DESCRIPTION OF REARED LARVAE AND EARLY JUVENILES OF THE CALICO ROCKFISH, *SEBASTES DALLII*

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ABSTRACT

The developmental stages of the calico rockfish, *Sebastes dallii*, are described marking the first time that a species of eastern Pacific *Sebastes* has been reared from birth to pelagic juvenile. Larvae were obtained from a field-caught pregnant female and reared on wild zooplankton screened to a size range of 105-272 μm. Calico rockfish larvae are 5 mm long at birth and transform into pelagic juveniles by 20-mm length. The larvae are slender compared to those of most other described species and have a distinctive pattern of melanophores. Morphological and meristic features are described, with particular attention to the development of head spines. Rearing techniques are outlined and discussed.

RESUMEN

Se describen los estadíos de desarrollo de *Sebastes dallii*, marcando la primera vez que se haya cultivado una especie de *Sebastes* del Pacífico oriental desde el parto hasta la etapa de juvenil pelágico. Se obtuvieron larvas de una hembra capturada en su hábitat, y se alimentaron de zooplancton que se cimió hasta obtener un rango de 105 a 272 μm. Las larvas de *Sebastes dallii* son 5 mm de largo al nacer y se convierten en juveniles pelágicos a los 20 mm de longitud. Estas larvas son más delgadas que las de la mayoría de otras especies descritas y tienen un patrón distintivo de melanóforos. Se describen sus características morfológicas y merísticas, con atención al desarrollo de las espinas de la cabeza. Se presentan y se discuten las técnicas de cultivo.

INTRODUCTION

Sebastes dallii is a small species of rockfish found in near coastal waters of 18- to 256-m depth from San Francisco, California, to Sebastian Viscaino Bay, Baja California (Miller and Lea 1972). It occurs in a variety of habitats from rocky reefs (Turner et al., 1969) to soft shelf substrates (Mearns 1979). Because of its small size and slow growth rate (Chen 1971), calico rockfish are not fished commercially and constitute a minor fraction of the sport fishery (Crooke 1978; Wine 1979). Mearns (1979), however, has

shown that small juveniles of this species exhibit episodes of high recruitment to the coastal shelf of southern California, which suggests that they may be of ecological importance.

Sebastes dallii, like other species of *Sebastes*, is a fecund ovoviviparous fish whose larval stages are part of the ichthyoplankton. The larval and early juvenile stages of some *Sebastes* species have been described (Moser et al. 1977; Richardson and Laroche 1979; Laroche and Richardson 1980); however, little is known about the early life history stages of shallow-water coastal rockfish species. The difficulty in identifying larvae of nearshore fishes and the recent interest in coastal ichthyoplankton generated by environmental concerns stimulated us to rear larvae of these fishes to obtain voucher life history series. The life history series of *Sebastes dallii* described herein marks the first time a species of eastern Pacific rockfish has been reared from birth to juvenile.

MATERIALS AND METHODS

A pregnant 104-mm SL *Sebastes dallii* was collected by hook and line in shallow water south of the Coronado Islands, Baja California, on February 24, 1978. Larvae were freely running from the female at the time of capture. The larvae were immediately placed in 1-gallon jars of seawater where they began swimming towards the surface. The larvae were transported to the laboratory in an ice chest and placed in a 400-liter cylindrical black culture container within six hours of capture. At this time, some larvae appeared neutrally buoyant, as they maintained their position in the water column with little effort. Many larvae sank to the bottom, and mortality of these larvae over the next two days was probably 100%. The viable larvae had considerable amounts of yolk left, although not as much as those that sank to the bottom. Food was added to the cultures after four days in captivity. The food consisted of live plankton collected from Mission Bay, San Diego, with a 70-μm-mesh plankton net. The zooplankton was first screened through a 272-μm-mesh screen and collected on a 105-μm-mesh screen to select for smaller copepodites and nauplii. The initial densities of food organisms were copepods, 2/ml; copepodites, 4.6/ml; nauplii, 3.9/ml; polychaete larvae, 1.1/ml; and rotifers, 3.9/ml. A liter of a dense

culture of algae, *Tetraselmis suesica*, was added daily as food for the zooplankton. The culture container was illuminated from above by four 40-W daylight fluorescent bulbs at 0.9 m from the surface. When the density of nauplii fell below 1/ml, additional zooplankton was added to the culture. As the larvae grew larger, larger zooplankton were added to the tanks. Moribund larvae and detritus were siphoned from the bottom of the container daily. Filtered seawater was added to maintain the culture volume at approximately 400 liters.

Larvae were removed from the culture tank over a period of 60 days and preserved in 4% buffered formaldehyde for subsequent analysis of morphometry and pigmentation and for meristic and osteological analysis. A series was cleared in a graded series of KOH-glycerin solutions and was stained with Alizarin Red-S. Terminology and methods of description follow those of Moser et al. (1977) and Moser and Ahlstrom (1978).

DESCRIPTION OF DEVELOPMENT

General Development

Larvae of *S. dallii* are released during winter and spring and are about 5.0 mm long at birth (Figure 1). Notochord flexion occurs between 6.2 and 8.0 mm, and the larvae have transformed into pelagic juveniles by 20.0 mm (Table 1). The larvae are comparatively slender with a relatively small head and large eyes. They develop a complex and distinctive pattern of

melanophores (Figure 1) of which the postanal lateral series may prove to be diagnostic when the larvae of other nearshore species of *Sebastes* become known.

The slender terete pelagic juveniles (Figure 1E) resemble those of *S. jordani* in form and pigmentation (see Moser et al., 1977 for comparison). Mearns (1979) has shown that the juveniles become demersal in early summer at a length of 20-25 mm standard length (SL). A 36.6-mm benthic juvenile collected by otter trawl has the adult pigment pattern (see Phillips 1957).

Morphology

Larvae and pelagic juveniles of *S. dallii*, like those of *S. jordani*, are slender-bodied compared to other species (Table 2). Other features shared with *S. jor-dani* are a comparatively small head and short snout-to-anus distance. The latter character, of course, is not as marked as in the shortbelly rockfish, *S. jordani*. Eye diameter is greater in *S. dallii* than in the other species studied.

Spine formation in larvae of *S. dallii* (Table 3) follows in general the pattern described for other species (Moser 1972; Moser and Ahlstrom 1978; Richardson and Laroche 1979; Laroche and Richardson 1980). In *S. dallii*, the pterotics, 2nd and 4th anterior preoperculars, 1st and 4th upper infraorbitals, 1st lower infraorbital, lower posttemporals, and nuchals are present in larvae but are lost in subsequent juvenile stages. The cleithral spine is present in pelagic juveniles but becomes minute and finally lost in benthic juveniles.

TABLE 1
Measurements of Reared Larvae[1] of *Sebastes dallii*.

Standard length in mm (age in days)	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
5.1 (1)	2.2	1.1	0.21	0.45	1.0	0.29	0.16	—	—
5.3 (3)	2.2	1.2	0.35	0.45	1.0	0.29	0.25	—	—
5.4 (5)	2.3	1.2	0.31	0.43	1.0	0.28	0.35	—	—
5.5(11)	2.3	1.2	0.34	0.46	0.87	0.31	0.35	—	—
5.6(10)	2.4	1.2	0.31	0.46	0.85	0.33	0.35	—	—
5.7 (8)	2.4	1.3	0.33	0.51	0.96	0.34	0.42	—	—
5.9(10)	2.5	1.4	0.35	0.54	1.1	0.35	0.41	—	—
6.2(15)	2.6	1.5	0.40	0.53	1.0	0.34	0.46	—	—
6.5(32)	2.8	1.6	0.43	0.60	1.2	0.50	0.44	—	—
6.9(32)	3.1	1.8	0.57	0.65	1.4	0.52	0.63	0.02	—
7.0(32)	3.1	1.8	0.52	0.66	1.3	0.49	0.60	0.08	—
7.1(33)	3.3	1.9	0.55	0.73	1.5	0.54	0.59	0.10	—
7.3(33)	3.5	2.1	0.56	0.83	1.7	0.65	0.60	0.16	4.1
8.0(20)	3.8	2.1	0.58	0.79	1.8	0.61	0.70	0.13	4.4
7.3(38)	3.6	2.2	0.68	0.85	1.8	0.64	0.64	0.17	4.2
8.6(26)	4.2	2.4	0.72	0.88	1.9	0.70	0.83	0.22	4.8
9.4(28)	4.5	2.8	0.80	1.0	2.1	1.1	1.0	0.27	5.3
9.8(42)	5.1	3.2	1.0	1.1	2.2	1.2	1.0	0.34	5.7
10.1(49)	5.7	3.2	1.0	1.2	2.8	1.4	1.1	0.86	5.9
20.2(60)	11.7	6.1	2.0	2.1	5.1	4.7	1.7	3.3	12.3
21.7(60)	12.2	6.3	2.1	2.1	5.5	5.2	1.8	3.2	12.8

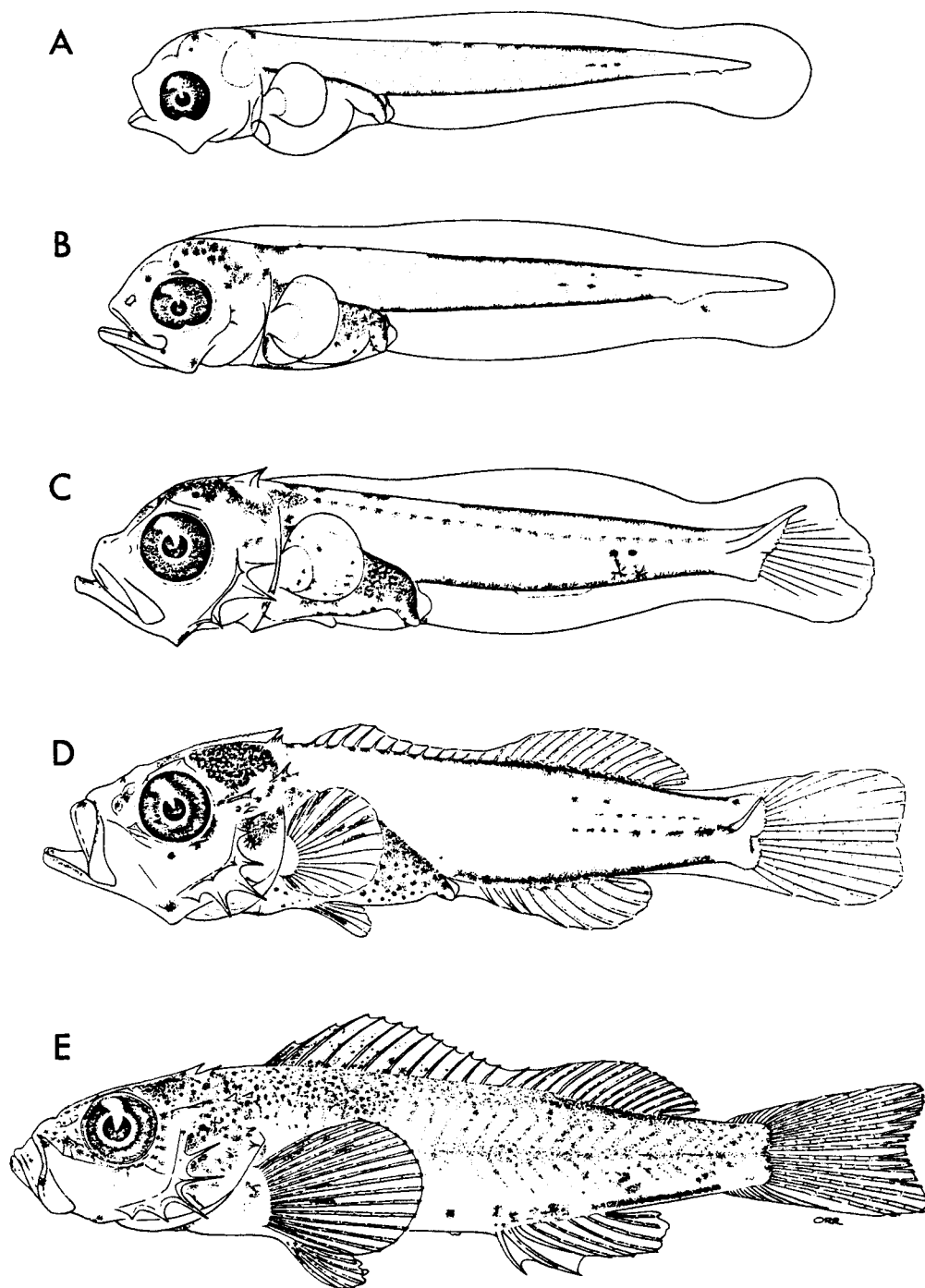[1]Specimens between dashed lines are undergoing notochord flexion.

Figure 1. Reared specimens of *Sebastes dallii:* A. 5.1-mm larva (Day 1); B. 6.2-mm larva (Day 15); C. 7.1-mm larva (Day 33); D. 10.1-mm larva (Day 49); E. 21.7-mm pelagic juvenile (Day 60).

TABLE 2
Comparative Morphometry of Five Species of Sebastes[1]

Species	Snout to anus distance Body length	Head length Body length	Snout length Head length	Eye diameter Head length	Body depth Body length	Pectoral fin length Body length	Pectoral fin base depth Body length	Pelvic fin length Body length
S. dallii A	42.4±0.52(42-43)	22.6±1.06(21-24)	25.6±3.02(19-29)	38.0±1.85(35-41)	17.6±1.85(15-20)	5.6±0.52(5-6)	5.9±1.36(3-7)	—
B	45.7 2.07(43-48)	26.5 1.38(25-29)	28.7 1.86(27-32)	37.8 1.33(36-40)	20.7 2.07(18-23)	8.0 0.63(7-9)	8.3 0.82(7-9)	1.26±0.73(0.3-2)
C	50.8 3.27(48-56)	30.6 1.95(28-33)	30.4 0.89(29-31)	36.8 1.92(34-39)	23.8 2.68(22-28)	11.0 2.45(9-14)	10.2 0.84(9-11)	4.0 2.83(2-9)
D	57.0 1.41(56-58)	29.5 0.71(29-30)	33.0 0.00(33)	33.5 0.71(33-34)	25.0 0.00(25)	23.5 0.71(23-24)	8.0 0.00(8)	15.5 0.71(15-16)
S. jordani A	36.5 0.84(36-38)	22.3 1.51(21-25)	26.8 3.43(23-31)	37.7 0.82(36-38)	17.0 1.26(16-19)	6.7 0.52(6-7)	6.5 0.55(6-7)	—
B	42.4 1.67(41-45)	28.4 2.19(26-30)	35.5 1.29(34-37)	32.2 2.50(29-35)	2.10 1.00(20-22)	8.4 1.14(7-10)	7.8 0.45(7-8)	1.4 0.55(1-2)
C	51.0 2.8(46-54)	32.3 1.44(31-36)	34.4 1.98(31-39)	29.3 2.10(27-34)	23.8 1.19(22-26)	16.8 3.25(11-20)	7.9 1.00(7-10)	9.0 3.62(3-13)
D	53.3 1.03(52-55)	31.2 1.94(28-33)	34.0 2.83(30-38)	26.5 1.52(24-28)	22.2 0.84(21-23)	20.5 1.05(19-22)	7.0 0.00(7)	13.5 1.22(12-15)
S. levis A	39.6 2.30(37-44)	24.7 1.60(23-28)	30.7 2.63(27-35)	33.1 2.67(29-36)	21.7 1.11(20-23)	17.4 5.29(11-24)	10.9 1.57(8-13)	—
B	48.9 3.44(45-56)	30.5 1.85(28-33)	34.8 0.87(34-36)	32.5 1.77(30-35)	28.5 3.51(24-35)	34.9 6.96(24-46)	12.9 0.64(12-14)	6.1 3.27(2-12)
C	59.2 2.87(57-63)	35.0 2.00(34-38)	30.2 2.22(28-33)	30.5 1.73(28-32)	34.0 1.41(33-36)	45.0 3.74(41-50)	11.2 0.96(10-12)	21.0 4.76(16-26)
D	63.0 0.82(62-64)	33.8 0.96(33-35)	30.5 2.38(28-33)	27.0 3.37(25-32)	35.0 1.41(34-37)	40.8 7.09(32-47)	10.2 0.96(9-11)	24.2 2.87(22-28)
S. macdonaldi A	42.4 3.53(36-47)	27.6 2.25(24-31)	30.6 4.16(25-36)	34.6 2.34(31-37)	23.1 3.99(13-27)	8.4 1.21(6-10)	—	1.8 0.84(1-3)
B	51.8 3.56(48-56)	35.6 1.52(34-38)	34.0 4.00(30-38)	32.0 1.41(31-34)	31.6 2.07(30-35)	13.0 1.22(12-15)	—	5.8 2.39(3-9)
C	60.3 3.06(55-64)	37.5 1.84(34-41)	32.9 3.00(29-37)	33.0 1.33(31-35)	34.4 1.17(33-36)	19.3 3.65(15-26)	—	14.3 3.77(10-21)
D	64.2 2.44(61-68)	35.1 2.37(32-38)	27.9 2.09(25-32)	30.7 2.74(26-34)	31.4 1.59(30-34)	30.4 1.74(28-34)		21.9 1.36(21-25)
S. paucispinis A	41.0 2.74(37-44)	26.8 2.28(24-29)	27.4 3.21(24-32)	32.8 3.77(29-37)	19.6 1.67(17-21)	16.4 4.56(11-21)	9.0 0.71(8-10)	5.3 4.93(2-11)
B	44.8 3.70(40-49)	29.6 1.95(27-32)	30.6 1.82(29-33)	30.2 1.64(29-33)	23.0 1.41(21-24)	27.2 2.49(25-31)	9.0 0.71(8-10)	13.6 9.28(9-26)
C	57.3 3.82(51-61)	37.1 1.07(36-39)	32.2 0.98(31-33)	31.3 1.70(28-33)	29.6 0.98(28-31)	35.7 1.25(34-37)	7.6 0.53(7-8)	35.1 2.79(31-39)
D	62.3 2.73(60-66)	36.2 1.72(33-38)	30.5 2.95(26-33)	27.8 1.72(26-30)	27.3 0.52(27-28)	28.2 3.40(25-34)	6.0 0.89(5-7)	25.2 2.71(22-30)

[1] A = preflexion larvae; B = larvae undergoing notochord flexion; C = postflexion larvae; D = pelagic juveniles.

TABLE 3

Sequence of Development of Head Spines[1] of *Sebastes dallii*.

Spine	5.6	5.9	6.0	6.3	6.4	7.1	7.3	8.0	8.6	9.8	10.1	20.2	36.6	49.1	53.0	67.5
Pterotic	X													0	0	0
2nd anterior preopercular	X												0	0	0	0
3rd posterior preopercular	X															
Postocular		X														
2nd posterior preopercular				X												
Parietal					X											
4th anterior preopercular						X						0	0	0	0	0
4th posterior preopercular								X								
Lower posttemporal									X							0
Lower opercular									X							
Interopercular									X							
1st upper infraorbital									X			0	0	0	0	0
3rd anterior preopercular									X/0	0	0	0	0	0	0	0
1st lower infraorbital										X				0	0	0
5th posterior preopercular										X						
Nuchal											X	0	0	0	0	0
Upper opercular											X					
Supracleithral											X					
Nasal											X					
Preocular											X					
1st posterior preopercular											X					
2nd lower infraorbital											X					
4th upper infraorbital											X		0	0	0	0
Cleithral												X				
Tympanic												X				
Upper posttemporal												X				
Subopercular													X			

[1]Presence of spine is indicated by an "X" or continuous line. Absence of a spine is indicated by "0." In asymmetrical specimens, the condition of the left and right sides is separated by a slash.

The absence of supraocular and the 2nd and 3rd upper infraorbitals in larvae of *S. dallii* may be useful in identifying this species.

Fin Development

The pectoral fins of *S. dallii* larvae are the smallest of any species studied (Table 2; Richardson and Laroche 1979; Laroche and Richardson 1980). Rays begin ossifying at about 8.0 mm, and the full comple-ment of 16-17 is present at 10.0 mm (Table 4). The pelvic fins begin to develop when the larvae reach 7.0-mm length, and they remain relatively small throughout the larval period (Table 2). Ossification of the rays begins in 9-mm larvae, and the full comple-ment of I,5 rays is present at 10.1 mm. The cartilagi-nous radial elements and rays of the dorsal and anal fins appear in 7-mm larvae, and the ossification of the rays is initiated in 9-mm larvae. The 10-mm larva has

TABLE 4

Meristics of Cleared and Stained Larvae of *Sebastes dallii*.

Length (mm)	Principal caudal fin rays superior	inferior	Procurrent caudal fin rays superior	inferior	Branchiostegal rays left	right	Pectoral fin rays left	right	Hypural elements superior	inferior	Gill rakers (right arch) upper limb	lower limb	Anal fin rays	Dorsal fin rays	Pelvic fin rays left	right	Vertebrae
5.9					1	1											
6.0					1	1											
6.2	1	1			2	2											
6.4	2	3			2	2											
7.1	3	4			3	3											2
7.3	4	4			4	4											2
8.0	7	8			6	6	7	7	1	2		10					20
8.6	8	7		2	7	7	11	11	1	2		12					23
9.8	8	7	3	4	7	7	15	15	1	2		14	II,6	IV,11	I,2	I,2	26
10.1	8	7	7	8	7	7	17	18	1	2	4	17	III,6	XIII,13	I,5	I,5	26
20.2	8	7	12	13	7	7	17	17	2	2	9	22	III,6	XIII,13	I,5	I,5	26

the adult complement of XIII, 13 dorsal and III,6 anal rays.

The caudal fin begins to form at about 6.0 mm with the appearance of some cartilaginous hypurals and principal rays. Ossification of the principal and procurrent rays is shown in Table 4. As described for *S. melanostomus*, the lowermost superior hypural and the uppermost inferior hypural each have two centers of ossification, which may relect the ancestral condition of 3+3 hypurals in the family (Moser and Ahlstrom 1978).

Pigmentation

The pigment pattern of newborn larvae consists of a postanal series of melanophores along the dorsal and ventral midlines, a short postanal series along the horizontal myosepta, one to several spots at the nape, a patch of melanophores above the brain, an embedded melanophore in each otic region, and a series of melanophores along the dorsolateral surfaces of the gut on each side (Figure 1A).

For 50 newborn larvae the number of melanophores in the ventral postanal series ranged from 29 to 49 ($\bar{x} = 37.7 \pm 4.33$ SD), whereas the number in the dorsal series ranged from 7 to 19 ($\bar{x} = 13.7 \pm 2.74$ SD). The ventral series extended from the first to the 15th or 16th postanal myomere, and the dorsal series extended from the 4th or 5th to the 14th or 15th postanal myomere. The lateral postanal melanophores ranged from 1 to 6 ($\bar{x} = 2.3 \pm 1.20$ SD) on the left side and 0 to 5 ($\bar{x} = 1.8 \pm 1.13$ SD) on the right side. Four specimens lacked lateral melanophores on the right side.

Melanophores above the brain ranged from 1 to 9 ($\bar{x} = 4.2 \pm 1.79$ SD) whereas those on the nape ranged from 0 to 6 ($\bar{x} = 2.0 \pm 1.17$ SD). Two specimens lacked nape melanophores. Of the 50 specimens, 12 had otic melanophores on both sides, 14 lacked them on one side, and 24 lacked them on both sides.

The ventral postanal series remains throughout the larval period, but becomes divided into two lines on either side of the developing anal fin in 7-mm larvae. Anterior to the anal fin, the two lines become embedded and extend anterior to the anus. In some larvae, one to several melanophores may form just lateral to the posterior region of the ventral midline series. They appear in 80% of the specimens from 6.2 to 10.1 mm and, when maximally developed, appear as a bridge between the ventral midline series and the series along the horizontal septa (Figure 1C).

Melanophores are added anteriorly to the dorsal midline series and reach the level of the anus when the larvae are about 6.0 mm (Figure 1B). Thereafter,

melanophores are added irregularly in the zone between the occiput and the anterior end of the dorsal midline series. These melanophores form in two lines on either side of the dorsal midline. When the dorsal fin begins to form in 7-mm larvae, the postanal dorsal midline series begins to separate into two series on either side of the midline, and these become continuous with the more anterior dorsal pigment lines. The smallest specimen in which the dorsal pigment is continuous from occiput to caudal peduncle is 7.3 mm.

The lateral postanal melanophores persist throughout the larval period. For 37 specimens between 5.0 and 8.0 mm, the number of lateral melanophores on the left side ranged from 0 to 7 ($\bar{x} = 2.5 \pm 1.43$ SD), and those on the right side ranged from 0 to 5 ($\bar{x} = 2.6 \pm 1.26$ SD). Of the 37 specimens, only four lacked lateral melanophores on one side, and all had them on at least one side. Melanophores are added to the lateral series in larger larvae, and in the two pelagic juveniles the entire horizontal myoseptum is heavily pigmented, as are the myosepta above and below it. A zone of solid pigmentation covers the dorsal region of the body (Figure 1E).

Melanophores are added to the patch above the nape so that the entire nape is covered when the larvae reach 6.0 mm (Figure 1B). At this size the patch begins to be overlain by dorsal musculature, and simultaneously, embedded melanophores begin to appear over the posterior region of the vertebral column. Melanophores are added between this region and the embedded nape patch, and in larvae as small as 6.9 mm, the series of embedded melanophores above the vertebral column is complete (Figure 1C).

Melanophores are added above the brain so that in 6-mm larvae, where there are 12-14 melanophores, the dorsal surfaces of the optic and cerebellar lobes are solidly pigmented. Melanophores also begin to appear on the lateral and ventrolateral surfaces of the cerebellar and medullary regions, and by 7.0 mm these areas are solidly pigmented (Figure 1C). Melanophores appear on the dorsal surface of the olfactory lobes at about 5.5 mm and number from 1 to 3 until the larvae reach 7.0 mm, when the region becomes solidly pigmented.

Melanophores appear on the lower jaw in larvae about 5.5 mm long. One to several melanophores are present anteriorly on one or both sides of the jaw in about half the larvae up to 7.0 mm. More are added in larger larvae to cover the anterior curve of the lower jaw (Figure 1D). Melanophores also form posteriorly on the jaw. One or two may be present on each side in the region of the articular bone, and one or two may form in the angular region. Melanophores may be absent in either the angular or articular region on either

side, but at least one melanophore is present on the posterior lower jaw.

At about 7.0 mm, melanophores appear at the anterior region of the snout. In about half the larvae larger than 7.0 mm, one or two melanophores are present in the midline of the snout between the maxillaries. From one to three melanophores may form along the maxillaries lateral to the median snout region, with about half the specimens lacking them altogether on one or both sides. More appear at about 10.0 mm to form a streak along the upper portion of each maxillary (Figure 1D). Also, in 7-mm larvae, one or two melanophores may be present on each nasal flap. In larvae of about 10.0 mm, the nasal flaps become solidly pigmented. In larvae larger than 7.0 mm, one to several melanophores are usually present on the upper region of the opercle (Figure 1C) along with a single melanophore on the preopercle posterior to the eye. Melanophores in these regions increase in number at about 10.0 mm, and the entire upper half of the head is pigmented in the pelagic juveniles (Figure 1D, E).

The initial melanophore pattern of the gut region is augmented in larvae between 5.0 and 6.0 mm. The dorsolateral gut pigment increases to form a shield over the gut (Figure 1B). Also, pigment extends forward internally to form an embedded melanistic zone medial to the cleithra. On the ventral midline of the gut a preanal and cleithral melanophore are at each end of a series that can range up to 10 in number. When expanded they appear as a partial or complete line. In later stage larvae the dorsolateral shield extends ventrad and reaches the ventral midline in larvae larger than 8.0 mm.

The fins are lightly pigmented. The first pigment to form is a single melanophore in the future hypural region of the developing caudal fin (Figure 1B). It is present in about one third of the larvae larger than 5.2 mm. When the hypurals begin to develop, the melanophore is usually located at the posterior margin of the hypural plate between the superior and inferior groups of elements. At about 10.0 mm, additional melanophores form along the posterior margin of the plate and outline the entire posterior margin in the pelagic juveniles. Pigment appears on the pectoral fins in some 7-mm larvae, where one to several melanophores may be present on the dorsal and on the ventral region of the blade (Figure 1C). A maximum of 7 upper and 4 lower melanophores is present in larvae up to 10 mm and a maximum of 12 was present on the fin blades of the pelagic juveniles. A patch of melanophores begins to form on the medial surface of the pectoral base in 8-mm larvae and intensifies with development. Pigmentation first appears on the pelvic

fins in 8-mm larvae as a melanophore at the base and one to several on the fin blade. Melanophores are added to the blade in later stages but are restricted to the proximal region (Figure 1C). Pigmentation is present on the spinous dorsal fin in the two pelagic juveniles. The first two interradial membranes of the spinous dorsal are solidly pigmented, and the membranes between the 3rd and 10th spinous rays have scattered pigmentation restricted to the proximal half of the fin (Figure 1E).

DISCUSSION

Although Japanese workers have successfully reared four species of western Pacific *Sebastes* (summarized in Moser et al. 1977), *S. dallii* is the first eastern Pacific species to be reared through to juveniles. Reasons for our previous lack of success in rearing larvae of several *Sebastes* species using a diet of *Artemia* nauplii (as used by the Japanese workers) and more recently a diet of the rotifer, *Brachionus plicatilis*, are open to speculation. One possibility is that *S. dallii*, being a moderately shallow species, has more robust larvae than those of the deeper water species used in previous rearing attempts. The four successfully reared western Pacific species are all shallow-water forms (Lo-chai Chen, personal communication). Also, the diet of wild zooplankton maintained at high densities during the first few days of feeding undoubtedly contributed to our success. *Artemia* nauplii are far from an optimally nutritional diet, and our experience with *Brachionus* was that even high densities of this organism did not elicit a feeding response in rockfish larvae.

Perhaps the most important factor in achieving success with *Sebastes* larvae is the stage of development at birth. Timing of birth in the wild appears to be precisely related to stage of development, perhaps by some biochemical or mechanical cue from the larvae, and capture of full-term females that are ready to give birth is a rare event. This raises the more general question of whether or not there is a maternal nutritional contribution in addition to the yolk. If this were true, one might speculate that such nutrition is critical to development of certain organ systems late in the pregnancy and that premature birth might impair organogenesis. Affirmation of this speculation must await future physiologial studies on intraovarian development of *Sebastes*.

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