Description of pelagic larval and juvenile stripetail rockfish, *Sebastes saxicola* (family Scorpaenidae), with an examination of larval growth

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Abstract.—Pigmentation, morphometrics, head spination, fin development, and meristic characters were described and illustrated for the developmental series of larval and pelagic juvenile (4.7–38.2 mm standard length) stripetail rockfish, *Sebastes saxicola*. Pigment patterns were sufficiently distinct to differentiate larval and juvenile *S. saxicola* from other *Sebastes* species occurring in the study area (central California). Early larvae of *S. saxicola* were identified by the presence of pigment on the postanal ventral midline and the nape and by the lack of pigment on the lower jaw and the pectoral fins. Late larval *S. saxicola* had areas of intense pigment along the dorsal, lateral, and ventral midlines. Juvenile *S. saxicola* were identified by their distinctive bar pattern and meristic characters. Examination of otolith characters indicated that the extrusion check radius of *S. saxicola* differed from that of other *Sebastes* species examined. Otolith characters, used in combination with pigment patterns, readily separated larval *S. saxicola* from other *Sebastes* species. Calculated growth rates for *S. saxicola* were slower than most previously reported growth rates for other *Sebastes* species.

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Rockfishes (*Sebastes* spp.) are important to the commercial and recreational fisheries of the northeastern Pacific. In 1993, they accounted for approximately 18% 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). Sixty-one species of rockfish are reported from California alone (Eschmeyer et al., 1983). Management of the fishery has been plagued by taxonomic problems. The need to separate adult rockfish landed by the fishery has long been recognized (Phillips, 1964; Chen, 1971). Larvae and juveniles are far more difficult to separate than are adults, but the need to differentiate them is growing with their use as subjects of 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 *S. saxicola*.

Stripetail rockfish, *Sebastes saxicola*, are small (maximum size 39 cm) and occur on soft bottom at depths of 46–421 m (Eschmeyer et al., 1983). This species accounts for less than 1% of the commercial groundfish catch by weight (Pearson[3]), perhaps because of its small size. It is one of the more abundant groundfish species off Santa Cruz, California (Adams et al., 1995), and is generally common in waters be-

[1] PFMC (Pacific Fishery Management Council). 1994. Status of the Pacific coast groundfish fishery through 1994 and recommended acceptable biological catches for 1995. Pacific Fishery Management Council, Portland, OR, 118 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. National Marine Fisheries Service, Southwest Fisheries Science Center, 3150 Paradise Drive, Tiburon, CA 94920.

[3] Pearson, D. E. 1994. National Marine Fisheries Service. 3150 Paradise Drive, Tiburon, CA 94920. Personal commun.

tween 100–149 fathoms off the central California coast (Gunderson and Sample, 1980). This study describes the development of *S. saxicola* from pre-extrusion larvae to the pelagic juvenile stage and describes the age and growth of larval *S. saxicola*.

Methods

Specimens of pelagic larval and juvenile *S. saxicola* were obtained from cruises conducted aboard the NOAA RV *David Starr Jordan* and the Moss Landing Marine Laboratories RV *Ed Ricketts*. Specimens were taken with Manta nets (0.505-mm mesh), bongo nets (0.505-mm mesh), a 5-m^2 Methot-Isaacs-Kidd (MIK) trawl (2-mm mesh and a 0.505-mm codend), and a 26 × 26 m midwater trawl (12.7-mm stretched mesh codend liner). Manta nets were used during surveys in January and February 1992, bongo nets in January and February 1992 and January 1994, MIK trawls in March 1992 and 1993, and midwater trawls in May and June 1990–93. Specimens taken with Manta nets, bongo nets, and MIK trawls were preserved in 95% EtOH, whereas specimens from midwater trawls were frozen. Pre-extrusion larvae were obtained from three adult females in February 1994 and preserved in 95% EtOH. All samples were collected off central California between Cypress Point (36°35'N) and Salt Point (38°35'N).

We examined and measured 197 *S. saxicola* larvae and juveniles from 3.3 mm notochord length (NL) to 43.9 mm standard length (SL). Specimens greater than 19.9 mm SL were identified by meristic characters (Chen, 1986; Matarese et al., 1989; Moreland and Reilly, 1991; Laroche[4]); melanophore patterns were recorded. Specimens less than 20 mm SL were initially identified by pigment patterns developed from a size-series based on pre-extrusion pigment patterns and 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 taken only on fish larger then 15 mm SL.

We measured snout to anus length, head length, snout length, eye diameter, body depth at the pectoral-fin base, pectoral-fin length, pectoral-fin base depth, and parietal spine length on 28 specimens from 3.3 mm NL to 20.9 mm SL. Terminology for morphometrics followed Richardson and Laroche (1979).

Eighteen specimens from 6.2 mm NL to 20.9 mm SL were stained with Alizarin Red S and examined for head spination. Terminology for head spination followed Richardson and Laroche (1979).

Otoliths were removed from 58 *S. saxicola* larvae (4.2 mm NL to 19.7 mm SL) and aged according to procedures in Laidig et al. (1991). In addition, otoliths from five species (*S. atrovirens*, *S. auriculatus*, *S. maliger*, *S. rastrelliger*, and *S. semicinctus*) and two species complexes (the copper complex [*S. atrovirens*, *S. carnatus*, *S. caurinus*, and *S. chrysomelas*] and the gopher complex [*S. carnatus* and *S. chrysomelas*]) were removed for comparison of otolith characters with *S. saxicola* (Laidig and Ralston, 1995). These five species and two complexes were chosen for similarity in pigment patterns with preflexion *S. saxicola*; *S. rastrelliger* was also selected for its similar pigmentation in postflexion fish. In addition, otoliths were removed and examined from 15 *Sebastes* larvae of unknown species with pigment patterns similar to *S. saxicola*, but with pigment present on the axillary surface of the pectoral fins.

Results

General development

Larvae were extruded at a size of 3.3–5.2 mm NL. Notochord flexion began at approximately 5.8 mm NL and was completed by 8.0 mm SL. The full adult complement of pectoral-fin rays developed during late-stage flexion and early postflexion (16 rays, Table 1). By 7.0 mm NL, anal-fin rays had begun to form and a full adult complement (7 rays, Table 1) was present in 90% of the fish by 8.0 mm SL. The dorsal, pectoral, and pelvic fins began to form around 7.5 mm NL and a full adult complement (dorsal=12 rays, pectoral=16, pelvic=5, Table 1) was present by approximately 9.0 mm SL. Lateral line pores first appeared around 17 mm SL and a complete series was apparent by approximately 38 mm SL. Because we had only a few specimens above 38 mm SL, we were unable to obtain accurate lateral line pore counts.

Morphometrics

Changes in body shape in *S. saxicola* were related to notochord flexion (Table 2). As the larvae began flexion, they became more stout-bodied, as evidenced by the increase in body depth at the pectoral-fin base. During flexion, the pectoral-fin length increased as the full adult complement of fin rays was attained (Table 2). The parietal spine length increased until approximately 10 mm SL when spine growth ap-

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

Table 1

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

Character	Count	Frequency of occurrence	Percent occurrence
Dorsal-fin rays	11	2	1.4
	12	136	91.8
	13	10	6.8
Anal-fin rays	6	4	2.5
	7	153	95.0
	8	4	2.5
Pectoral-fin rays	15	14	10.4
	16	117	86.6
	17	4	3.0
Gill rakers	28	2	3.1
	29	6	9.2
	30	15	23.1
	31	15	23.1
	32	22	33.8
	33	3	4.6
	34	2	3.1

peared to cease. All other measurements showed a marked increase after flexion was completed (Table 2).

Head spination

Head spines first began to appear during flexion (Table 3). By 9 mm SL, the postocular, parietal, pterotic, inferior posttemporal, inferior and superior opercular, 1st inferior and 1st superior infraorbital, and all preopercular spines were present. By approximately 10 mm SL, the supracleithral, nuchal, 2nd inferior intraorbital, and nasal spines were formed. By 20 mm SL, the preocular, superior posttemporal, and tympanic spines formed. The cleithral, 3rd superior infraorbital, and 3rd inferior infraorbital spines were not present in larvae less than 21 mm SL. Supraocular and coronal spines did not occur at any size.

Pre-extrusion pigmentation

Pre-extrusion larvae had pigment along the ventral midline extending from the anus to myomere 23 or 24 (second and third most posterior myomeres). This pigment was typically strong, with 2–4 melanophores per myomere (Fig. 1A). Pigment consisting of 6–16 melanophores was also located along the dorsal midline from approximately myomeres 15–23. The dorsal and posterior surfaces of the gut cavity were also heavily pigmented. In addition, in 72% of the larvae very small melanophores (1–5 in number) were observed on the ventral surface of the gut cavity. A single melanophore was located in the nape region of the head in 80% of specimens (Fig. 1A).

Body pigmentation

After extrusion, melanophores along the dorsal midline increased in number and size (Fig. 1B). This increase was most noticeable in the advancement of pigment in the anterior direction (there was little or no advancement posteriorly). At approximately 12 mm SL, the nape and dorsal midline pigments merged to form a solid line along the dorsal body surface. This dorsal body pigment increased in intensity as larvae grew.

A distinct pattern of five body bars (numbered 1–5 from anterior to posterior) was apparent in juveniles greater than 25 mm SL. Body-bar 1 began to appear in the nape region at 13 mm SL (Table 4; Fig. 1D). This bar extended from the dorsal midline to the operculum and was fully formed by approximately 24 mm SL. The next bar to form was body-bar 4 (an inverted triangle under the soft dorsal fin), which appeared at 17 mm SL (Fig. 1E), and was completely developed by approximately 35 mm SL (Table 4; Fig. 1F). Body-bar 2 was the next bar to form (from the spinous dorsal fin to the dorsal surface of the gut), appearing at approximately 19 mm SL and becoming fully developed by 33 mm SL. Body-bars 3 and 5 (from the spinous dorsal fin to the anus and an inverted triangle on the caudal peduncle, respectively) were the last bars to form; both appeared at approximately 20 mm SL and were fully developed at 38 mm SL (Fig. 1F).

The postanal ventral midline melanophores near the anus were lost soon after extrusion (Fig 1B). By 6 mm NL, the anteriormost melanophores were located approximately three myomeres posterior to the anus. The anterior melanophores decreased in number with increased fish length until approximately 10 mm SL. At this size, postanal ventral midline pigment began to advance anteriorly with increased fish size. In addition, pigment intensified to form a very dark area extending from the middle of the anal fin posteriorly to the first few ventral pterygiophores of the caudal fin. In larger juveniles (greater than 25 mm SL), the postanal ventral midline pigment became less intense and only a few melanophores remained near the anal fin articulations (Fig. 1, E and F).

Pigment on the lateral midline began to develop in 6 mm NL fish with a few melanophores near the caudal peduncle (Table 4; Fig. 1B). As fish length increased, the lateral midline pigment increased and became most intense at approximately 20 mm SL,

Table 2

Morphometrics (mm) of stripetail rockfish, *Sebastes saxicola*. Fish undergoing flexion are shown between the dashed lines. — = measurements not taken.

SL (mm)	Snout–anus length	Head length	Snout length	Eye diameter	Body depth	Pect.-fin length	Pect.-fin base depth	Parietal spine length
3.3	1.15	0.70	0.08	0.29	0.51	0.18	0.15	0.00
3.9	1.35	0.74	0.05	0.30	0.47	0.23	0.17	0.00
4.1	1.42	0.71	0.07	0.28	0.48	0.18	0.16	0.00
4.1	1.41	0.76	0.09	0.33	0.50	0.25	0.16	0.00
4.4	1.61	0.79	0.07	0.36	0.63	0.22	0.20	0.00
4.6	1.53	0.72	0.07	0.29	0.57	0.24	0.15	0.00
4.7	1.77	0.88	0.13	0.36	0.64	0.29	0.21	0.00
4.7	1.72	0.85	0.14	0.40	0.71	0.25	0.18	0.00
4.7	1.71	0.85	0.09	0.34	0.62	0.20	0.21	0.00
5.0	1.66	0.85	0.13	0.34	0.63	0.20	0.21	0.00
5.0	1.73	0.80	0.09	0.32	0.52	0.26	0.16	0.00
5.1	1.76	0.90	0.22	0.39	0.73	0.26	0.19	0.00
5.8	—	1.8	0.4	0.7	1.2	—	0.4	0.2
6.2	3.2	2.2	0.6	0.8	1.5	0.4	0.5	0.3
6.9	3.6	2.2	0.6	0.8	1.6	0.6	0.6	0.3
7.3	3.6	2.5	0.7	0.8	1.7	0.7	0.6	—
8.1	4.0	2.5	0.7	0.9	1.8	0.7	0.6	0.4
8.7	4.5	2.8	0.9	1.0	1.9	0.9	0.7	0.5
9.1	5.3	3.0	0.9	1.1	2.4	1.3	0.7	0.5
10.2	6.0	3.5	1.1	1.2	2.9	1.5	0.9	0.5
10.4	6.1	3.7	1.1	1.3	2.8	1.6	0.8	0.3
11.3	6.5	3.9	1.2	1.2	3.0	1.9	0.9	0.4
12.2	7.0	4.2	1.2	1.5	3.2	2.2	1.1	0.3
13.4	7.7	4.5	1.4	1.5	3.7	2.5	1.1	0.5
14.3	8.0	4.9	1.3	1.5	3.9	3.2	1.1	0.4
16.4	9.3	5.5	1.3	1.8	4.5	3.9	1.3	0.4
18.4	10.4	6.3	1.5	2.2	4.9	4.5	1.5	0.4
20.9	12.4	7.5	2.5	2.4	5.4	4.9	1.6	0.3

forming a line stretching from the posterior caudal peduncle (sometimes onto the caudal fin) to the posterior edge of the operculum. After 20 mm SL, pigment on the body intensified (mostly above the lateral midline), causing the lateral midline pigment to become much less evident (Fig. 1E). By 35 mm SL, the lateral midline pigment was virtually indistinguishable as it merged with the body pigment and the five body bars (Fig. 1F).

The hypural region remained mostly unpigmented until approximately 15 mm SL, when pigment formed on the posterior edge of the hypural plates (Fig. 1D). At 20 mm SL, when body-bar 5 became noticeable, the hypural region was highly pigmented (Fig. 1E).

Fin pigmentation

The pelvic and pectoral fins were relatively unpigmented in the larval and pelagic juvenile stages. Pigment was noted in the pelvic fins of only two fish. In these two fish, pigment occurred at the base of the rays of the left pelvic fin. In larger individuals, a few melanophores were noted on the pectoral fin, but these were not in a consistent area of the fin and did not constitute a regular pattern (Table 4). In addition, the axillary surface of the pectoral fin remained unpigmented throughout development.

Pigment on the dorsal fin began appearing at 17 mm SL with a few melanophores on the spinous fin. Melanophores appeared first on the anterior portion of the spinous dorsal fin and spread along the entire fin length as fish size increased. By 25 mm SL, most of the length of the spinous dorsal fin had some pigment, and melanophores were just beginning to appear on the soft dorsal fin (Fig. 1E). By 38 mm SL, the spinous dorsal fin was completely pigmented and the soft dorsal fin had a distinctive pattern. This pattern consisted of two horizontal pigment bands: the first was located just ventral to the tips of the soft fin rays, and the second at the fin ray bases. In addi-

Table 3

Development of head spines in stripetail rockfish, *Sebastes saxicola*. "1" means spine was present and "0" means spine was absent.

	Standard length (mm)																	
Spines	6.2	6.9	7.3	8.1	8.5	8.7	9.1	9.7	10.2	10.4	11.3	12.2	13.4	14.3	15.4	16.4	18.4	20.9
Nasal	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Preocular	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Supraocular	0	0	0	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	1	1	1
Coronal	0	0	0	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	0	0	0	0	0	0	0	1	1
Parietal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nuchal	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
Pterotic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Posttemporals																		
Superior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Inferior	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Supracleithral	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Cleithral	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opercular																		
Superior	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Inferior	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Preopercular																		
1st Anterior	1	1	1	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	1	1	1
3rd Anterior	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1st Posterior	0	0	0	0	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	1	1	1
3rd Posterior	1	1	1	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	1	1	1
5th Posterior	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Infraorbitals																		
1st Inferior	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2nd Inferior	0	0	0	0	0	0	0	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	0	0	0
1st Superior	0	1	1	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	0	1	1
3rd Superior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4th Superior	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

tion, there was an unpigmented area at the base of the first two soft rays and the last spine (Fig. 1F).

Pigment began appearing on the anal fin at approximately 30 mm SL. Pigment intensified quickly, and by 38 mm SL a pattern had developed, consisting of a band through the middle of the fin and extending from the first anal spine to the last ray (Fig. 1F).

The caudal fin remained unpigmented until approximately 38 mm SL, when pigment began forming near the base of the rays. On the largest fish examined (43.9 mm SL), pigment was observed sporadically on a few fin rays.

Head pigmentation

Pigment on top of the cranium began forming soon after extrusion (Table 4). Four to five melanophores were present by 5 mm NL. The number and size of melanophores increased with increased fish size and by 7 mm NL, the head had become highly pigmented (Fig. 1B). Nape pigment also increased from one melanophore to five or six melanophores by 6 mm NL (Fig. 1B). At around 7 mm NL, nape pigment was overgrown by muscle tissue and became embedded. After flexion, pigment again appeared on the surface of the nape area. This pigment intensified with increased fish size.

At 7 mm NL, pigment began to develop on the anterior portion of the head between the eyes. As fish size increased, more pigment was added to this area. Pigment began forming on the upper jaw at approximately 8 mm SL. By 10 mm SL, pigmentation on the upper jaw and the anterior section of the head was well developed and could not always be differenti-

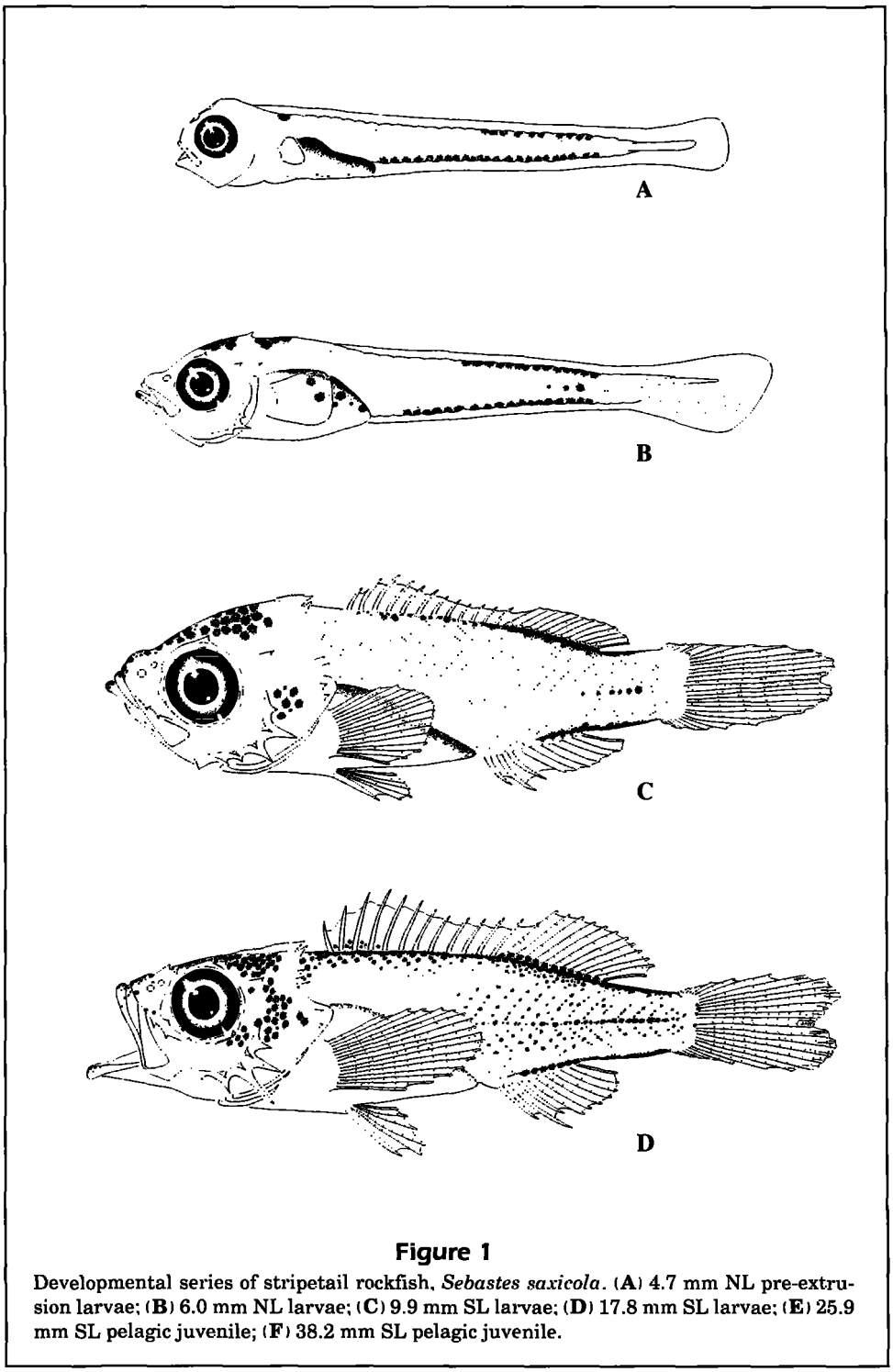

Figure 1

Developmental series of stripetail rockfish, *Sebastes saxicola*. (**A**) 4.7 mm NL pre-extrusion larvae; (**B**) 6.0 mm NL larvae; (**C**) 9.9 mm SL larvae; (**D**) 17.8 mm SL larvae; (**E**) 25.9 mm SL pelagic juvenile; (**F**) 38.2 mm SL pelagic juvenile.

ated (Fig. 1C). At this time, pigment on the cranial region and the anterior section of the head also merged, forming a solid pigment line extending from the upper jaw to the posterior side of the cranium (Fig. 1C).

Pigment began forming on the tip of the lower jaw at approximately 5 mm NL (Table 4). With increased development, pigment spread posteriorly along the jaw. At 30 mm SL, the upper and lower jaw pigments merged to encircle the mouth (Fig. 1F).

Pigment on the operculum began forming at 8 mm SL (Table 4; Fig. 1C). More melanophores were added to this region creating a large area of pigment by 12

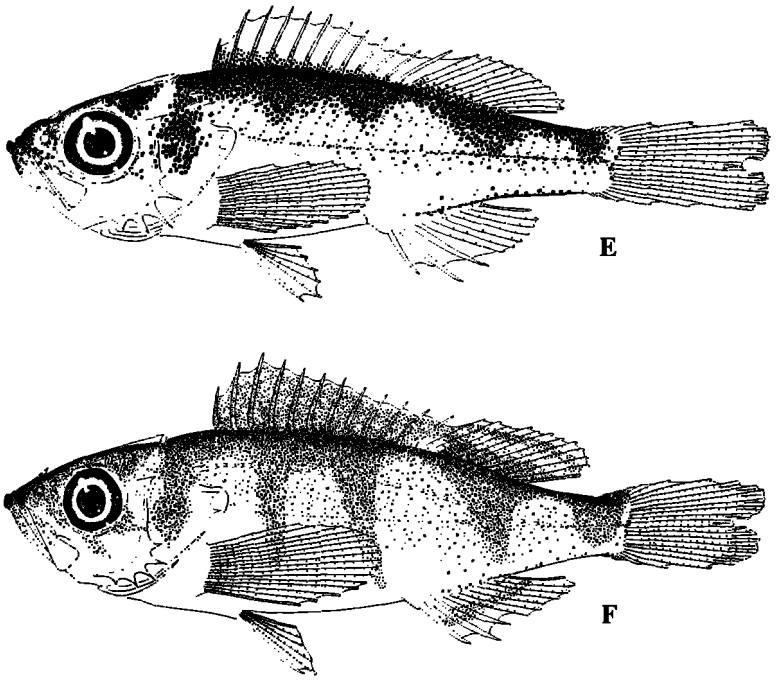

Figure 1 (continued)

mm SL. This pigment area intensified with increased fish size and merged with body-bar 1 at 22 mm SL (Fig. 1F).

Pigment along the ventral and posterior regions of the eye orbit began forming at 12 mm SL (Table 4). This pigment intensified and developed into two cheek bars. The more dorsal cheek bar formed first at 14 mm SL. By 36 mm SL, this bar extended from the eye orbit across the preopercle to the operculum, ending just below the operculum pigment (Fig. 1F). The more ventral cheek bar began forming at 28 mm SL at the base of the eye orbit and extended ventrally. At 44 mm SL, this bar was not completely formed.

Otolith examination

The extrusion check radius for *S. saxicola* ranged from 11.0 to 13.6 μm, averaging 11.9 μm (standard deviation [SD]=0.526 μm)(Fig. 2). The extrusion check radius of *S. saxicola* was not significantly different from the copper (P=0.132; extrusion check radius=10.5 μm; SD=0.354 μm) and gopher complexes (P=0.056; extrusion check radius=10.6 μm; SD=0.288 μm). Three species had extrusion check radii significantly larger (P<0.05) than those of *S. saxicola* (*S. rastrelliger* at 14.0 μm, SD=0.389;

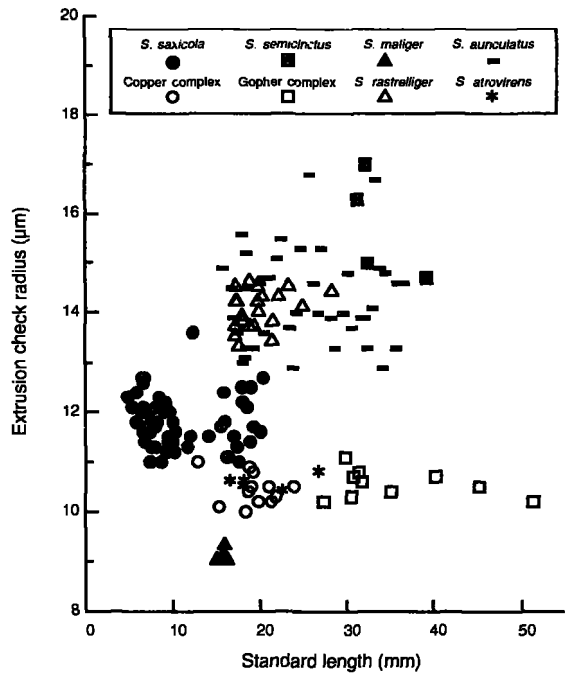

Figure 2

Comparison of extrusion check radius between stripetail rockfish, *Sebastes saxicola*, and other species.

Table 4

Proportions of stripetail rockfish, *Sebastes saxicola*, with melanophores present at various pigment loci averaged over 1.0 mm (range=+/– 0.5 mm) and 2.0 mm (range=+/– 1.0 mm) size bins. SL = standard length in mm. Definitions of pigment loci are given below.

SL	N	LJ	EYE	HEAD	FACE	OPER	CHK	NAPE	DORS	VENT	MID	HYP	DFIN	AFIN	PEC	PEL	B1	B2	B3	B4	B5
4	2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2	0.5	0.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	14	0.4	0.0	1.0	0.3	0.0	0.0	0.7	1.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	17	0.5	0.0	1.0	0.9	0.1	0.0	0.3	1.0	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	14	1.0	0.0	1.0	0.9	0.9	0.0	0.6	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	15	1.0	0.0	1.0	1.0	1.0	0.0	0.7	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	8	1.0	0.1	1.0	1.0	1.0	0.0	0.9	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	15	1.0	0.1	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	12	1.0	0.3	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
13	10	1.0	0.1	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
14	10	1.0	0.7	1.0	1.0	1.0	0.6	1.0	1.0	1.0	1.0	0.2	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
15	7	1.0	0.8	1.0	1.0	1.0	0.7	1.0	1.0	1.0	1.0	0.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
16	8	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0
17	3	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	0.3	0.3	0.0	0.0	0.0	0.7	0.0	0.0	0.3	0.0
18	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0
19	2	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.0	0.5	0.4	0.0	0.5	0.0
20	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.5	0.0	1.0	1.0	0.5	1.0	0.5
22	8	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.0	0.5	0.4	0.4	0.5	0.4
24	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.6	1.0	0.4	0.6	0.4
26	6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	0.8	1.0	1.0
28	6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.0	0.0	1.0	1.0	1.0	1.0	1.0
30	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	0.2	0.0	1.0	1.0	1.0	1.0	1.0
32	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.0	0.0	1.0	1.0	1.0	1.0	1.0
34	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.0	0.0	1.0	1.0	1.0	1.0	1.0
36	6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.7	0.0	1.0	1.0	1.0	1.0	1.0
38	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.6	0.0	1.0	1.0	1.0	1.0	1.0
40	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	0.0	1.0	1.0	1.0	1.0	1.0
44	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0

LJ=anterior tip of the lower jaw, EYE=posterio-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, PEL=pelvic fin, B1=body-bar 1 (most anterior), B2=body-bar 2, B3=body-bar 3, B4=body-bar 4, B5=body-bar 5 (on peduncle)

S. auriculatus at 14.3 μm, SD=0.939 μm; *S. semicinctus* at 15.8 μm, SD=1.085 μm). The two remaining species had extrusion check radii significantly smaller ($P<0.05$) than that of *S. saxicola* (*S. maliger* at 9.1 μm [SD=0.141 μm] and *S. atrovirens* at 10.6 μm [SD=0.148 μm]).

The extrusion check radius from individuals with axillary pectoral-fin pigment varied from that of *S. saxicola* (Fig. 3). The difference between extrusion check radius in all the larvae with axillary pigment (11.08μm; SD=1.79μm) and *S. saxicola* was not significant. However, when the larvae with axillary pigment were separated into two groups (one with extrusion check radius greater than 13 μm and the other with extrusion check radius less than 11 μm), the extrusion check radius of each group (13.46 μm [SD=0.055 μm] for the larger and 9.89 μm [SD= 0.532 μm] for the smaller) was significantly different from that of *S. saxicola* and from each other ($P<0.001$).

A linear model provided the best fit for the relationship of total otolith radius versus SL ($r^2=0.967$) (Fig. 4). A power curve was used to fit the relationship of SL and age ($r^2=0.927$)(Fig. 5). The model predicted that a fish would be 4.5 mm NL at extrusion (age=0), which is similar to what we observed.

Discussion

Sebastes saxicola have unique pigment patterns which allow them to be distinguished from other *Sebastes* spp. Of the 51 *Sebastes* spp. with published illustrations of pre-extrusion or the recently extruded larvae that occur in the study area, 10 are similar to *S. saxicola* (Morris, 1956; Moser et al., 1977; Stahl-Johnson, 1985; Matarese et al., 1989; Moreno, 1990; Wold, 1991; Sakuma and Laidig, 1995; Laroche[4]). Pre-extrusion *S. saxicola* larvae can be separated

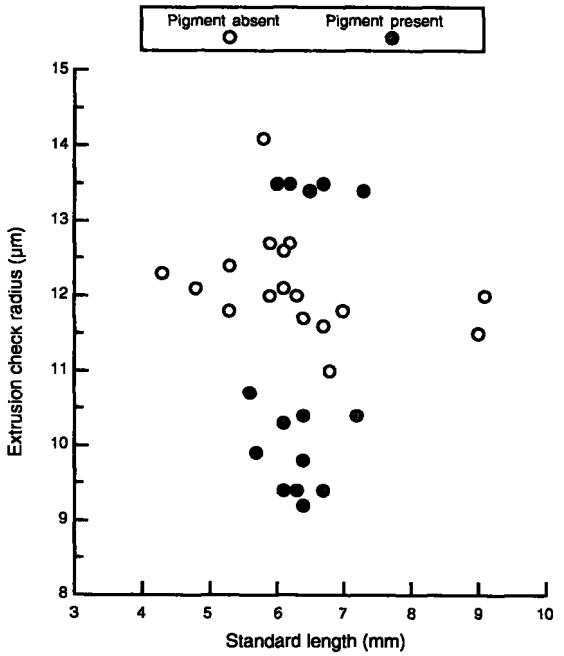

Figure 3

Comparison of extrusion check radius between stripetail rockfish, *Sebastes saxicola* (open circles), which has no axillary pectoral fin pigment, and other *Sebastes* spp. that are similarly pigmented except for the presence of axillary pectoral-fin pigment.

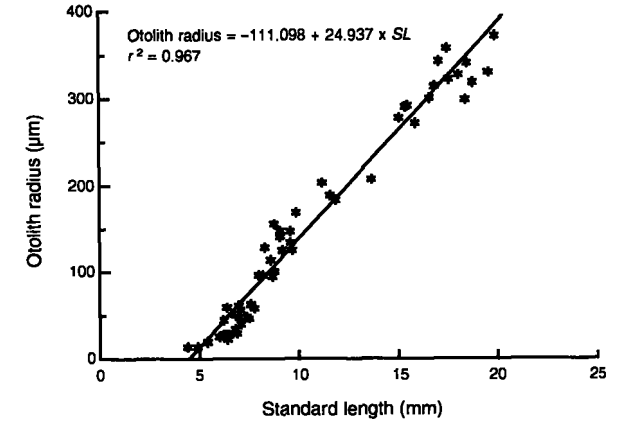

Figure 4

Plot of total otolith radius and standard length of all aged stripetail rockfish, *Sebastes saxicola* (n=58). Solid line indicates predicted values from linear model.

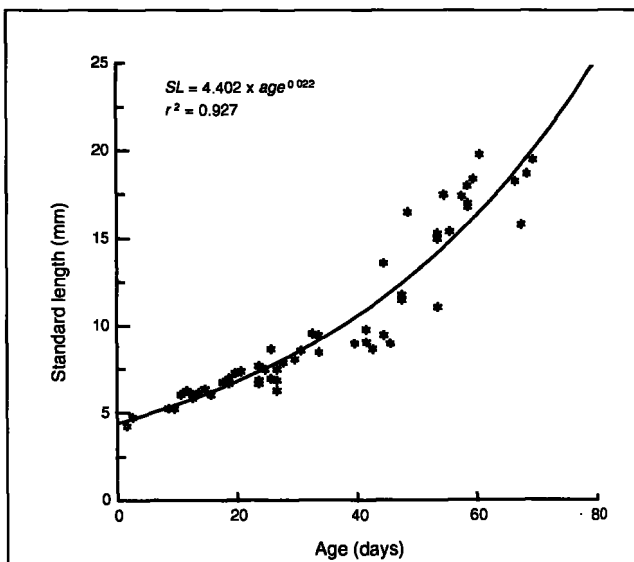

Figure 5

Plot of standard length and age of all aged stripetail rockfish, *Sebastes saxicola* (n=58). Solid line indicates predicted values from model (power curve).

from these 10 species by the extent of pigment along the ventral midline of the tail (i.e. the ventral midline pigment extends almost to the anus), the presence of the single nape pigment, and the absence of pigment on the pectoral fin and lower jaw.

As larval *S. saxicola* increase in length, they become readily distinguishable from most other *Sebastes* species. By early flexion, *S. saxicola* pigment patterns may be confused with only six other rockfish species (*S. atrovirens*, *S. carnatus*, *S. chrysomelas*, *S. maliger*, *S. rastrelliger*, and *S. semicinctus*) (Moreno, 1990; Wold, 1991). The pigment patterns of these six species are not completely described in all larval stages; thus direct comparisons with *S. saxicola* are not possible.

Sebastes saxicola can be separated from these six species on the basis of otolith characters, a technique used by Laidig and Ralston (1995). The size of the extrusion check radius for *S. saxicola* is significantly different from that for *S. atrovirens*, *S. maliger*, *S. rastrelliger*, and *S. semicinctus* (Fig. 2), as well as that for each group of larvae that had axillary pectoral-fin pigment (extrusion check radii greater than 13 µm and less than 11 µm [Fig. 3]). The extrusion check radii of the two groups with axillary pigment correspond well with the copper and gopher complexes (smaller radius) and *S. rastrelliger* (larger radius). Both *S. carnatus* and *S. chrysomelas* have axillary pectoral-fin pigment (Moreno, 1990; Wold, 1991). Thus, the presence of axillary pigment and the difference in size of the extrusion check radius could be used to separate the gopher complex from *S. saxicola*.

Sebastes saxicola can be separated from other *Sebastes* spp. greater than 10 mm SL on the basis of meristic characters and pigment patterns. The average fin ray counts of 12 dorsal rays, 7 anal rays, and 16 pectoral rays (Table 1) are similar to those reported by Moreland and Reilly (1991), who found this combination of meristic counts typical only for *S. saxicola*. The strong lines of pigment on the lateral, dorsal, and ventral midlines help to distinguish late larval *S. saxicola* from other *Sebastes* spp. As the larvae transform into juveniles, the distinctive bar pattern becomes evident (Fig. 1, E and F). In later stage juveniles, body-bars 3 and 4 become quite distinct and allow for field identification.

The growth of *S. saxicola* is similar to that of other *Sebastes* spp. occurring in the study area (Laidig et al., 1991; Woodbury and Ralston, 1991). The growth rate (as determined by the power curve model) for the first 40 days for *S. saxicola* is 0.125 mm/d, which is slightly slower than that reported for other species. Sakuma and Laidig (1995) found that *S. goodei* had a growth rate of 0.135 mm/d for the first 40 days, whereas Laidig et al. (1991) found that the growth rate of *S. jordani* in the first 20 days was approximately 0.165 mm/d. As *S. saxicola* larvae develop, their growth rate increases to 0.367 mm/d (for days 40–70). The change from slower growth to faster growth for *S. saxicola* occurs at approximately 9 mm SL (Fig. 5), which corresponds to the end of flexion. During flexion, the notochord turns up and the hypural plates form, creating the caudal fin. During this period, little growth in length is recorded, but the fish appears to grow in depth (Table 2). This period of slow apparent growth is similar to that found for *S. jordani* (Laidig et al., 1991).

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