A second, much less abundant form, called *Pontinus* Type B, is distinguishable down to a length of about 5.0 mm. Its largest pelagic juveniles have a pigment pattern similar to the smallest known benthic juveniles of *Pontinus sierra* (Gilbert) and it is likely that *Pontinus* Type B is *P. sierra*. A third form, here called *Pontinus* Type C, is known from a few small larvae and is presently not identifiable.

Since larvae of *Pontinus* have not been previously described, a detailed description of *Pontinus* Type A is given below along with a brief description of Type B.

Pontinus Type A, Figure 35

Literature.—None.

Distinguishing features.—The smallest larva available to us is a specimen 2.3 mm long that has no yolk sac. When the larvae reach about 15 mm, pigment saddles begin to form dorsally on the trunk. Although there is no associated abrupt morphological change we have designated this as the beginning of the pelagic juvenile stage. This stage is protracted in *Pontinus* Type A, our largest pelagic specimen being 27.4 mm long. Apparently, there is a large size range over which *Pontinus* Type A pelagic juveniles may become demersal since bottom-caught specimens as small as 17.2 mm are present in our collections.

Larvae of *Pontinus* Type A are deep-bodied. Body depth increases from a minimum of 25% of the body length in the smallest larva to 33% at notochord flexion (Table 36). Body depth averages 39% in postflexion larvae and pelagic juveniles. In small benthic juveniles, average body depth is reduced slightly to 36% of the body length.

The gut is compact in small larvae of *Pontinus* Type A and undergoes a relative lengthening throughout the larval period. Snout-anus distance averages 48% of the body length before notochord flexion, 54% during flexion, and 61% following flexion. In pelagic and small benthic juveniles, snout-anus length averages 64% of the body length.

Table 36. Measurements (mm) of larvae of Pontinus Type A. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
2.3	1.0	0.67	0.20	0.24	0.58	0.41	0.36	-	-
2.7	1.2	0.70	0.19	0.24	0.73	0 49	0.40	-	-
3.0	1.6	1.0	0.30	0.31	0.96	0.55	0.45	-	-
3.4	1.7	1.0	0.33	0.30	1.0	0.65	0.50	-	-
4 1	2.2	1.3	0.52	0.40	1.4	1.1	0.65	0.10	2.4
4.6	2.5	1.5	0.63	0.46	1.5	1.2	0.70	0.24	2.8
5.2	3.0	2.0	0.70	0.62	2.0	1.4	0.85	0.84	3.2
5.5	3.5	2.4	0.95	0.56	2.2	1.6	0.86	0.73	3.6
5.9	3.8	2.6	0.90	0.56	2.4	1.8	0.86	1.0	3.8
6.4	3.8	2.5	0.85	0.65	2.6	1.8	1.0	1.2	3.8
6.7	4.0	2.6	0.95	0.68	2.6	2.0	1.0	1.3	4.2
7.1	4.1	2.7	1.0	0.72	2.7	2.1	1.1	1.2	4.2
7.5	4.4	2.9	1.1	0.75	2.8	2.2	1.1	1.4	4.5
8.0	4.8	3.1	1.0	0.84	3.2	2.4	1.1	1.6	5.0
8.6	5.1	3.4	1.0	0.91	3.4	2.7	1.2	1.8	5.5
9 2	5.5	3.5	1.0	0.95	3.6	2.8	1.2	1.8	5.7
9.8	6.0	4.2	1.2	1.0	3.7	2.8	1.2	2.0	6.2
10.6	6.3	4.2	1.2	1.2	3.8	3.8	1.5	2.5	6.5
11.2	7.3	4.8	1.6	1.2	4.7	3.9	1.6	2.8	7.5
12.2	7.5	4.8	1.4	1.5	4.4	4.1	1.6	2.6	8.1
13.2	8.1	5.2	1.5	1.5	5.1	4.2	1.8	2.9	8.7
14.4	8.8	5.8	1.7	1.8	5.3	4.3	1.9	3.3	9.5
*15.0	9.7	6.0	1.8	1.8	6.0	5.3	2.0	3.6	10.1
*16.4	10.0	6.2	1.8	1.8	6.5	5.4	2.2	3.3	10.5
*17.7	11.2	7.3	2.1	1.9	7.2	6.1	2.4	3.9	11.7
*19.6	12.7	7.8	2.1	2.1	8.0	6.7	2.6	4.2	13.4
*21.3	13.7	8.8	2.7	2.3	8.0	6.7	2.7	4.3	14.4
*23.0	14.7	9.6	2.7	2.6	8.3	7.6	2.8	4.6	15.5
*25.7	16.4	10.1	3.2	2.9	9.5	7.9	3.2	4.8	17.2
*27.4	17.9	11.7	3.2	2.6	9.8	8.8	3.3	5.1	19.3
**17.2	10.6	6.9	1.8	1.9	6.2	5.9	2.2	3.8	11.7
**18.9	12.2	7.5	2.1	2.2	6.7	5.7	2.4	4.2	12.8
**20.8	13.0	8.2	2.2	2.4	7.4	6.8	2.6	5.0	14.0
**24 5	16.0	9.8	2.9	2.7	8.8	7.5	3.0	5.2	17.4

*Pelagic juvenile.

**Benthic juvenile.

The head is large in *Pontinus* Type A larvae. Head length increases from a mean of 30% of the body length in preflexion larvae to 32% in larvae undergoing notochord flexion, and averages 40% in postflexion larvae and in pelagic and small benthic juveniles. The moderately small eyes undergo a relative diminution during the larval period. Eye diameter averages 32% of head length before and during notochord flexion and is reduced to a mean of 27% in postflexion larvae and pelagic juveniles. Eye diameter increases slightly to a mean of 28.5% of head length in newly transformed benthic juveniles. Snout length increases from a mean of 32% of head length in preflexion larvae to a mean of 41% in larvae undergoing flexion. Thereafter the mean decreases to 33% in postflexion larvae and to 29% in pelagic juveniles.

The pectoral fins are prominent in the smallest larvae in our collection. At this stage they have a slight aliform shape; however, during later larval stages they become distinctly aliform. Fin length increases from an average of 20% of the body length in preflexion larvae to 26% in larvae undergoing notochord flexion, and to 32% in postflexion larvae and pelagic and small benthic juveniles. The depth of the pectoral fin base is not as great as in other eastern Pacific scorpaenine genera but is greater than in sebastine genera. It decreases from an average of 16% of the body length before and during notochord flexion, to 14% in postflexion larvae and 13% in pelagic and early benthic juveniles. Sequence of ossification of fin elements was not analyzed because only a few larger larvae could be properly stained. Apparently calcium in the larvae leached out in preservative. Pectoral ray counts for nine stained specimens ranged from 17 to 19.

The dorsal, anal, and pelvic fins begin to develop in larvae about 4.0 mm long. The counts for the nine stained specimens were D. XII, 9; A. III, 5; P. I, 5. Hypural anlagen of the caudal fin are visible in the smallest larvae;

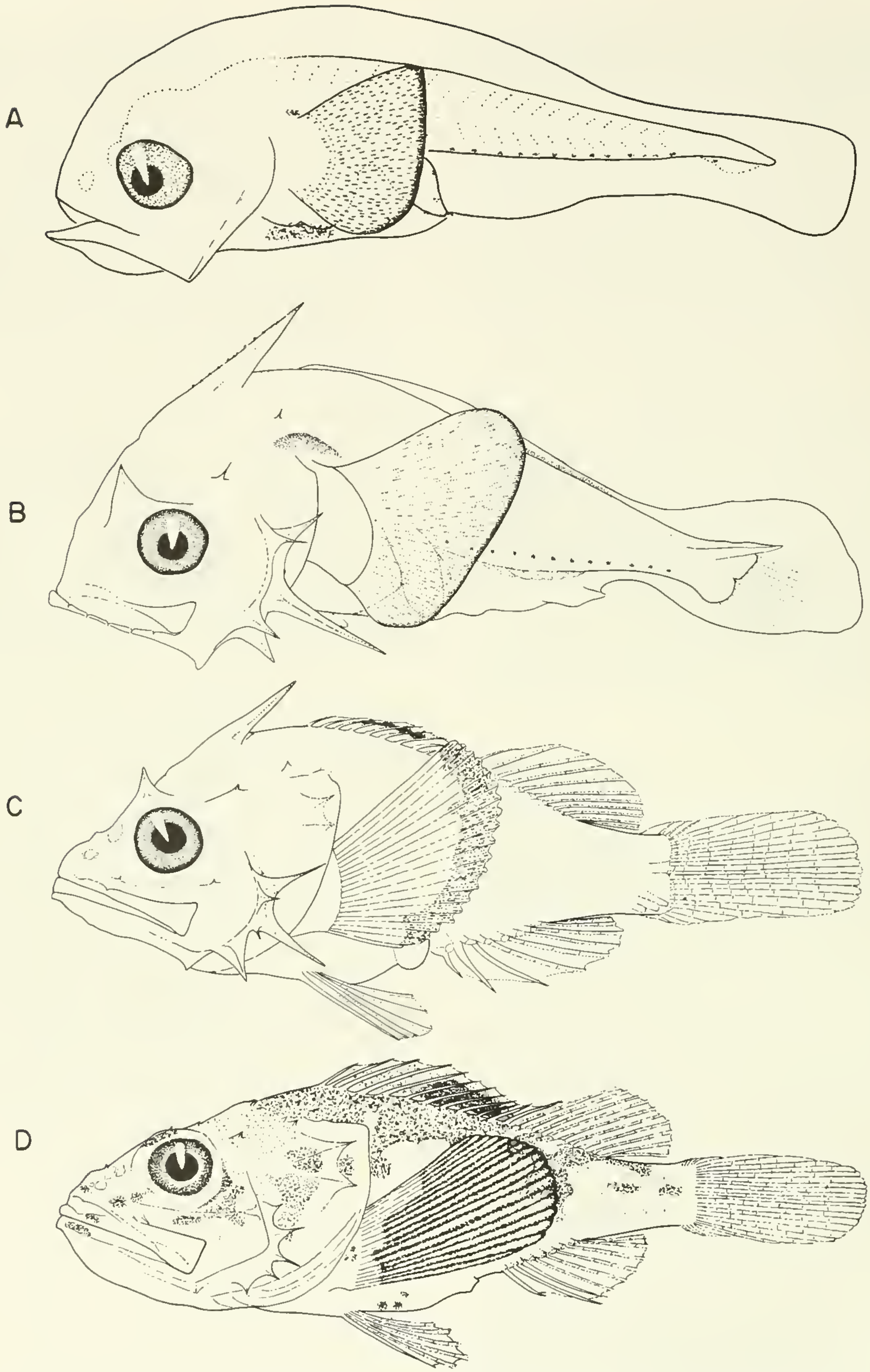

Figure 35.—Developmental series of *Pontinus* Type A. A. 2.3-mm larva; B. 4.1-mm larva; C. 8.0-mm larva; D. 24.5-mm benthic juvenile.

the adult complement is 3 + 2 hypurals. The stained larvae had 8 + 7 principal rays and 6 + 6-7 procurrent rays. All stained larvae had 24 vertebrae. Gill rakers ranged from 5 to 6 on the upper limb and 8 to 12 on the lower limb of the first arch. There were 7 branchiostegal rays.

Early larvae of *Pontinus* Type A are sparsely pigmented. The initial melanophore pattern is similar to that of *Scorpaenodes*. A series of 11 to 16 melanophores (mean of 13 ± 1.3 SD for 14 larvae counted) is present along the ventral midline of the tail. The series extends from the anus posteriad to the hypural anlage of the caudal fin. A wider space separates the ultimate melanophore from the others. The number of melanophores and their spacing is similar in *Scorpaenodes xyris* except that in that species the series extends farther anteriad to the point of divergence of the terminal section of the gut. In *Pontinus* Type A larvae the ventral tail melanophores begin to become embedded during notochord flexion and are not visible in larvae larger than 6.0 mm.

Other pigment present initially is a medial blotch anterodorsad to the axillary region. With further development this expands to form a shield over the gas bladder. It becomes progressively less visible with thickening of the trunk musculature. Similar pigment is present in *Scorpaenodes* and *Ectreposebastes*.

Pigment is present initially on the gut as a few faint melanophores along the dorsal surface of the preterminal section of the gut and as a streak along the ventral midline, with heaviest concentration below the liver. Also, fine melanophores are present along the edge of the finfold just anterior and posterior to the anus. These areas of pigmentation persist in larvae up to about 5.5 mm in length and are present thereafter. When the larvae reach about 10.0 mm in length, large melanophores begin to appear internally on the perivisceral membrane and, with further development, eventually cover the entire membrane.

The other pigmentation present initially is on the pectoral fins. Minute melanophores cover the entire blade of the fin and are present at the margin of the medial surface of the fin base. This contrasts with the pattern in early larvae of *Scorpaenodes* which have, at most, the distal half of the fin blade covered with melanophores and which have none on the fin base. The pattern of pigmentation on the pectorals of *Pontinus* Type A goes through a series of distinct changes as larval development proceeds. Towards the end of notochord flexion the melanophores disappear from the fin base and begin to recede from the basal region of the fin blade. The basal clear area continues to enlarge and, at maximum recession in larvae of about 10 mm in length, pigment is reduced to the distal margin. At about 10.0 mm the distal band begins to expand and becomes progressively wider during the remainder of the larval period and pelagic juvenile phase. At the end of the pelagic juvenile stage only a small portion of the fin remains unpigmented. Newly transformed benthic juveniles have a mottled pattern on the fins with a prominent dark blotch near the base.

In larvae about 6.5 mm long, a melanistic blotch appears on the membrane between the 3rd and 4th spinous rays of the dorsal fin. Additional blotches appear anterior and posterior to this as development proceeds, and larvae larger than 7.0 mm have a series of blotches from the 2nd and 3rd interradial membrane to the 5th or 6th membrane. In pelagic juveniles the entire membrane of the spinous dorsal fin becomes pigmented; however, a much darker blotch is present between the 6th and 11th spines. This dark blotch persists in benthic juveniles.

Melanophores appear on the brain in 10-mm larvae, initially with a single pigment spot above each optic lobe. Others form rapidly and the entire dorsal surface of the brain is covered in larvae larger than 13.0 mm.

Saddles of melanistic pigment begin to form on each side of the dorsal midline in 13-mm larvae, one between the 1st and 2nd dorsal spines, and the other between the 5th and 7th spines. These enlarge to include the regions between the 1st and 3rd dorsal spines and the 5th and 10th spines in larvae larger than 15.0 mm. Two other pigment saddles appear in pelagic juveniles, one below the soft dorsal fin and the other at the caudal peduncle. In the largest pelagic juveniles, the anterior pigment saddle covers the nape, the large one posterior to it bifurcates and extends ventrad to the horizontal septum, the one below the soft dorsal extends ventrad to the base of the anal fin, and the one at the peduncle is a weak band. These markings break up into a more complex pattern in benthic juveniles.

Pigmentation appears on other regions in pelagic juveniles. At about 15.0-mm length, a blotch forms at the midregion of each pelvic fin and the entire membrane of the fin is pigmented at about 20.0-mm length. When pelagic juveniles reach about 25-mm length, a blotch appears at the midregion of the soft dorsal and the soft anal fin. These appear as extensions of the prominent trunk band in benthic juveniles.

The head becomes pigmented in pelagic juveniles first on the opercle and on the region above the opercle. At the end of the pelagic phase, the entire lateral aspect of the head is mottled.

Distribution.—The midwater trawl and plankton collections of CalCOFI, EASTROPAC, and the STOR group show the geographic distribution of larvae and pelagic juveniles of *Pontinus* Type A (Fig. 36). CalCOFI plankton collections show that larvae and pelagic juveniles of *Pontinus* Type A occur in the Gulf of California up to about lat. 28°N. On the outer coast of Baja California, pelagic juveniles of *Pontinus* Type A have been taken as far north as Punta Eugenia (about lat. 28°N). Collections of the EASTROPAC expedition and STOR show that larvae and pelagic juveniles occur southward to the northern coast of Peru (about lat. 5°S). It has an extensive distribution in the Gulf of Panama and westward to the Galapagos Islands. In general, its distributional pattern is similar to that of *Scorpaenodes xyris* except that *Pontinus* Type A is more abundant in offshore regions along the tropical American coast. Larvae occurred in small numbers in both CalCOFI and

Figure 36.—Stations at which larvae and pelagic juveniles of *Pontinus* Type A were collected on CalCOFI cruises (triangles) during 1956 and 1957, EASTROPAC expeditions (closed circles) during 1967 and 1968, and Scripps Tuna Oceanography cruises (open circles) during 1958 and 1959. Open square represents a station from the Scripps Institution of Oceanography fish collection and closed square a station from the University of California, Los Angeles, fish collection.

EASTROPAC plankton tows. The mean number of specimens for all plankton tows was 3.4 ± 6.36 SD with a range of 1 to 34; 50% of all plankton tows had only a single specimen.

In the tropical waters surveyed during the EASTROPAC expedition, the number of occurrences was about equal on the winter cruises (February to April) and the summer cruises (July to September).

Pontinus Type B, Figure 37

Literature.—None.

Distinguishing features.—The smallest larva available is a 5.0-mm specimen undergoing notochord flexion. Dorsal pigment saddles are already beginning to form at this size, and well-formed saddles are present in specimens as small as 10 mm. In *Pontinus* Type A the pigment saddles begin to form at about 15 mm, a size chosen for convenience as the beginning of the pelagic juvenile stage. Since pigment saddles begin to form in midstage larvae of *Pontinus* Type B it is more appropriate to consider the appearance of scales at about 10 mm as the event marking the beginning of the pelagic juvenile stage. The largest pelagic juvenile in our collection is 23.1 mm. The size at transformation into benthic juveniles is not known since the smallest benthic juvenile of *Pontinus* Type B in our collection is 29.0 mm.

The smallest larva in our collection, 5.0 mm long, has almost completed notochord flexion indicating that notochord flexion is probably initiated in 4-mm larvae. At 6.0 mm, notochord flexion is completed. Notochord flexion occurs at a smaller size in larvae of *Pontinus* Type A and is completed when the larvae reach about 5.0-mm length.

Larvae of *Pontinus* Type B are deeper-bodied than those of *Pontinus* Type A. Body depth at the pectoral fin base in *Pontinus* Type B larvae undergoing notochord flexion is 45 to 46% of the body length (Table 37). In postflexion larvae the mean is 43%, and in pelagic juveniles it is 41%. The more slender-bodied larvae of *Pontinus* Type A show an opposite trend. Body depth increases from a mean of 33% of the body length in larvae undergoing notochord flexion to a mean of 39% for postflexion larvae and pelagic juveniles.

The compact gut is already masked by trunk musculature in the smallest larva in our collection. Snout-anus length is relatively longer in *Pontinus* Type B than in *Pontinus* Type A. It averages 64% of the body length in *Pontinus* Type B larvae undergoing notochord flexion and 67% in postflexion larvae and pelagic juveniles while in comparable stages of *Pontinus* Type A the means are 54% and 62%.

The head is larger in *Pontinus* Type B than in *Pontinus* Type A. Head length in the former averages 45% of the body length during notochord flexion and in postflexion larvae and 42% in pelagic juveniles. Relative head length shows an opposite trend in *Pontinus* Type A, averaging 32% in larvae undergoing flexion and 40% in postflexion larvae and pelagic juveniles. The eye is relatively larger in *Pontinus* Type B compared with *Pontinus* Type A; eye diameter averages 32% of head length for larvae and pelagic juveniles of the former and 27% in comparable stages of *Pontinus* Type A. Snout length is relatively shorter in *Pontinus* Type B compared with *Pontinus* Type A. In the former it averages 30% of the head length in larvae undergoing notochord flexion, 28% in postflexion larvae, and 24% in pelagic juveniles. At comparative stages of *Pontinus* Type A it averages 41%, 33%, and 29% of the head length.

Pectoral fin length averages 33% of the body length in *Pontinus* Type B larvae undergoing notochord flexion and 27% in postflexion larvae and pelagic juveniles. In comparable stages of *Pontinus* Type A, fin length

Table 37. Measurements (mm) of larvae of *Pontinus* Type B. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
5.0	3.0	2.2	0.70	0.65	2.3	1.7	0.85	0.96	3.0
5.5	3.8	2.5	0.73	0.70	2.5	1.8	1.0	1.0	3.8
6.0	4.0	2.8	0.82	0.78	2.8	1.8	1.1	1.2	4.0
8.7	5.9	3.8	0.98	1.2	3.5	2.1	1.2	1.7	6.0
*10.5	7.0	4.8	1.3	1.5	4.2	2.9	1.6	2.2	7.4
*11.2	7.7	4.7	1.1	1.6	4.7	2.7	1.7	2.1	8.2
*12.7	8.5	5.7	1.4	1.8	5.2	3.5	1.8	2.7	9.1
*13.7	9.5	5.8	1.4	1.9	5.8	3.9	1.9	2.8	10.0
*14.0	9.5	6.2	1.7	2.2	5.4	4.0	1.8	3.0	10.0
*15.4	10.0	6.2	1.5	2.2	6.2	4.4	2.1	3.3	10.6
*17.1	11.3	6.7	1.5	2.5	7.2	4.6	2.3	3.8	11.8
*22.0	13.5	8.8	1.9	2.9	8.8	6.2	2.9	4.3	14.7
*23.1	14.9	9.6	2.2	3.3	9.0	6.2	2.9	4.8	15.9

*Pelagic juvenile.

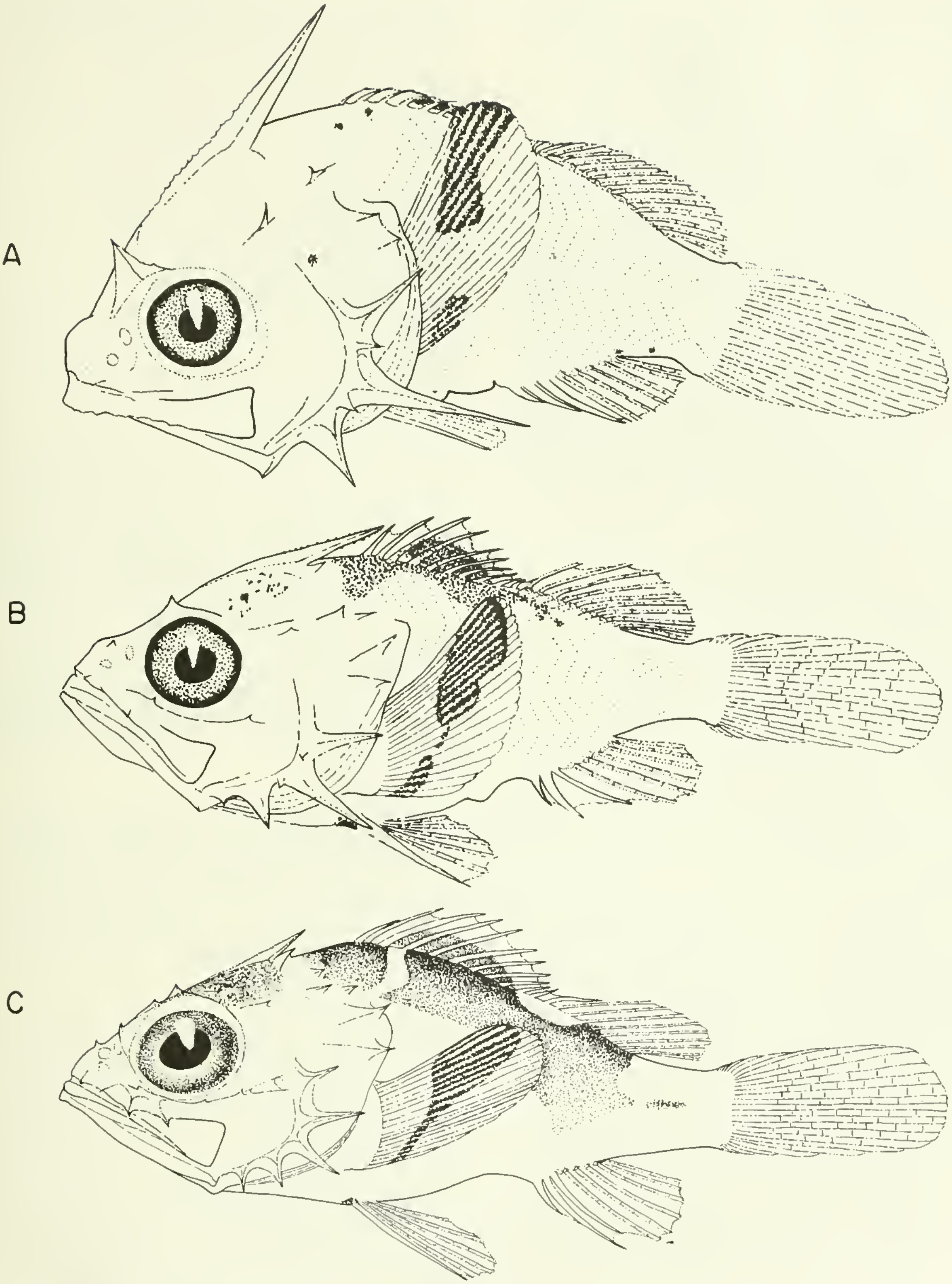

Figure 37.—Developmental series of *Pontinus* Type B. A. 5.0-mm larva; B. 8.7-mm larva; C. 15.4-mm pelagic juvenile.

averages 26% and 32%, respectively. The pectoral fin base is slightly deeper in *Pontinus* Type B compared with *Pontinus* Type A and like the latter becomes relatively shallower as development proceeds. The fin base averages 17% of the body length in *Pontinus* Type B larvae undergoing notochord flexion, 16% in postflexion larvae, and 14% in pelagic juveniles. In comparable stages of *Pontinus* Type A, the averages are 15%, 14%, and 13%. The shape of the fin in *Pontinus* Type B is aliform as it is in *Pontinus* Type A. The sequence of ossification of fin elements and rays could not be determined because of calcium leaching in the small larvae during preservation and storage. In six larger larvae and pelagic juveniles which were stained, all had 18 pectoral rays. The dorsal, anal, and pelvic fins were well formed in the smallest larvae available. The counts of the stained specimens were D. XII, 9; A. III, 5; P. I, 5. Three superior and two inferior hypural elements develop in the caudal fin; there are 8 + 7 principal and 5-7 + 5-7 procurrent rays. All stained larvae had 24 vertebrae. Gill rakers of the stained pelagic juveniles ranged from 5 to 6 on the upper limb and 9 to 11 on the lower limb of the first arch. There were 7 branchiostegal rays.

The absence of specimens of *Pontinus* Type B smaller than 5.0 mm precludes knowledge of the pigment pattern of early larval stages. Pigmentation of larvae larger than this and pelagic juveniles is similar to that in larvae and pelagic juveniles of *Pontinus* Type A, but there are distinctive differences that allow separation of the two forms.

Several melanophores are present at the ventral midline posterior to the developing anal fin. These remnants of the ventral midline series are not found in larvae larger than 8.7 mm. Another component of the original pigment pattern, the melanistic shield covering the gas bladder, is already masked by trunk musculature in the 5.0-mm larva and becomes further embedded with continued development.

The pattern on the pectoral fins is markedly different from that on the fins of *Pontinus* Type A larvae. On the 5.0-mm specimen a pigment streak extends obliquely ventrad from the dorsal tip of the fin blade to the midregion of the fin. Also, a small blotch is present along the base of the six most ventral rays and one is present on the medial surface of the fin base in this region. The medial blotch is not present in larvae larger than 6.0 mm; however, the ventral blotch at the base of the fin blade extends dorsad with further development and ultimately connects with the dorsal streak to produce a complete bar in larvae longer than 10.0 mm. This oblique bar remains a prominent feature throughout the larval and pelagic juvenile stages. Other fin pigment present in the 5.0-mm larva is a patch of melanophores at the base of each pelvic fin. It remains in larger larvae and in pelagic juveniles.

Pigment is also present in 5-mm larvae on the spinous dorsal fin. The blotch on the spinous dorsal membrane extends from the 3rd or 4th spine to the 6th, 7th, or 8th spine and remains throughout later developmental stages. It enlarges slightly with development and covers the membrane from the 1st to 10th rays in the 23.1-mm pelagic juvenile. A portion of this blotch from the 6th to 10th ray is darker than the background and stands out as a black spot. This same pattern is present on the spinous dorsal fin of a 39.0-mm benthic juvenile of *P. sierra*.

The dorsal pigment saddles appear much earlier than in larvae of *Pontinus* Type A and are distinctly different in form. In 5-mm larvae of *Pontinus* Type B, small blotches are present on either side of the dorsal midline at the anterior end of the spinous dorsal fin and at the posterior region of the fin. In 8-mm larvae the anterior saddle has enlarged to occupy the region along the anterior one-third of the spinous dorsal and has enlarged ventrad to the head and forward over the nape. A narrow space separates the anterior saddle from the posterior saddle which now extends along the posterior two-thirds of the spinous dorsal and ventrad about halfway to the lateral line. A third pigment saddle is beginning to form on either side of the soft dorsal fin. In 10-mm larvae the posterior saddle of the spinous dorsal fin extends to the lateral line and the one at the soft dorsal extends to the horizontal septum. In 14-mm larvae the latter saddle extends ventrad to the anal fin where it meets a blotch of pigment on the membrane of the soft anal rays. Anterior to this bar three distinctive blotches lie along the horizontal septum. At about 17 mm a blotch forms on each side of the caudal peduncle, and in the largest pelagic juvenile (23.1 mm) it has connected with dorsal midline pigment to form a saddle. Also, in this largest specimen a blotch is present over each side of the hypural region. The pattern of pigment saddles and blotches in the largest pelagic juveniles matches closely the pattern found in a 39.0-mm benthic juvenile of *P. sierra*.

Head pigment first appears in 8-mm larvae on the dorsal and lateral surfaces of the brain and remains throughout the larval period. In 10-mm larvae, pigment appears along the basal region of the branchiostegal rays and on the posterior region of the opercle. Also, a blotch of pigment is present on the cheek ventroposterior to the eye. In the largest pelagic juvenile additional pigment appears anterior to the eye.

Distribution.—*Pontinus sierra* is known to range from the Gulf of California to Peru. Pelagic juveniles of *Pontinus* Type B were taken on two midwater trawl stations in the southern Gulf of California and on a single midwater trawl station on the outer coast between Magdalena Bay and Cape San Lucas (Fig. 38). A wide latitudinal gap separates these occurrences from the remainder of the pelagic juveniles and larvae which were taken off the Central and South American coasts, as far south as the equator. They appear to be more restricted to coastal waters than are larvae and pelagic juveniles of *Pontinus* Type A and there were no occurrences at the Galapagos Islands.

Larvae and pelagic juveniles of *Pontinus* Type B are rare compared to catches of *Pontinus* Type A. Of the 23 total positive hauls, 17 contained a single specimen and 6 contained two specimens.

Figure 38.—Collections of larvae and pelagic juveniles of *Pontinus* Type B from various sources. Open circles, Scripps Tuna Oceanography cruises, closed circles, EASTROPAC Expedition; open squares, Scripps Institution of Oceanography fish collection.

Ectreposebastes Garman

Literature.—In their review of the scorpaenid subfamily Setarchinae, Eschmeyer and Collette (1966) gave a brief description of two larval specimens (15 and 16 mm SL) of *E. imus*. Illustrations of the larvae have not appeared in the literature.

Distinguishing features.—Larvae of *Ectreposebastes* can be distinguished from those of other eastern Pacific scorpaenid genera by a combination of characters. They have enormous pectoral fins. The depth of the fin base is 19 to 22% of the body length while in the larvae of other tropical scorpaenid genera, except *Scorpaenodes*, it ranges from 12 to 18% of the body length. In *Scorpaenodes*, the depth of the pectoral fin base ranges from 16 to 21% of the body length over most of the larval period. Larvae of *Scorpaenodes* have a bifurcate parietal ridge whereas *Ectreposebastes* larvae have a spikelike spine at the terminus of each parietal ridge. Also, the pectoral fins of *Ectreposebastes* are longer than in other scorpaenid genera. In larvae which have completed notochord flexion, the pectorals reach or extend beyond the base of the caudal fin. Also, larvae of *Ectreposebastes* are deeper-bodied than other scorpaenid genera in the eastern Pacific. The rays of the dorsal and anal fins are highly elongate and the pterygiophores and overlying muscles appear to protrude from the body profile. Eschmeyer and Collette (1966) considered *Ectreposebastes* to be a monotypic genus of the tropical Atlantic and Pacific but, in a recent paper, Eschmeyer and Randall (1975) suggested that *E. niger* (Fourmanoir) may be a distinct species. Only a single larval form was recognizable and is herein referred to as *E. imus*.

Ectreposebastes imus Garman, Figure 39

Literature.—As above.

Distinguishing features.—Size at hatching is unknown; the smallest larva in our collection is 2.8 mm. The larvae attain a larger size than any other known species in the family. A 28.2-mm specimen is just beginning to develop juvenile pigmentation on the head.

Larvae of *E. imus* are the deepest- and narrowest-bodied of all known eastern Pacific scorpaenid larvae. Body depth averages 37% of body length in the preflexion larvae and increases gradually thereafter to 55% in the 28.2-mm transforming specimen (Table 38). The gut has a compact anterior mass with a long intestinal section extending posteriad to the anus. Snout-anus distance is large; it averages 53% of the body length in preflexion larvae and increases thereafter to a maximum of 76% in the 23.0-mm specimen.

The head is large and develops a pair of spikelike parietal spines, each with a short posteriorly directed nuchal spine behind it. Head length averages 34% of the body length before and during notochord flexion, and averages 38% at completion of flexion. The eyes are small and undergo a relative diminution during the larval period. Eye diameter averages 32% of head length before and during notochord flexion and is gradually reduced to a minimum of 22% in the 23.0-mm larva. Snout length averages 33% of head length over the entire larval period.

Larvae of *E. imus* have distinctive fins. The pectoral fins are the longest of any known scorpaenid. Pectoral fin length averages 33% of the body length in preflexion larvae, 38% during flexion, and increases to a maximum of 57% of the body length in the transforming specimen. They extend to or beyond the hypural elements in larvae 6.7 mm and longer. Also, the fin base is unusually deep; it ranges from 19 to 22% of the body length during the larval period. Although there were too few larvae in the series to permit staining, the development of fin rays can be observed on unstained specimens. The full complement of 18 to 20 pectoral rays is present in the smallest larva (3.8 mm) in our collection. The pelvic fin is moderate in size and is first apparent in the 5.5-mm larva where its length is 9% of the body length. Fin length increases gradually during the remaining larval period to

Table 38 Measurements (mm) of larvae of Ectreposebastes imus. (Specimens between dashed lines are undergoing notochord flexion.)

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-anal fin distance
2.8	1.6	1.0	0.31	0.31	1.0	0.68	0.54	-	-
3.2	1.8	1.1	0.38	0.38	1.1	1.2	0.68	-	-
3.4	1.9	1.2	0.43	0.42	1.4	1.3	0.76	-	-
3.8	1.9	1.2	0.43	0.38	1.4	1.2	0.72	-	-
4.2	2.0	1.4	0.45	0.40	1.5	1.3	0.90	-	2.2
5.5	3.2	1.9	0.65	0.58	2.2	2.1	1.2	0.50	3.2
6.2	3.4	2.2	0.76	0.71	2.5	2.3	1.3	0.66	3.4
6.7	4.2	2.7	0.88	0.80	2.8	3.3	1.5	1.2	4.3
9.8	6.5	3.8	1.2	1.1	4.6	4.2	2.1	2.2	6.7
11.3	7.6	4.5	1.2	1.2	5.4	5.0	2.5	2.5	7.7
23.0	17.6	9.2	2.7	2.0	11.2	11.3	4.4	5.0	17.7
*28.2	19.9	10.1	3.3	2.5	15.5	16.0	5.8	7.9	20.3

*Transforming specimen.

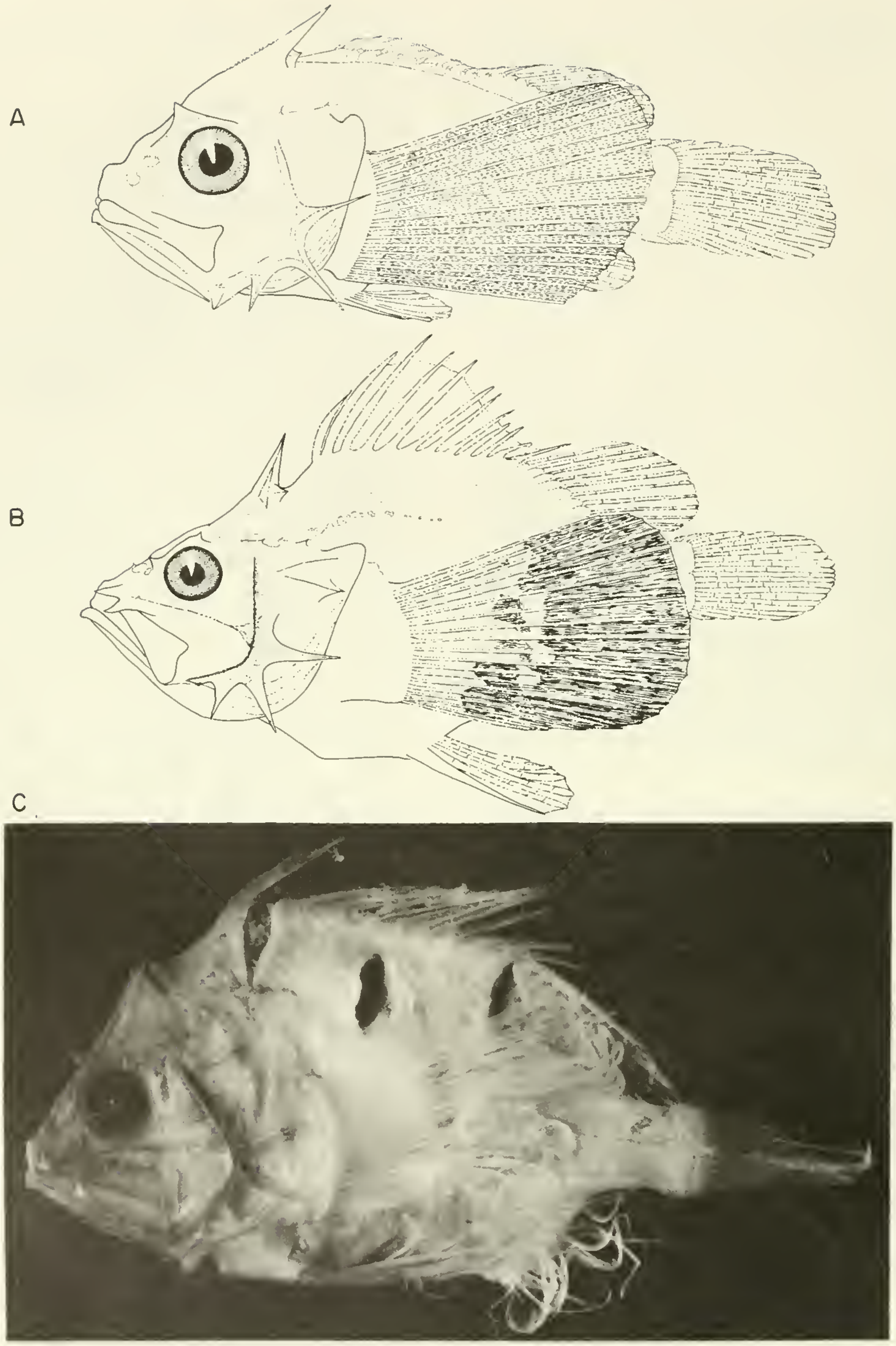

Figure 39.—Developmental stages of *Ectreposebastes imus*. A. 6.7-mm larva; B. 23.0-mm larva; C. 28.2-mm transforming specimen from stomach of *Alepisaurus* (note teeth lacerations).

a maximum of 28% of the body length in the transforming specimen. The full complement of I, 5 pelvic rays is present in the 6.7-mm larva.

The dorsal and anal fins are beginning to develop in the 4.2-mm larva and the full complements of XII, 10(9) dorsal rays and III, 6(5) anal rays are present in the 6.7-mm larva. In the 23.0-mm larva the third dorsal spine is 2.5% of the body length.

The hypural anlagen and the principal caudal rays have begun to develop in the 3.8-mm larva. The full complements of 3 + 2 hypurals and 8 + 7 caudal rays are visible in the 5.5-mm larva. The procurrent rays are beginning to form at 5.5 mm, however, the full complement of 5-6 + 6-7 rays is not present until late in the larval period.

In the smallest larvae, melanistic pigment is present on the dorsal surface of the developing gas bladder, along the ventral surface of the gut, and on the pectoral fins. The series of melanophores along the ventral midline of the tail contains 11 to 14 pigment spots which disappear before the beginning of notochord flexion. The ventral gut pigment is lost before the larvae reach 4.0 mm and that above the gas bladder becomes obscured by trunk musculature. In the smallest larvae, the pectoral fin membrane is covered solidly with small melanophores. When the larvae reach 5.5 mm, there is an unpigmented region at the base of each fin and, with continued development, the melanistic zone becomes more distally located. In the 23.0-mm larva, the distal half of the fin is pigmented and in the transforming specimen the distal third of each fin is pigmented. In the latter specimen, the fine melanophores that will eventually cover the entire body are beginning to appear on the head and upper trunk.

Distribution.—According to Eschmeyer and Collette (1966) and Eschmeyer and Randall (1975), *E. imus* is known from the eastern and western Atlantic, the southeastern Pacific off the Galapagos Islands, and Peru, Hawaii, and Japan. Specimens in this study were taken from about lat. 2° to 6°N off the coast of Colombia and Ecuador, at the equator between long. 100° and 127°W, and at the Hawaiian Islands (Fig. 40). Larvae of *E. imus* are extremely rare in plankton collections. Of the 15 specimens available to us, 8 came from EASTROPAC 1-m plankton hauls, 6 were taken by midwater trawls, and the transitional specimen came from an *Alepisaurus* stomach.

Figure 40.—Collections of larvae of *Ectreposebastes imus* from EASTROPAC expeditions, Scripps Tuna Oceanography cruises, Scripps Institution of Oceanography fish collection, and the University of Hawaii.

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