DESCRIPTION OF THE LARVAE AND EARLY JUVENILES OF THE PACIFIC BUTTERFISH, *PEPRILUS SIMILLIMUS* (FAMILY STROMATEIDAE)

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ABSTRACT

Larvae of the stromateid fish, *Peprilus simillimus*, are relatively common in nearshore samples of California Cooperative Oceanic Fisheries Investigation (CalCOFI) plankton samples taken off central California to Baja California. This paper describes the larvae of *P. simillimus* from hatching to juvenile and presents criteria for distinguishing early-stage larvae of this species from those of similar-appearing species, in particular the white croaker, *Genyonemus lineatus*. Analysis of *P. simillimus* larvae from CalCOFI survey cruises of 1975 showed a near-coast distribution with areas of concentration in the Southern California Bight and Bahia Sebastian Viscaino, where the shelf is relatively broad.

RESUMEN

Las larvas de *Peprilus simillimus* son bastante comunes en las muestras de plancton colectadas en la zona nerítica durante el programa CalCOFI (California Cooperative Oceanic Fisheries Investigations), desde California central hasta Baja California. En este trabajo se describen las fases larvales de *P. simillimus*, desde su eclosión del huevo hasta la fase juvenil, y se presentan los criterios básicos para distinguir los primeros estados larvales de esta especie y de otras especies similares, en particular *Genyonemus lineatus* (roncador blanco). Las larvas de *P. simillimus* colectadas durante los cruceros de CalCOFI en 1975, presentaron una distribución nerítica, y se concentraron principalmente en la Bahía del Sur de California y la Bahía Sebastián Vizcaíno, donde la plataforma continental es más ancha que en el resto del litoral.

INTRODUCTION

The stromateid fish, *Peprilus simillimus,* is one of four eastern Pacific species of *Peprilus* and is the only one found north of Mexico (Horn 1970). It ranges from Bahia Magdalena, Baja California (ca. 24°N), north to British Columbia (ca. 55°N; Miller and Lea 1972). Marketed as Pacific butterfish or Pacific pompano, it is the subject of a minor fishery with a recent peak of 182,000 pounds in 1971 (Oliphant 1973).

Juveniles and adults of *P. simillimus* are found associated with nearshore soft-bottom habitats, and the larvae occur in coastal CalCOFI stations from Point Conception, California, to Bahia Magdalena, Baja California (Horn 1970).

The early larval stages of *P. simillimus* can be confused with those of some other species, particularly the white croaker, *Genyonemus lineatus*. The purpose of this paper is to describe the development of *P. simillimus* from hatching to juvenile, to provide criteria for distinguishing the early larval stages from those of similar-appearing species, and to summarize the distribution of the larvae in CalCOFI samples from 1975.

METHODS AND MATERIALS

A life history series was assembled consisting of newly hatched larvae to fully transformed juveniles. Most of the larvae were obtained from the CalCOFI ichthyoplankton collections. Other larval and juvenile material was obtained from Scripps Institution of Oceanography (Food Chain Research Group), SIO Fish Collection, and the Los Angeles County Museum. A few specimens were reared incidentally with other species at the Southwest Fisheries Center, La Jolla.

A series was established for the study of morphological development, morphometrics and pigment formation, using the techniques and terminology of Ahlstrom et al. (1976). A second series was cleared in KOH-glycerine and stained with Alizarin Red-S to study the development of meristic characters.

Terminology of specimen length follows that described in Moser and Ahlstrom (1978). Standard length is defined as the distance between the tip of the snout and the posterior edge of the hypural plate. In larvae that have not completed notochord flexion, that is, before the edge of the hypural plate becomes vertical, the body length is measured from the snout to the tip of the notochord.

DESCRIPTION

Literature

Larvae of two Atlantic species have been described, *P. paru* by Pearson (1941) and *P. triacanthus* by several workers (summarized in Martin and Drewry 1978).

Distinguishing Features

P. simillimus hatch at 1.8-2.0 mm, undergo notochord flexion at about 4.8-6.2 mm, and begin to transform into juveniles at about 20 mm. Our smallest fully transformed juvenile is 27.9 mm.

Yolk-sac larvae have scattered melanophores along

[Manuscript received 18 March 1980.]

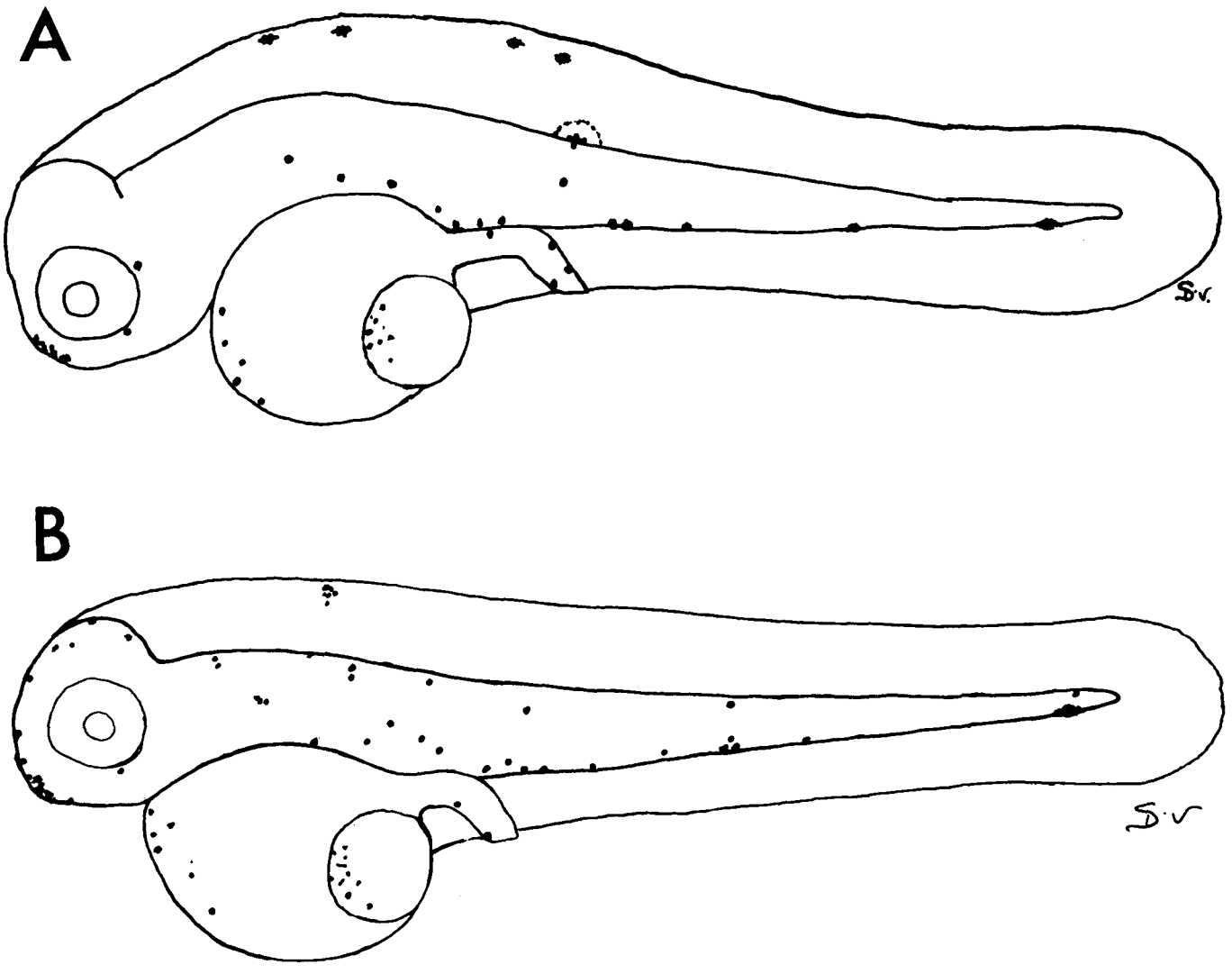

Figure 1. Yolk-sac larvae of A. *Peprilus similimus* (2.0 mm) and B. the white croaker, *Genyonemus lineatus* (2.1 mm).

the ventral region of the head and body and are characterized by a prominent median dorsal melanophore located slightly posterior to a vertical from the anus. This serves to distinguish them from the yolk-sac larvae of the white croaker, *G. lineatus*, which lack pigment in this area (Figure 1). At the completion of yolk absorption, the larvae have a prominent zone of large melanophores on the trunk above the gut and a median ventral series extending from the cleithrum to the anus (Figure 2). The latter series helps to distinguish early larvae of *P. simillimus* from those of the spotted turbot, *Pleuronichthys ritteri*, which lack the median ventral series. In larger *P. simillimus* larvae, the deep head and body form, and the lateral zone of large melanophores, which gradually expands to cover the entire body, are distinguishing features (Figure 3).

Morphology

Newly hatched larvae have a robust body form, a sizable yolk-sac with a posteriorly located oil globule (ca. 0.2-mm diameter), a moderately long gut (snout to anus distance/body length = ca. 0.50 mm), an incomplete mouth, and unpigmented eyes. At a length of 2.2 mm the yolk is absorbed, the mouth is formed, the eyes are becoming pigmented, and the gut is beginning to coil. Notochord flexion occurs in the larval length range of 5.0-7.0 mm (Table 1). Morphometric proportions are summarized in Table 2. The most conspicuous trend is the twofold increase in relative body depth during ontogenesis. Other more subtle ontogenetic trends are a relative shortening of snout-to-anus length, an increase in relative head length, and a decrease in relative eye size.

Small spines develop on the preopercular margin.

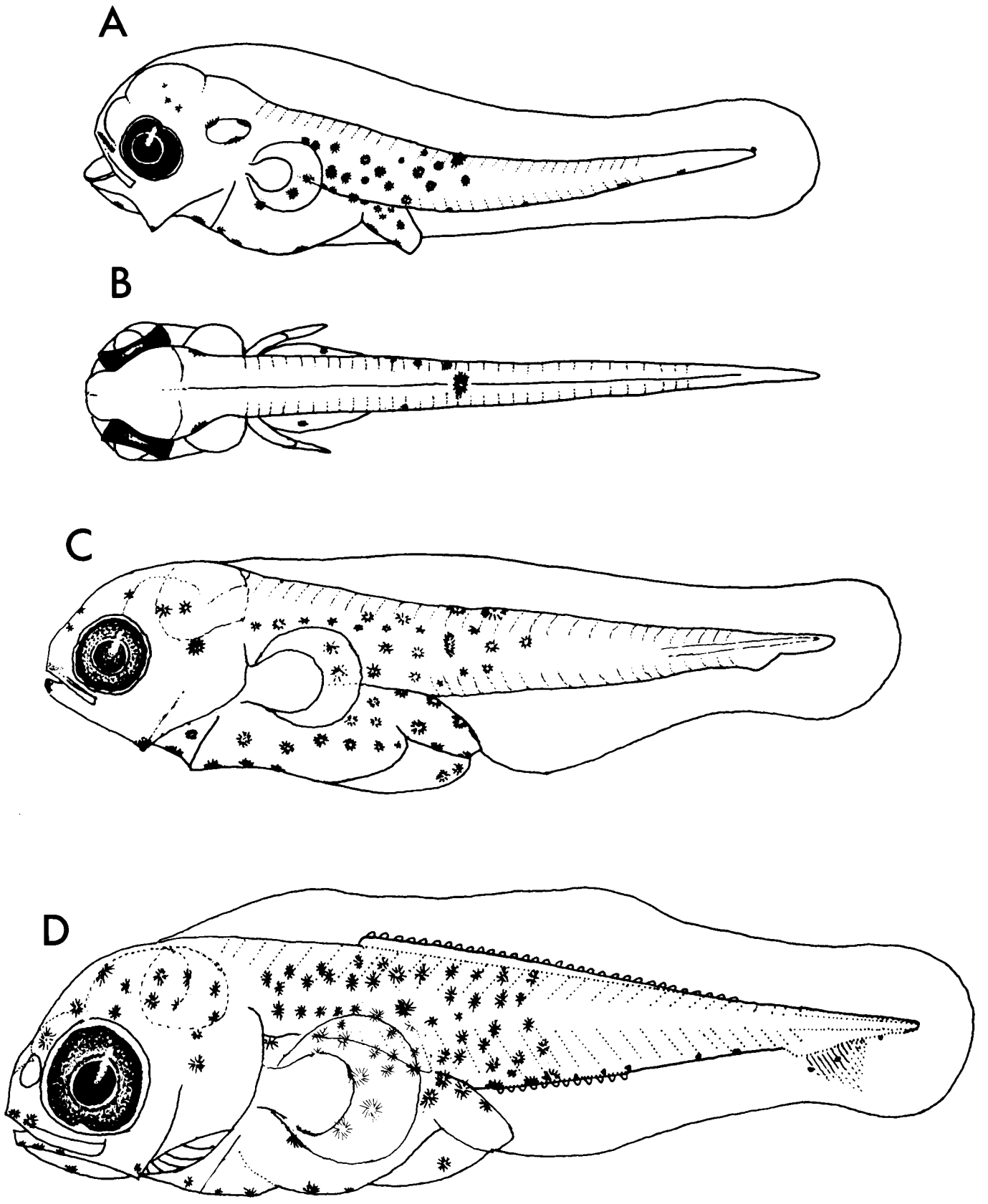

Figure 2. Developmental stages of *Peprilus simillimus*: A) 2.4 mm; B) 2.4 mm, dorsal view; C) 4.1 mm; D) 4.7 mm.

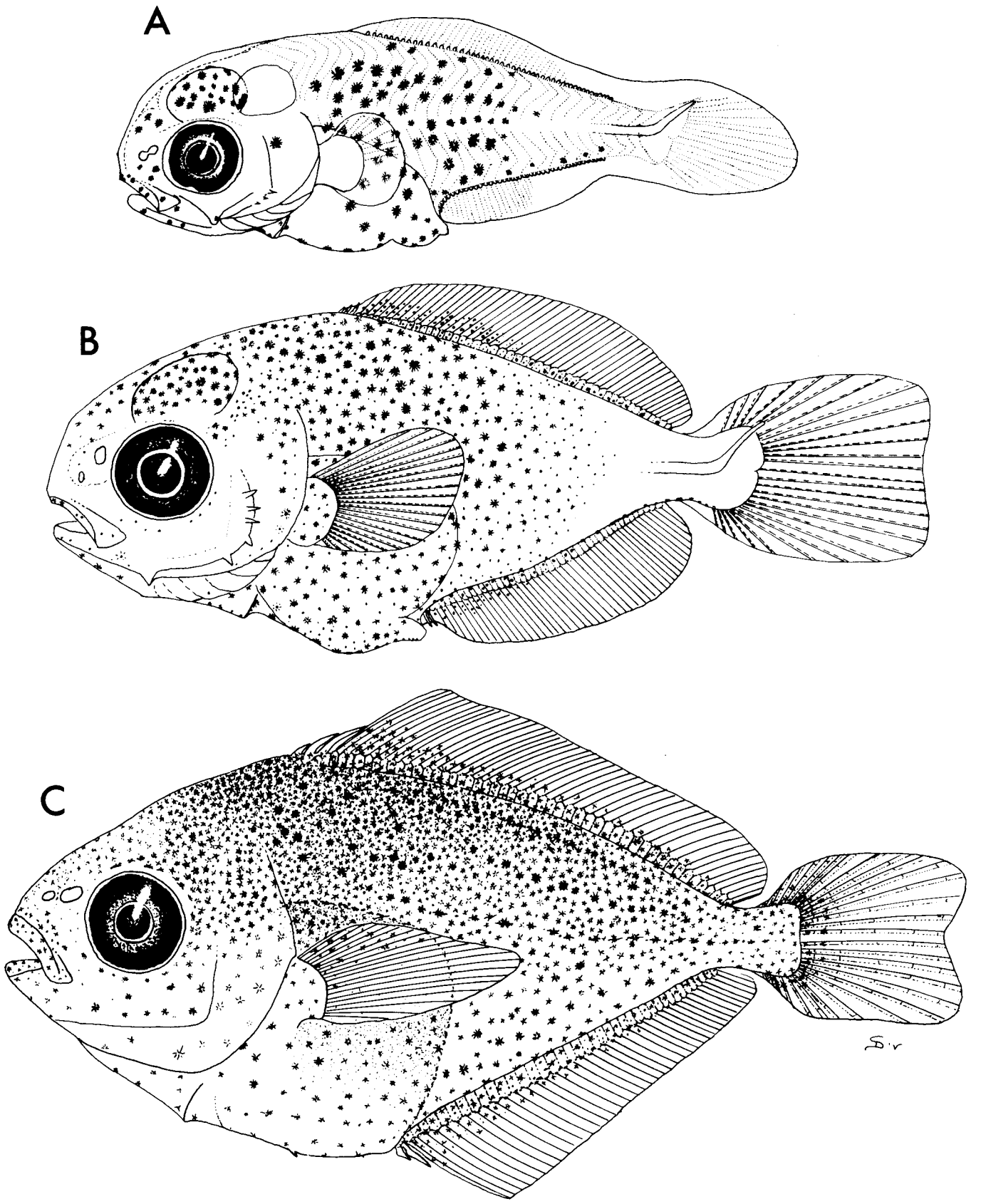

Figure 3. Developmental stages of *Peprilus simillimus*: A) 6.5 mm; B) 10.8 mm; C) transforming specimen, 21.3 mm.

TABLE 1

Measurements in mm of Developmental Series of *Peprilus simillimus*.[1]

Station	Body length	Snout to anus	Head length	Eye diameter	Snout length	Body depth at pectoral fin base	Snout to dorsal fin origin	Snout to anal fin origin	Snout to pelvic fin origin
7505-120.26	1.9	1.0	0.27	0.18	0.08	0.48	–	–	–
7505-120.26	2.3	1.1	0.39	0.22	0.12	0.52	–	–	–
7505-120.24	2.6	1.4	0.54	0.23	0.12	0.58	–	–	–
7803-90.27.6	3.3	1.9	0.83	0.36	0.16	0.98	–	–	–
7803-90.27.6	3.9	2.2	0.98	0.40	0.18	1.1	–	–	–
7803-87.36	4.2	2.5	1.0	0.44	0.23	1.4	–	–	–
7510-120.25	4.8	2.6	1.3	0.49	0.31	1.4	–	2.5	–
6204-130.30	5.4	3.0	1.5	0.56	0.29	1.5	–	2.9	–
6902-127.34	5.5	3.0	1.5	0.56	0.35	1.6	–	3.0	–
7803-93.29	5.8	3.3	1.7	0.64	0.39	1.8	–	3.2	–
7511-83.44.7	6.0	3.2	1.7	0.64	0.39	1.8	–	3.2	–
7801-87.32.7	6.2	3.4	1.7	0.66	0.33	1.8	–	3.2	–
7803-80.60	5.9	3.4	1.8	0.72	0.40	2.0	–	3.1	–
7511-83.55	6.9	4.2	2.4	0.92	0.56	2.8	–	4.1	–
SCBS-4-103	7.5	4.3	2.7	0.96	0.58	2.9	3.0	4.3	–
7606-Los Angeles Bight, CA	8.9	4.7	2.9	1.2	0.80	3.7	3.7	5.0	–
6204-133.25	9.2	4.8	3.1	1.2	0.76	3.7	3.7	4.8	–
6707-117.30	10.2	5.5	3.6	1.4	0.84	4.6	4.2	5.5	4.0
5707-137.35	12.0	5.6	4.4	1.4	1.2	5.4	5.0	6.0	damaged
TC50-sta. 28	13.0	6.0	4.8	1.7	1.3	6.5	5.2	7.0	4.6
7803-73.50	15.2	7.3	5.5	2.2	1.1	6.8	5.4	7.6	6.2
7510-117.30	18.0	7.4	5.8	2.4	1.2	8.5	6.8	8.3	7.2
7510-117.30	19.6	9.4	6.0	2.3	1.4	9.4	7.4	9.1	6.9
7808-MWT22	21.3	9.9	6.7	3.0	1.9	10.3	7.4	10.4	8.0
6402-140.30	23.0	10.5	7.5	3.0	1.9	11.7	9.2	10.5	9.2
LACM 9659-7 Mex. Cedros Isl.	27.9[2]	12.9	9.6	3.2	1.5	14.0	9.8	13.4	11.0
SIO H52-221	28.6	14.1	10.0	3.2	2.2	13.4	11.2	13.7	12.1
SWFC reared	33.6[2]	14.3	12.2	4.8	2.2	17.8	13.3	16.8	12.4
LACM 9659-7, Mex. Cedros Isl.	36.0[2]	17.0	12.0	4.9	2.1	17.0	12.0	17.4	14.5
C6208-Cobb 55-18	45.9[2]	19.9	13.9	4.4	3.1	22.5	16.2	20.5	15.0
SIO 60 409.42A	47.0[2]	19.0	15.8	5.3	3.6	20.6	15.9	18.2	17.3

[1]Specimens between dashed lines are undergoing notochord flexion.
[2]Juvenile.

TABLE 2

Body Proportions of Larval and Juvenile *Peprilus simillimus*.[1]

Body proportion	N	Snout to anus / body length	Head length / body length	Eye diameter / head length	Snout length / head length	Body depth at pectoral fin base / body length	Snout to dorsal fin / body length	Snout to anal fin / body length	Snout to pelvic spine / body length
Preflexion ...	7	54.4±3.9 (49-60)	22.0±4.8 (14-27)	46.8±9.4 (38-64)	23.4±4.5 (18-30)	25.2±4.5 (22-33)	–	–	–
Flexion	6	55.4±1.06 (54-57)	28.8±1.5 (28-31)	37.6±1.0 (36-39)	21.4±1.6 (19-23)	29.8±2.3 (27-34)	–	53.5±0.6 (53-54)	–
Postflexion ...	10	51.5±5.6 (41-61)	35.0±1.8 (32-38)	37.2±2.9 (32-41)	23.5±2.2 (21-27)	43.5±3.6 (38-50)	39.9±1.8 (36-42)	53.0±4.0 (46-59)	38.9±2.1 (35-41)
Transforming	4	47.4±1.63 (46-49)	32.4±1.9 (31-35)	38.6±5.0 (32-44)	25.0±2.7 (22-29)	48.5±1.7 (47-51)	38.0±2.3 (35-40)	47.2±1.4 (46-49)	38.8±3.1 (32-42)
Juvenile	5	43.9±2.76 (40-47)	33.6±2.2 (30-36)	35.7±4.1 (32-41)	19.2±3.2 (16-23)	48.6±3.4 (44-53)	35.4±2.5 (33-40)	46.0±4.5 (39-50)	37.2±2.9 (33-39)

[1]Values are expressed as percent of body or head length (mean, standard deviation, and range).

TABLE 3
Meristics of Cleared and Stained Larvae of *Peprilus simillimus*.[1]

Size (mm)	Dorsal fin	Anal fin	Pectoral fin	Pelvic spine	Caudal fin	Vertebrae	Branchiostegal rays	Gill rakers
4.2	–	–	–	–	–	–	2	–
4.8	–	–	–	–	–	–	–	–
5.8	–	–	–	–	3+2	–	5	–
6.2	16	16	10	–	0+9+8+1	–	6	–
6.5	19	16	9	–	0+8+8+1	–	6	4
7.1	36	37	13	–	3+9+8+3	–	6	6
7.8	I, 35	0, 32	13	–	2+9+8+2	–	6	8
9.7	II, 46	II, 42	17	damaged	5+9+8+4	13+17=30	6	10
10.5	III, 43	II, 38	19	spine bud	5+9+8+5	13+17=30	6	5
12.0	III, 44	II, 39	18	✓	6+9+8+6	13+17=30	6	0+14
12.4	II, 45	II, 40	19	✓	5+9+8+4	13+17=30	6	0+11
13.9	III, 45	II, 42	21	✓	7+9+8+6	13+17=30	6	0+11
15.0	III, 46	II, 42	19	✓	6+9+8+6	13+17=30	6	0+12
17.0	III, 46	II, 42	19	✓	7+9+8+6	13+17=30	6	1+13
18.8	III, 44	II, 40	20	✓	7½+9+8+7	13+17=30	6	3+13
20.0	III, 46	III, 40	21	✓	6+9+8+6	13+17=30	6	3+11

[1]Specimens between dashed lines are undergoing notochord flexion. Check indicates presence of pelvic spine.

They begin to form at about 6.5-mm length and become incorporated into the preopercular bone by about 14-mm length. The number of observed spines ranged from one in the small sizes to as many as nine seen in a 12-mm specimen.

Fin Formation and Internal Structures

The caudal, pectoral, dorsal, and anal fin rays begin to ossify towards the end of the notochord flexion phase (Table 3). The adult complement of 9+8 principal caudal rays is ossifying before notochord flexion is complete. The full ray complements are ossifying in the pectoral (19-23), dorsal (II-IV, 41-48), and anal (II-III, 35-44) fins at about 10.0-mm length. Pelvic fins are represented by a single minute spine projecting from near the distal end of the pelvic bone. The pelvic bone begins to ossify at about 9.5-mm length and the pelvic spine at about 10 mm. Ossification of the vertebral column begins after the completion of notochord flexion, and the full complement of 29-31 vertebrae is ossifying by about 10.0-mm length. The stellate teeth of the pharyngeal sacs begin ossifying at about 7.1-mm length, and most are present by about 9.7-mm. The three predorsal bones begin to ossify at about 9.7-mm length. These interdigitate with the neural spines such that they precede the first, second, and third neural spines. Scales on the lateral line begin forming at about 19-mm length, marking the beginning of transformation. The smallest completely scaled specimen seen was 27.9 mm.

Pigmentation

Yolk-sac larvae have melanophores on the snout, around the eyes, on the anterior region of the yolk-sac, on the anterior surface of the oil globule, just above the gut on each side, along the ventral midline from the anus to the notochord tip, and at the margin of the dorsal finfold above the trunk (Figure 1). A characteristic median dorsal pigment structure, on about the 16th myomere, can be seen in the earliest stages and persists through larval development. This structure is composed of 1-6 pigment clumps and in yolk-sac larvae is usually slightly above the dorsum in the finfold. It is associated with an opaque zone in the surrounding finfold and may be a large melanophore or a complex of small ones.

After yolk absorption, melanophores fill in around the dorsal spot and down the side of the trunk and gut towards the head so that the anterior half of the trunk is fairly well pigmented by about 3.0-mm length. The head, nape, and dorsum are bare of pigment (Figure 1). A median ventral line of pigment extends from the cleithrum to the anus at this stage. The head is usually pigmented on the isthmus, at the symphysis of the lower jaw, over the brain, and internally on the floor of the cranium.

As development continues, the lateral melanophore zone extends posteriorly and the unpigmented nape and dorsum gradually become covered (Figures 2 and 3). The dorsal aspect of the head becomes solidly pigmented, whereas the cheek region remains relatively unpigmented (Figure 3). By 12-mm length, 70% of the body is covered by melanophores, and some pigment can be seen over the hypural plates. The pectoral fin has a few melanophores at the fin base and some which extend out onto the upper rays. At 15-mm length, 90% of the body is pigmented, leaving only the caudal peduncle unpigmented. By 20-mm length, the caudal peduncle is completely pigmented, and melanophores are present over the hypural region as well

as at the base of the caudal fin rays. Pigment forms in the anterior part of the dorsal and anal fins in a narrow band adjacent to the base of the rays. It gradually spreads posteriorward and also increases in width. In juveniles the pigmented area on the dorsal fin extends over much of the fin. The pigmented zone on the anal fin is narrowest and extends out on the fin for a third or less of its width. Pigment gradually spreads throughout the caudal fin, but the individual melanophores are smaller and their distribution is less dense than on the dorsal and anal fins.

DISTRIBUTION

Larvae of *P. simillimus* occur in comparatively low numbers in CalCOFI samples (Ahlstrom 1965); however, this may reflect the relatively low sampling effort in the nearshore region inhabited by this species. Horn (1970) summarized the geographic and seasonal distribution of *P. simillimus* larvae sampled by CalCOFI during 1955-59 and showed that larvae are taken at coastal stations from Point Conception, California, southward to the vicinity of Bahia Magdalena, Baja California. Larvae occurred in the samples throughout the year but were collected in greatest number during May, June, and July. Greatest larval catch was in upper central Baja California in the vicinity of Bahia Sebastian Viscaino (ca. 28°N).

The distribution and relative abundance of *P. simillimus* larvae on CalCOFI cruises during 1975 (Figure 4) was similar to 1955-59. Larvae occurred from Point Conception south to Bahia Magdalena with three major areas of concentration; i.e. the Southern California Bight, Bahia Sebastian Viscaino area, and in the bight north of Bahia Magdalena. These are regions where the shelf is relatively broad with a mud or sand substrata. The enlarged adult habitat in these regions (contrasted with intervening regions that have narrow shelves) is reflected by greater larval catch and more extensive offshore larval distribution (Figure 4). Relative abundance and extent of offshore distribution are greatest in the Bahia Viscaino area were the shelf is broadest.

In 1975 the number of *P. simillimus* larvae reached a peak during summer cruises, but larvae occurred relatively frequently on the October cruise. In fact, cruise 7510 (October 1975) accounted for 45% of the total occurrences for the year. During 1955-59 almost no *P. simillimus* larvae were taken after August, and occurrences during the October cruises of 1955-59 accounted for 2% of the total occurrences.

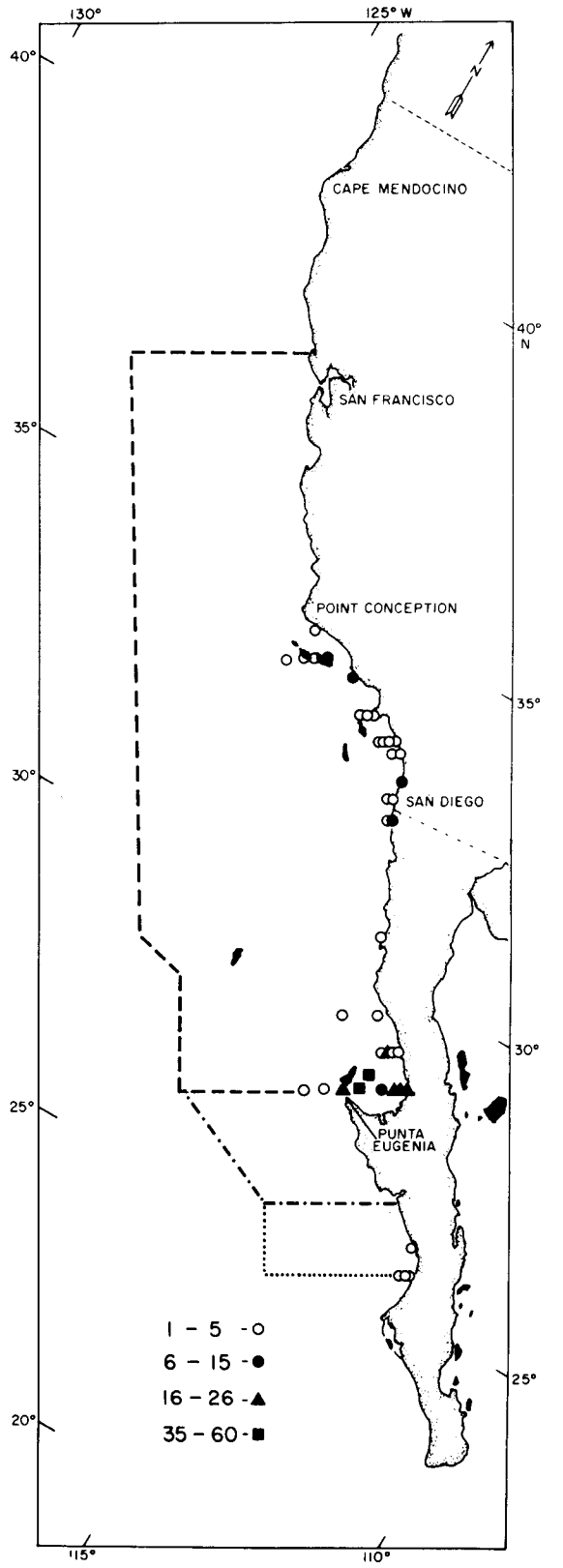

Figure 4. Distribution of total catch of *Peprilus simillimus* larvae collected on five CaLCOFI cruises during 1975. Legend indicates actual numbers of larvae taken on each CalCOFI station. Dashed lines indicate approximate area sampled by five cruises. More southerly areas were sampled by four (. _ .) and by three (. . .) cruises.

ACKNOWLEDGMENTS

We thank Richard Rosenblatt and Dennis Gruber (Scripps Institution of Oceanography) and Robert Lavenberg (Los Angeles County Museum) for specimen loans. Many staff members of the Southwest Fisheries Center provided assistance during this study. George Mattson

produced the original wash drawings of four of the larvae from which tracings were made. Henry Orr provided drafting assistance. We are grateful to Morgan Busby, John Butler, Richard Charter, Elaine Sandknop, Betsy Stevens, and Barbara Sumida-MacCall for advice and assistance during the preparation of the manuscript. Kate Coleman and Lorraine Prescott typed drafts of the manuscript.

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