Abstract.—Pigmentation patterns, meristic characters, morphometric measurements, and head spination were recorded and illustrated for the developmental series of larval and pelagic juvenile (10.0–27.7 mm SL) grass rockfish, *Sebastes rastrelliger*. Larvae were identified by the presence of strong dorsal and postanal ventral midline pigment and by the presence of pigment on the lateral midline. Juveniles became highly pigmented over most of their body and fin surfaces at a length of 27.7 mm. Pigment patterns were sufficiently distinct and consistent to differentiate larval and juvenile *S. rastrelliger* from other *Sebastes* species occurring off central California. Otolith characters were also useful in identification of this species. Larval and juvenile *S. rastrelliger* grew at a rate of 0.36 mm/day, similar to the growth rates observed in other species of *Sebastes*.

Manuscript accepted 11 February 1998.
Fish. Bull. 96:788–796 (1998).

Description of pelagic larval and juvenile grass rockfish, *Sebastes rastrelliger* (family Scorpaenidae), with an examination of age and growth

Thomas E. Laidig
Keith M. Sakuma
Tiburon Laboratory, Southwest Fisheries Science Center
National Marine Fisheries Service
Tiburon, California 94920
E-mail address (for T. E. Laidig): toml@tib.nmfs.gov

Rockfishes (*Sebastes* spp.) support important commercial and recreational fisheries in the northeastern Pacific Ocean. During 1995, they accounted for approximately 12.6% of the commercial groundfish catch in weight (PFMC[1]) and 19.4% of all species in the recreational landings off California, Oregon, and Washington (Witzig et al., 1992). Management of rockfishes has been difficult owing to the large number of species within this genus. Sixty-one species of rockfish are reported from California alone (Eschmeyer et al., 1983). The need to identify and separate adult rockfish landed by the fishery has long been recognized (Phillips, 1964; Chen, 1971). Larvae and juveniles are far more difficult to differentiate than adults, but the need for their accurate identification is growing with their use in biomass estimates and recruitment studies (Moser and Butler, 1987; Hunter and Lo, 1993; Ralston et al.[2]). Here we provide means to identify the larvae and juveniles of grass rockfish, *S. rastrelliger*.

Sebastes rastrelliger is a thick-bodied, medium-size (maximum size, 56 cm), bottom-dwelling rockfish that inhabits shallow, rocky areas (maximum depth, 46 m) from central Baja California to Yaquina Bay, Oregon (Eschmeyer et al., 1983). This species accounts for less than 1% of the commercial groundfish catch by weight (Pearson[3]). However, in recent years landings have increased from 1.5 metric tons (t) in 1991 to 52 t in 1995. This may be attributed to a relatively new live fish fishery for this species in southern California (Love, 1996). Additionally, *Sebastes rastrelliger* is also an important part of the nearshore recreational catch (Love, 1996).

[1] PFMC (Pacific Fishery Management Council). 1996. Status of the Pacific coast groundfish fishery through 1994 and recommended acceptable biological catches for 1997. Pacific Fishery Management Council, Portland, OR, 168 p.

[2] Ralston, S., J. R. Bence, M. B. Eldridge, and W. H. Lenarz. 1993. Estimating the spawning biomass of shortbelly rockfish (*Sebastes jordani*) in the region of Pioneer and Ascension Canyons using a larval production method, 32 p. Southwest Fisheries Science Center, Natl. Mar. Fish. Serv., NOAA, 3150 Paradise Drive, Tiburon, CA 94920.

[3] Pearson, D. E. 1994. Southwest Fish. Sci. Center, Natl. Mar. Fish. Serv., 3150 Paradise Drive, Tiburon, CA, 94920. Personal commun., 1997.

Only a few studies have been conducted on the development of *S. rastrelliger*. Moreno (1990) described the pigmentation patterns of laboratory-reared larvae up to 53 days old and 7.2 mm in length. Laroche[4] described the pigmentation of a 27.0-mm individual. The purpose of this study is to describe the development of *S. rastrelliger* from larvae to the pelagic juvenile stage and to examine the age and growth of larvae and juveniles.

Methods

Specimens of pelagic larval and juvenile *S. rastrelliger* were obtained from research cruises conducted aboard the NOAA RV *David Starr Jordan*. Specimens were collected with a 26 × 26-m midwater trawl (12.7-mm stretched mesh codend liner). Surveys were conducted in the spring of 1990, 1992–94, and 1996. Specimens from midwater trawls were frozen for later analysis. All samples were collected off central California between Cypress Point (36°35'N) and Salt Point (38°35'N).

We examined pigmentation patterns and physical characteristics of 18 *S. rastrelliger* larvae and pelagic juveniles. Standard length (SL) was measured for each individual, and sizes ranged from 10.0 mm to 27.7 mm. Specimens greater than 19.9 mm were identified by meristic characters (Chen, 1986; Matarese et al., 1989; Moreland and Reilly, 1991; and Laroche[4]), and pigment patterns were recorded. Specimens less than 20 mm were initially identified from pigment patterns developed from a size series based on the patterns observed by Moreno (1990) and the pigment patterns of the smallest, positively identifiable individuals with complete meristic characters. Whenever possible, dorsal, anal, and pectoral-fin ray counts and the number of gill rakers on the first gill arch were recorded and subsequently used in identifications. Gill-raker counts were obtained only from fish larger than 15 mm in length.

Snout to anus length, head length, snout length, eye diameter, body depth at the pectoral-fin base, body depth at anus, and pectoral-fin length were measured on 17 specimens ranging from 10.0 to 27.7 mm. Terminology for morphometrics follows Richardson and Laroche (1979).

Fifteen specimens (ranging from 10.0 to 27.7 mm) were stained with alizarin red-S and examined for head spination. Terminology for head spination follows Richardson and Laroche (1979).

[4] Laroche, W. A. 1987. Guide to larval and juvenile rockfishes (*Sebastes*) of North America. Box 216, Enosburg Falls, VT 05450. Unpubl. manuscript, 311 p.

Otoliths were removed from 16 larvae and juveniles (10.0 to 27.7 mm) and ages were determined following the procedures in Laidig et al. (1991). Additionally, extrusion check radius was measured following the procedures in Laidig and Ralston (1995). Transformation from the larval stage to the juvenile stage was ascertained by the presence of secondary primordia in the otolith (Laidig et al., 1991).

Results

General development

At 10.0 mm, *S. rastrelliger* larvae had already undergone flexion, and a full complement of adult fins rays was present (13 dorsal, 6 anal, and 19 pectoral-fin rays), although the spinous dorsal rays were not quite fully developed (Table 1; Fig. 1C). Meristic counts were similar to those reported by Laroche[4] and Moreland and Reilly (1991). In our sample, the earliest signs of transformation were observed in a specimen 20.9 mm in length, and all specimens 27.7 mm or larger had completed transformation. Lateral line pores were present only in the largest individual; therefore a full complement was never observed during this study.

Morphometrics

Notable changes in body proportion for *S. rastrelliger* occurred between lengths of 10.0 and 13.8 mm and during juvenile transformation (Table 2). At 10.0 mm, larvae had large heads in relation to their body size, whereas larger larvae became more elongate and thus decreased the proportion of head size in relation to body

Table 1

Frequency of occurrence of dorsal, anal, and pectoral-fin ray, and gill-raker counts in larval and juvenile grass rockfish, *Sebastes rastrelliger*.

Character	Count	Frequency of occurrence	Percent occurrence
Dorsal-fin rays	12	2	11.1
	13	16	88.9
Anal-fin rays	6	18	100
Pectoral-fin rays	18	2	11.8
	19	15	88.2
Gill rakers	21	2	16.7
	22	6	50.0
	23	3	25.0
	24	1	8.3

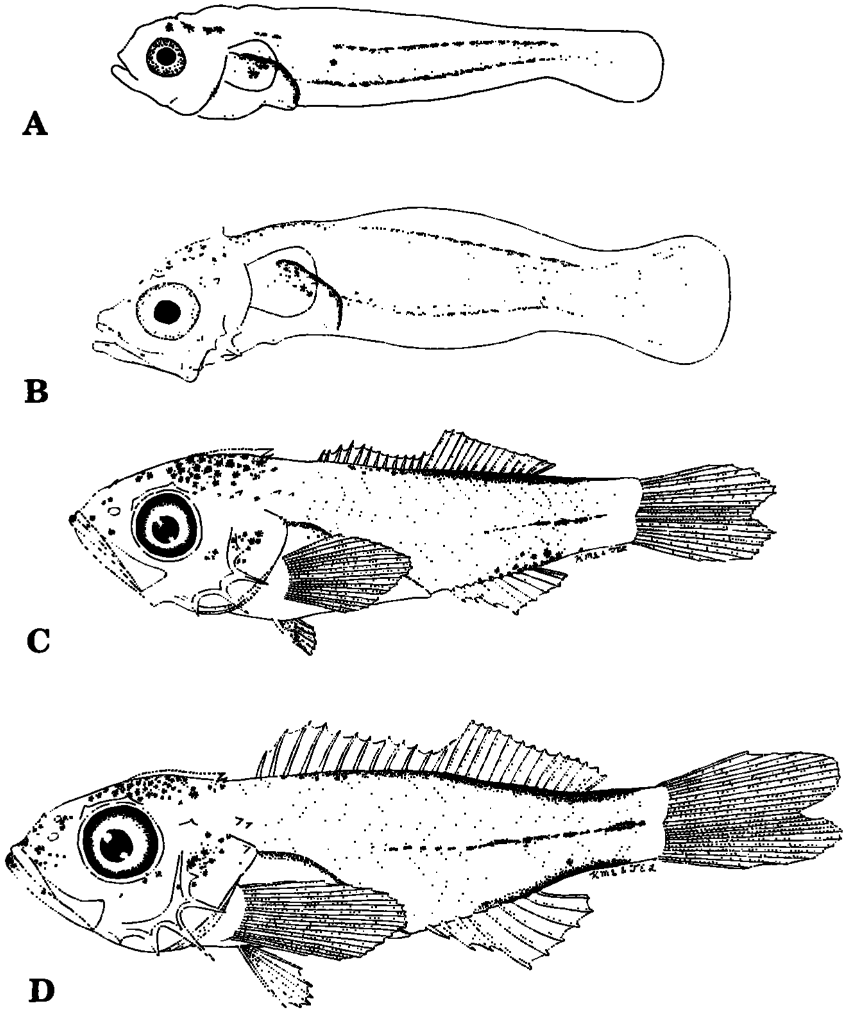

Figure 1

Developmental series of grass rockfish, *Sebastes rastrelliger*. (**A**) 4.6 mm SL yolksac preflexion larva; (**B**) 7.2 mm SL flexion larva; (**C**) 10.0 mm SL larva; (**D**) 13.8 mm SL larva; (**E**) 18.3 mm SL larva; (**F**) 21.6 mm SL transforming larva; (**G**) 27.7 mm SL pelagic juvenile. Illustrations A and B (4.6 and 7.2 mm SL, respectively) from Moreno, 1993.

length. After transformation, the fish became more thick-bodied, as evidenced by the increase in body depth at the pectoral-fin ray base and at the anus.

Head spination

Several head spines had already developed by a length of 10.0 mm (Table 3). The nasal, postocular, parietal, nuchal, pterotic, inferior posttemporal, supracleithral, operculars, and preoperculars were all well formed, whereas the 1st inferior and 1st superior infraorbital were barely perceptible at 10.0 mm. By 13.8 mm, the preocular, 2nd inferior infraorbital, and the superior posttemporal were developed. At 18.8 mm, the 4th superior infraorbital was formed. The tympanic formed at 19.7 mm. The pterotic became overgrown and embedded by 21.6 mm. The supraocular, coronal, 3rd inferior infraorbital, and 2nd and 3rd superior infraorbital were not apparent at any length examined.

Body pigmentation

A distinct pattern of heavy dorsal and postanal ventral midline pigment, along with strong lateral midline pigment, was characteristic at a length of 10.0

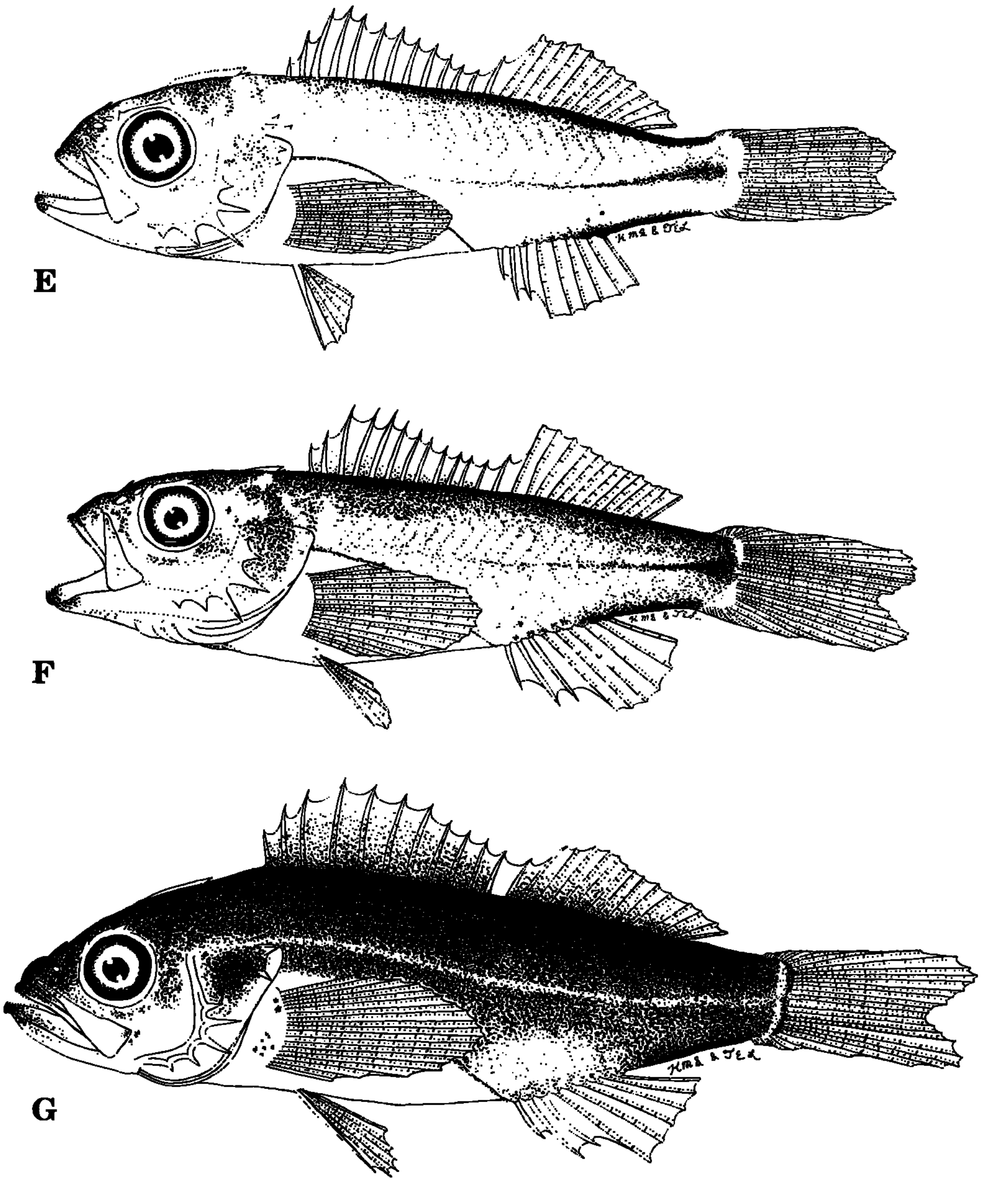

Figure 1 (continued)

mm (Fig. 1C; Table 4). Pigment was also evident along the anterior tip of the lower jaw, on the snout anterior to the eye orbit, on the top of the cranium, on the operculum, and along the dorsal and posterior margin of the gut cavity.

Pigmentation patterns at a length of 13.8 mm were similar to, but more intensely developed than, those at 10.0 mm (Fig. 1D). Pigment advanced in the anterior direction along the postanal ventral and lateral midline, and to a lesser degree along the dorsal midline. In addition, pigment along the posterior-ventral portion of the eye orbit had begun to form.

At a length of 18.3 mm, the dorsal half of the fish had become highly pigmented (Fig. 1E). Nape pigment had developed and merged with the dorsal midline pigment, forming a continuous band from the parietal and nuchal spines to the beginning of the caudal fin at this size. Snout and cranial pigment also had merged to form a solid line of pigment from the upper jaw to the parietal and nuchal spines at a

Table 2

Morphometric measurements (in mm) of grass rockfish, *Sebastes rastrelliger*.

SL (mm)	Snout–anus length	Head length	Snout length	Eye diameter	Body depth at pectoral-fin ray base	Body depth at anus	Pectoral fin length
10.0	6.4	3.7	1.2	1.2	2.9	2.4	1.7
13.8	7.9	4.5	1.5	1.6	3.4	3.1	2.9
16.7	8.4	5.0	1.7	1.8	3.8	3.3	3.4
16.7	8.4	5.0	1.7	1.8	3.8	3.3	3.4
16.8	8.9	5.4	1.8	1.9	3.8	3.4	3.4
17.4	10.2	5.8	2.1	1.9	3.9	3.3	3.6
18.0	10.5	5.9	2.2	2.0	4.3	3.4	3.8
18.3	10.5	6.2	2.2	2.0	4.3	3.9	3.7
18.8	10.8	6.3	2.3	2.1	4.5	3.9	3.8
19.2	10.9	6.5	2.4	2.1	4.6	3.7	4.0
19.3	11.1	6.8	2.5	2.2	4.6	3.8	4.2
19.7	11.4	6.9	2.5	2.2	4.8	3.9	4.3
20.9	11.7	7.2	2.7	2.3	5.1	4.4	4.5
21.6	12.8	7.5	2.9	2.4	5.9	5.2	4.8
22.7	13.7	7.9	3.0	2.5	6.2	5.5	5.2
24.3	14.0	8.7	2.5	2.7	6.7	5.7	5.8
27.7	15.9	9.0	2.6	2.9	7.6	6.5	6.7

length of 18.3 mm. An unpigmented section was conspicuous between the nape and cranial regions. Pigment on the flanks of the dorsal body intensified, especially in between the myomeres. Lateral midline pigment extended from the caudal peduncle to the gut cavity. Pigment on the lateral midline near the caudal peduncle coalesced into a large pigmented area, which decreased in intensity anteriorly. Much of the dorsal half of the operculum was covered with pigment.

At 18.3 mm, the ventral half of the body remained mostly unpigmented, except for the presence of a series of melanophores on the ventral surface anterior to the gut cavity and between the branchiostegals (Fig. 1E). Pigment at the anterior tip of the lower jaw remained similar in intensity to that of the 13.8-mm specimen. Postanal ventral midline pigment became reduced, especially at the base of the anal fin. Pigment was also absent between the ventral myomeres.

By 21.6 mm, pigmentation increased over the entire body surface (Fig. 1F). The dorsal midline pigment merged with the nape, head, snout, and anterior tip of the upper jaw pigment to form a solid line along the dorsal surface of the body from the mouth to the caudal fin. Pigment formed on the ventral half of the membranes of the spinous dorsal fin. Pigment increased around the ventral surface of the eye orbit. Nape, head, and operculum pigment merged to form a vertical bar from the operculum to the dorsal midline, except for a small unpigmented area near the nuchal and parietal spines. Hypural pigment began to form, and the caudal peduncle became highly pigmented. The ventral surface of the body remained only lightly pigmented. A few pigment spots were observed at the base of the pelvic fin.

Juvenile *S. rastrelliger* became highly pigmented throughout most of their body surface by 27.7 mm (Fig. 1G). The entire dorsal surface of the body was completely pigmented. Pigment also covered much of the ventral surface of the body. The gut cavity, the ventral surface of the head, and the area just above the anal fin still remained largely unpigmented. Some pigment was observed at the base of the pectoral fin. A line of light pigment occurred along the lateral midline. Hypural pigment became intense, but an area of decreased pigment was evident just anterior to the hypural area. The spinous and soft dorsal fins were highly pigmented, except for the membrane between spine 11 and 12 which was completely devoid of pigment. A few pigment spots occurred on the anal and caudal fins.

Otolith examination

A linear model provided a good fit for the relationship of total otolith radius versus SL (r^2=0.94)(Fig. 2). The growth rate of *S. rastrelliger* was estimated by a linear model fitted to the relationship of SL and age (coefficient of determination, r^2=0.88)(Fig. 3). This model estimated a growth rate of 0.36 mm/day and an extrusion SL of 0.15 mm. The extrusion check radius for *S. rastrelliger* ranged from 13.3 to 14.6 µm, averaging 14.0 µm (SD=0.39). Secondary primordia

Table 3

Development of head spines in grass rockfish, *Sebastes rastrelliger*. "1" means spine present and "0" means spine absent.

	Standard length (mm)														
Spines	10.0	13.8	16.7	17.4	18.0	18.3	18.8	19.2	19.3	19.7	20.9	21.6	22.7	24.3	27.7
Nasal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Preocular	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Supraocular	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Postocular	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Coronal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tympanic	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Parietal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nuchal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pterotic	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Posttemporals															
Superior	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
Inferior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Supracleithral	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Operculars															
Superior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Inferior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Preoperculars															
1st anterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2nd anterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3rd anterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1st posterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2nd posterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3rd posterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4th posterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5th posterior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Infraorbitals															
1st inferior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2nd inferior	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3rd inferior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1st superior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2nd superior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3rd superior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4th superior	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1

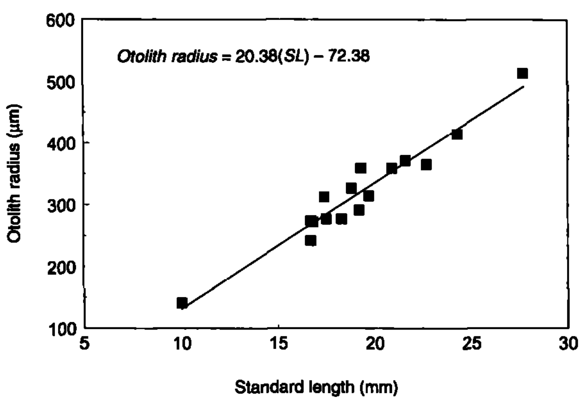

Figure 2

Plot of total otolith radius and standard length of grass rockfish, *Sebastes rastrelliger* (n=16). Solid line indicates predicated values from linear model.

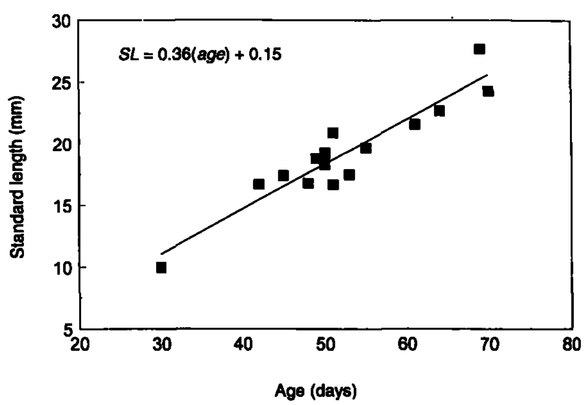

Figure 3

Plot of standard length and age of grass rockfish, *Sebastes rastrelliger* (n=16). Solid line indicates predicated values from linear model.

Table 4

Pigment occurrence at various pigment loci for grass rockfish, *Sebastes rastrelliger*. SL = standard length in mm. Definitions of pigment loci are given below. 0.0 = no pigment, 1.0 = some pigment present, and 2.0 = area heavily pigmented. LJ = anterior tip of the lower jaw, EYE = posterior-ventral edge of the eye orbit, HEAD = cranial surface, FACE = dorsal surface anterior to the eyes, OPER = operculum, CHK = radiating cheek bars, NAPE = nape pigment, DORS = dorsal body surface, VENT = ventral body surface, MID = along the lateral midline, HYP = hypural region, DFIN = spinous dorsal fin, AFIN = anal fin, PEC = blade of the pectoral fin.

SL	LJ	EYE	HEAD	FACE	OPER	CHK	NAPE	DORS	VENT	MID	HYP	DFIN	AFIN	PEC
10.0	2.0	0.0	2.0	2.0	2.0	0.0	1.0	2.0	2.0	1.0	0.0	0.0	0.0	0.0
13.8	2.0	2.0	2.0	2.0	2.0	0.0	1.0	2.0	2.0	2.0	1.0	0.0	0.0	0.0
16.7	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
16.7	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
16.8	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
17.4	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
17.5	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
18.0	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
18.3	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
18.8	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	1.0	0.0	0.0
19.2	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
19.3	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	1.0	0.0	0.0
19.7	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
20.9	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	1.0	1.0	0.0	0.0
21.6	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	1.0	2.0	0.0	0.0
22.7	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	1.0	2.0	0.0	0.0
24.3	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	1.0	2.0	0.0	0.0
27.7	2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0	0.0

first appeared in the otoliths of the 20.9-mm specimen and was subsequently observed in the otoliths of all specimens larger than 20.9 mm. By 27.7 mm, the otolith was completely encircled by secondary primordia, signaling the end of juvenile transformation.

Discussion

Sebastes rastrelliger have developed a unique pigment pattern by 10 mm (Fig. 1C), which allows them to be distinguished from other *Sebastes* spp. At this size, the presence of dorsal, ventral, and lateral body midline pigment is distinctive for only three species (*S. dallii* [Moser and Butler, 1981], *S. rufus* [Moser and Butler, 1987], and *S. saxicola* [Laidig et al., 1996]) that co-occur with *S. rastrelliger* off California. All four species have anterior lower jaw, snout, and opercular pigments, which could add to the confusion between these species. One major difference in pigmentation between these species is that *S. dallii* and *S. rufus* have pectoral-fin pigment. We found no pectoral-fin pigmentation in *S. rastrelliger* larger than 10.0 mm, and Moreno (1990) found no pectoral-fin pigment for individuals smaller than 8 mm. *Sebastes saxicola* also lacks pectoral-fin pigment in fish smaller than 20 mm (Laidig et al., 1996). *Sebastes saxicola* and *S. rastrelliger* can exhibit similar pigmentation at 10 mm. This similarity occurs until approximately 18 mm, when *S. saxicola* develops hypural and dorsal fin pigment and when saddling along the dorsal surface eventually changes into a barred pattern. *Sebastes rastrelliger* was also found to have a relatively small pectoral fin for its SL (Table 2) in comparison with other *Sebastes* spp. (Moser et al., 1977; Richardson and Laroche, 1979; Laroche and Richardson, 1980, 1981; Sakuma and Laidig, 1995; Laidig et al., 1996)

Meristics can aid in differentiating *S. rastrelliger* from other species. The average counts of 13 dorsal, 6 anal, and 19 pectoral-fin rays (Table 1) are similar to those observed by Moreland and Reilly (1991) and Laroche.[4] Moreland and Reilly (1991) found this combination of fin-ray counts typical for only two species: *S. rastrelliger* and *S. babcocki*. *Sebastes babcocki* has a distinct barred pigmentation pattern and typical gill-raker counts of 30–31. *Sebastes rastrelliger* had no barred pattern and average gill-raker counts of 22. This count is lower than that observed by Moreland and Reilly (1991) (an average of 25) and Laroche[4] (an average of 24). Gill-raker counts may be low in our study because the gill rakers may not have fully developed in some of our specimens (Sakuma and Laidig, 1995). Therefore, the use of pigment patterns in conjunction with meristics should aid in the identification of *S. rastrelliger*.

Otolith characters can also be useful in separating *Sebastes rastrelliger* from some other *Sebastes* species. Laidig et al. (1996) showed that the extrusion check radius of *S. rastrelliger* (14.0 µm) was significantly different from those of *S. saxicola*, *S. maliger*, *S. atrovirens*, and the copper complex (*S. carnatus*, *S. caurinus*, and *S. chrysomelas*). It was not different from those of *S. auriculatus* or *S. semicinctus*. However, these latter two species have distinctly different meristic counts and pigmentation patterns. In addition, the extrusion check radii found by Laidig and Ralston (1995) for *S. paucispinis*, *S. flavidus*, *S. entomelas*, and *S. mystinus* were smaller (10.93–12.20 µm) than that for *S. rastrelliger*, whereas the extrusion check radii for *S. jordani* and *S. goodei* were much larger (15.15–16.96 µm).

Postflexion *Sebastes rastrelliger*, from 10.0 to 27.7 mm, grew at a rate of 0.36 mm/day. Moreno (1990) found that the growth rate for reared preflexion *S. rastrelliger* less than 8 mm was 0.07 mm/day. This slow growth rate may be attributed to laboratory rearing of the fish. However, slow growth rates have been shown for the first few weeks in *S. goodei* (Sakuma and Laidig, 1995), *S. saxicola* (Laidig et al., 1996), and *S. jordani* (Laidig et al., 1991). Sakuma and Laidig (1995) observed growth rates of 0.135 mm/day in *S. goodei* less than 40 days old whereas Woodbury and Ralston (1991) noted growth rates of 0.399–0.555 mm/day in specimens 35–170 days old. Laidig et al. (1996) observed growth rates of 0.125 mm/day in *S. saxicola* less than 40 days old, whereas larvae and juveniles older than 40 days exhibited increased growth rates of 0.367 mm/day. Laidig et al. (1991) determined that in *S. jordani* there were large fluctuations in growth rates associated with flexion, with relatively slow growth prior to flexion, almost no growth during flexion, and relatively rapid growth after flexion. Because the *S. rastrelliger* in this study had already undergone flexion, we expected a faster growth rate than that of smaller fish as recorded by Moreno (1990). For this reason, our growth curve does not accurately express the growth in the first few weeks of life; this lack of fit is consistent with the smaller than expected estimate of SL at extrusion (0.15 mm). Therefore, extrapolating growth rates for flexion and preflexion larvae from our model would not be advised.

Acknowledgments

We would like to thank the officers and crew of the RV *David Starr Jordan* and the scientific personnel onboard who assisted in the collection of larval and juvenile fish. We also thank Mary Nishimoto for help in identifications during this study.

Literature cited

Chen, L.
1971. Systematics, variation, distribution, and biology of rockfishes of the subgenus *Sebastomus* (Pisces, Scorpaenidae, *Sebastes*). Univ. California Press, Berkeley, CA, 115 p.
1986. Meristic variation in *Sebastes* (Scorpaenidae), with an analysis of character association and bilateral pattern and their significance in species association. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 45, 17 p.

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

Hunter, J. R., and N. C. -H. Lo.
1993. Ichthyoplankton methods for estimating fish biomass introduction and terminology. Bull. Mar. Sci. 53:723–727.

Laidig, T. E., and S. Ralston.
1995. The potential use of otolith characters in identifying larval rockfish (*Sebastes* spp.). Fish. Bull. 93:166–171.

Laidig, T. E., S. Ralston, and J. R. Bence.
1991. Dynamics of growth in the early life history of shortbelly rockfish, *Sebastes jordani*. Fish. Bull. 89: 611–621.

Laidig, T. E., K. M. Sakuma, and M. M. Nishimoto.
1996. Description of pelagic larval and juvenile stripetail rockfish, *Sebastes saxicola* (family Scorpaenidae), with an examination of larval growth. Fish. Bull. 94:289–299.

Laroche, W. A., and S. L. Richardson.
1980. Development and occurrence of larvae and juveniles of the rockfishes *Sebastes flavidus* and *Sebastes melanops* (Scorpaenidae) off Oregon. Fish. Bull. 77(4):901–922.
1981. Development of larvae and juveniles of the rockfishes *Sebastes entomelas* and *S. zacentrus* (family Scorpaenidae) and occurrence off Oregon, with notes on head spines of *S. mystinus*, *S. flavidus*, and *S. melanops*. Fish. Bull.79(2): 231–257.

Love, M.
1996. Probably more than you wanted to know about the fishes of the Pacific coast. Really Big Press, Santa Barbara, CA, 381 p.

Matarese, A. C., A. W. Kendall Jr., D. M. Blood, and B. M. Vinter.
1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 80, 652 p.

Moreland, S. L., and C. A. Reilly.
1991. Key to the juvenile rockfishes of central California. *In* T. E. Laidig and P. B. Adams (eds.), Methods used to identify pelagic juvenile rockfish (genus *Sebastes*) occurring along the coast of central California, p. 59–180. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-166, 180 p.

Moreno, G.
1990. Description of the larval stages of five northern California species of rockfishes (Family Scorpaenidae) from rearing studies. M.S. thesis, California State Univ., Stanislaus, CA, 68 p.
1993. Description of early larvae of four northern California species of rockfishes (Scorpaenidae: *Sebastes*) from rearing studies. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 116, 18 p.

Moser, H. G., and J. L. Butler.
1981. Description of reared larvae and early juveniles of the calico rockfish, *Sebastes dallii*. Calif. Coop. Oceanic. Fish. Invest. Rep. XXII:88–95.

1987. Descriptions of reared larvae of six species of *Sebastes*. *In* W. H. Lenarz, and D. R. Gunderson (eds.), Widow rockfish. Proceedings of a workshop, Tiburon, California, December 11–12, 1980, p. 19–29. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 48.

Moser, H. G., E. H. Ahlstrom, and E. M. Sandknop.
1977. 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. U.S. Dep. Commer., NOAA Tech. Rep. NMFS Circ. 402, 71 p.

Phillips, J. B.
1964. Life history studies on ten species of rockfish. Calif. Dep. Fish Game Fish Bull. 126, 70 p.

Richardson, S. L., and W. A. Laroche.
1979. Development and occurrence of larvae and juveniles of the rockfishes *Sebastes crameri*, *Sebastes pinniger*, and *Sebastes helvomaculatus* (Family Scorpaenidae) off Oregon. Fish. Bull. 77(1):1–46.

Sakuma, K. M., and T. E. Laidig.
1995. Description of larval and pelagic juvenile *Sebastes goodei* with an examination of larval growth. Fish. Bull. 93:720–730.

Witzig, J. F., M. C. Holliday, R. J. Essig, and D. L. Sutherland.
1992. Marine recreational fisheries statistics survey, Pacific coast, 1987–1989. National Marine Fisheries Service, Silver Springs, MD, 367 p.

Woodbury, D. P., and S. Ralston.
1991. Interannual variation in growth rates and back-calculated birthdate distributions of pelagic juvenile rockfishes (*Sebastes* spp.) off the central California coast. Fish. Bull. 89:523–533.