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**Additions to Knowledge  
of *Sebastes* Larvae  
Through Recent Rearing**

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ADDITIONS TO KNOWLEDGE OF SEBASTES  
LARVAE THROUGH RECENT REARING

by

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## ABSTRACT

Partial larval developmental series of 21 species of Sebastes reared from larvae extruded from adults collected in the Northeast Pacific Ocean north of California are described. Of these, 3 were previously completely unknown, 6 are stages that were previously unknown, and 18 are compared with illustrations already published. This information should help reach the eventual goal of the ability to identify field-caught larvae of the 40 or so species of Sebastes that occur in the Northeast Pacific, north of California.

## INTRODUCTION

Despite the fact that preflexion larvae and pelagic juveniles of most species of Sebastes occurring in the Northeast Pacific have been illustrated, and complete larval series are available for several species, most larvae from plankton collections still cannot be identified beyond the generic level. Laboratory rearing of larvae extruded from pregnant females will probably be required to enable the species of field-collected larvae to be determined routinely. Rearing of Sebastes from the Northeast Pacific has proven to be very difficult, and no completely successful procedures have yet been established. Attempts at larval rearing are ongoing as opportunity permits at several locations along the Northeast Pacific coast. The present report summarizes the morphology of larvae that have resulted from some such rearings conducted north of California from 1980 through 1989, and compares the appearance of these larvae with published illustrations as available (Table 1). Some of the illustrations included here have been published elsewhere, although without detailed information on their origin or descriptions of their morphology (S. jordani, 4.6 mm SL; S. melanops, 4.0 mm SL; S. polyspinis, 6.1 mm SL in Matarese et al. 1989, S. auriculatus, 10.4 mm SL in Kendall in press). In addition to those described here, Moser and Lenarz (1987) described early larvae of S. entomelas reared by G. W. Boehlert at Newport, Oregon in March 1981.

## METHODS AND MATERIALS

Larvae described here were reared as part of one of several programs. There was little coordination among these programs, and since a standard protocol has not been established for rearing Northeast Pacific Sebastes larvae, the methods used varied considerably. Because the primary purpose of the present report is to describe reared larvae, the culture techniques will be mentioned only briefly. For more extensive information on rearing techniques used, refer to the literature cited. In all cases larvae were fixed and preserved in about 10% formalin in seawater at intervals during development. They were later examined microscopically and selected specimens were illustrated with the aid of a camera lucida. The larvae are described using the static, rather than dynamic approach (see Moser and Ahlstrom 1970, pg. 4), since each series starts at extrusion and continues for varying portions of development, and limited numbers of specimens at intervals during rearing were preserved and examined for this report. Complete larval series are not available from any of the rearing that provided the specimens described here. Since most of the larvae described here are preflexion or early flexion, standard length (SL) is the length from the tip of the upper jaw to the tip of the notochord before flexion, and to the posterior end of the hypurals thereafter. No specimens were cleared-and-stained, so fin ray counts and head spine observations may be incomplete. Beverly Vinter drew the larvae illustrated here, except for S. nigrocinctus, which was drawn by Danny Kent at the

Table 1. Sources of larval Sebastes reared north of California for descriptions, 1980-1989.

Species ( <u>Sebastes</u> )	Principal culturist	Rearing site	Dates	Source of parent	Maximum age of larvae
<u>S. aleutianus</u>	Demory/Barss	<u>Marathon</u>	26 May 1985	Trawl	11 hr
<u>S. alutus</u>	Moser	<u>Jordan/Sand Point</u>	24 Mar-15 May 1989	Trawl	52 day
<u>S. auriculatus</u>	Canino	Friday Harbor	7 Jun-8 Aug 1988	Aquarium	62 day
<u>S. aurora</u>	Demory/Barss	<u>Marathon</u>	24-26 May 1985	Trawl	34 hr
<u>S. caurinus</u>	Canino	Friday Harbor	14 Apr- 7 Jun 1988	Angling	18 day
<u>S. ciliatus</u>	Long	<u>Tomi Maru 88</u>	31 May 1988	Trawl	0 hr
<u>S. crameri</u>	Moser	<u>Jordan</u>	1-4 Mar 1989	Trawl	57 hr
<u>S. diploproa</u>	Demory/Barss	<u>Marathon</u>	21-23 May 1985	Trawl	24 hr
<u>S. elongatus</u>	Demory/Barss	<u>Marathon</u>	15-23 May 1985	Trawl	79 hr
<u>S. flavidus</u>	Moser	<u>Jordan</u>	27 Feb-14 Mar 1989	Trawl	16 day
<u>S. helvomaculatus</u>	Demory/Barss	<u>Marathon</u>	23-24 May 1985	Trawl	17 hr
<u>S. jordani</u>	Demory/Barss	<u>Marathon</u>	25-26 May 1985	Trawl	20 hr
<u>S. maliger</u>	Canino	Friday Harbor	5 Mar 1987	Trawl	1 day
<u>S. melanops</u>	Boehlert	Newport	15 Mar-22 May 1981	Angling	52 day
<u>S. melanops</u>	Boehlert	Newport	1-9 Feb 1984	Angling	6 day
<u>S. mystinus</u>	Boehlert	Newport	1-9 Feb 1984	Angling	9 day
<u>S. nebulosus</u>	Canino	Friday Harbor	4 May-7 Jun 1988	Aquarium	34 day
<u>S. nigrocinctus</u>	Marliave	Vancouver Aquarium	18 May 1989	Aquarium	?
<u>S. polyspinis</u>	Rose	<u>Poseydon</u>	Jul 1985	Trawl	0 hr
<u>S. proriger</u>	Demory/Barss	<u>Marathon</u>	15-18 May 1985	Trawl	78 hr
<u>S. ruberrimus</u>	Canino	Friday Harbor	7 Jun-2 Jul 1988	Aquarium	30 day
<u>S. zacentrus</u>	Demory/Barss	<u>Marathon</u>	15-24 May 1985	Trawl	5 hr

Vancouver Public Aquarium.

Boehlert and Yoklavich (1982) held hook-and-line caught pregnant adult S. melanops in laboratory tanks where one released viable larvae after about 5 weeks. A few larvae survived through 52 days on an initial diet of rotifers which was later supplemented with brine shrimp nauplii. In subsequent years Boehlert and Yoklavich obtained and cultured larvae of S. melanops and S. mystinus in the same way, although none survived more than a few days.

In spring 1985, larvae were extruded from pregnant females of S. elongatus, S. progriger, S. zacentrus, S. diploproa, S. helvomaculatus, S. aurora, S. jordani, and S. aleutianus obtained during a resource assessment cruise off Washington and Oregon aboard the FV Marathon by members of NWAFC RACE Division, Groundfish Task and Robert Demory and William Barss from the Oregon Department of Fish and Wildlife. These larvae were maintained in seawater and preserved at intervals until the larvae died, after only a day or two.

In July 1985, larvae were extruded from a pregnant female of S. polyspinis aboard the Soviet research vessel Poseydon during a groundfish survey of the northeastern Gulf of Alaska. The larvae were preserved immediately by Craig Rose (NWAFC).

In spring 1987, Michael Canino attempted to rear larvae of S. caurinus and S. maliger at University of Washington Laboratories at Friday Harbor, Washington. Larvae were extruded from pregnant females collected by trawl or angling in the San Juan Islands and



were held in the laboratory for a few days until severe mortality occurred.

In spring 1988, Michael Canino conducted more extensive rearing trials at Friday Harbor using several species of Sebastes (S. caurinus, S. nebulosus, S. ruberrimus, and S. auriculatus). Pregnant females were collected locally by fishermen, or were obtained at the Seattle Aquarium (Canino and Francis 1989). Extruded larvae were maintained at about 10 C in cylindrical black 20 or 100 l plastic tanks with low illumination and fed mixtures of Brachionus, and wild zooplankton. Larvae were reared for 18-62 days. S. auriculatus larvae had completed flexion, and some were released into the wild at the end of the experiments.

On 31 May 1988, Jim Long (then with NWAFC) extruded larvae from a pregnant female S. ciliatus collected during a groundfish assessment cruise in the Bering Sea aboard the Japanese research vessel Tomi Maru. The larvae were preserved immediately.

In May 1988 and 1989, Dr. Jeff Marliave reared S. nigrocinctus larvae for a few days at the Vancouver Public Aquarium. The larvae were extruded from pregnant females collected in the area by aquarium suppliers. The larvae were held at 10 C without food and survived for 15 days in 1988 and were preserved after 1 day in 1989.

In February-March 1989, larvae were extruded from pregnant females of S. crameri, S. flavidus, and S. alutus collected off the Oregon coast during a research cruise aboard the NOAA ship David Starr Jordan and maintained aboard ship in static seawater in liter jars in the dark in a refrigerator at about 10 C. Some

of the S. flavidus were also held in the light in a water bath at about 10 C in a 4-liter white plastic jar in static seawater with Brachionus added for food. Larvae of S. alutus were later transferred to rearing facilities at the NWAFC in Seattle where they were held at 6 C in static culture in black 40 1 cylindrical tanks at low levels of illumination (14 hr light/ 10 hr dark). The larvae were offered a diet of Brachionus, brine shrimp nauplii, and sieved wild zooplankton and some survived for up to 52 days. Heaviest mortality seemed to occur at certain times: at yolk sac absorption, and starting after about 24 days, at which time histological examination revealed necrosis of liver and kidney tissue indicative of a toxic reaction or inadequate diet (Frank Morado, NWAFC Pathology Task, personal communication, June 1989).



## RESULTS

Sebastes aleutianus: Well developed embryos at a pre-hatch stage of development were extruded from a female rougheye rockfish collected off the Oregon coast in 1985. The embryos were maintained for 11 hr in culture. These larvae are quite similar in appearance to illustrations of preflexion larvae of this species by Westrheim et al. (1968).

Sebastes alutus: Pacific ocean perch larvae extruded from females collected off Oregon in March 1989 were reared aboard ship and some were then transferred to NWAFC in Seattle where they were maintained for 52 days. Larvae were extruded from a total of four females. The larvae from the first two females were maintained aboard ship for 10 and 11 days, at which time the temperature in the rearing bath exceeded 13 C and all of the larvae died. The other two females were collected on the same tow and their larvae were not reared separately after reaching Seattle. Larvae from three of the four had not yet hatched; those from the other female were more advanced, but still may have been premature.

The larvae had all hatched after 3 days, were about 6.2 mm SL live (5.3 mm SL preserved), the yolk was 0.7 mm in diameter, and the oil globule was 0.3 mm in diameter. The oil globule is in the antero-ventral part of the yolk sac. There are about 14 melanophores in the postanal ventral midline series, which extends from the 4th to the 17th postanal myomeres. The only other pigment is the gut shield which covers the dorsal and lateral aspects of

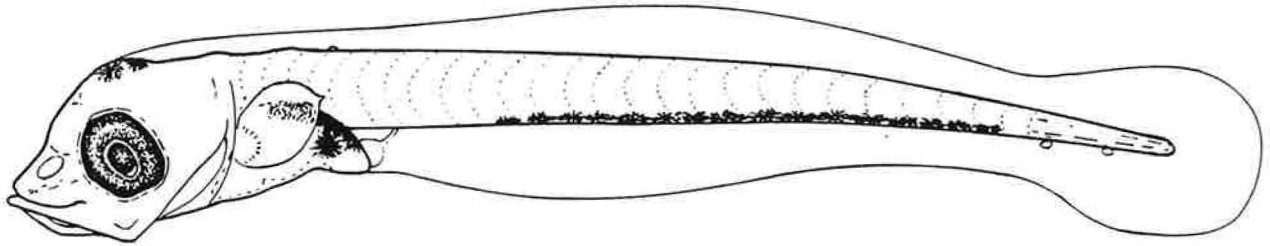


Figure 1. Preflexion larva of Sebastes alutus, 6.4 mm SL, 38 days old, extruded from an adult collected 24 March 1989, off the coast of Oregon, reared by H.G. Moser and A.W. Kendall, Jr.



the hindgut region and adjacent yolk sac. Among the three published illustrations of S. alutus preflexion larvae, the pigment pattern shown by Efremenko and Lisovenko (1970) most closely resembles that on the larvae described here. DeLacy et al. (1964) show heavy pigment along the posterior half of the dorsal part of the gut cavity, but no pigment on the posterior aspect of the hindgut. Westrheim et al. (1968) show a few distinct melanophores on the hindgut, but no other gut pigment. This pigment extends onto the yolk sac in the larvae described here.

By 7 days, the larvae were 6.4 mm SL live (5.7-5.9 mm SL preserved), the yolk sac was 0.4-0.5 mm in diameter, and the oil globule was 0.3 mm in diameter. There are about 15 melanophores in the postanal ventral midline series, extending from postanal myomere 4 to postanal myomere 18. The gut pigment is still confined mainly to the dorsal and lateral parts of the hindgut. The midgut is coiling to the left, and its dorsal region has a few large dendritic melanophores which come to lie on the left side of the larvae as the gut coils.

On day 10-11 the larvae from the first two females died. The larvae were preserved and their pigment and state of development examined, but measurements are not reliable. The postanal ventral midline melanophores of some of the dead larvae are contracted and easy to count. There are 25-30 melanophores in this series which originates about three myomeres posterior to the anus and terminates about two myomeres anterior to the last myomere. The larvae preserved live are 5.9 mm SL preserved. The yolk sac is about half its size at extrusion and the oil globule is still

prevalent. The midgut continues to coil to the left making gut pigment asymmetrical. There is a melanophore in the region of the swim bladder on some larvae.

By day 14 the larvae were feeding and food is present in the guts of the preserved larvae, although the yolk and oil globule are still present. They are 6.0 mm SL preserved. Pigment has changed little, except on one of the four preserved larvae there are two melanophores in the dorsal midline near the posterior end of the ventral midline series.

On day 17 the yolk and oil globule are noticeably smaller, and the larvae are 6.1 mm SL preserved. On four of the five preserved larvae there are a few large melanophores on the crown of the head. All of the larvae now have a melanophore in the region of the swim bladder. None of these larvae has dorsal trunk pigment. The gut pigment is more symmetrical now with a large melanophore added to the right lateral surface of the gut cavity in the region of the midgut.

On day 21 the larvae are 6.4 mm SL preserved, with little or no yolk or oil globule left. All of the six preserved larvae have pigment on the crown of their heads. Two of the six have dorsal midline melanophores over the posterior end of the ventral series. Pigment is present anterior to the melanophore in the region of the swim bladder, in the antero-dorsal margin of the gut cavity. There is nape pigment on three of the six preserved larvae.

By day 24 significant mortality began, so sampling frequency was reduced to attempt to allow some larvae to survive as long as possible in culture. On day 27 some of the larvae residing near

the bottom of the tank were preserved in ethanol primarily for otolith examination. These are dehydrated, but their pigment patterns are still valid. Besides the pigment noted earlier, 7 of the 12 preserved larvae have pigment on the tip of their lower jaw. Three of these larvae have dorsal midline pigment opposing the posterior end of the ventral midline series. Nape pigment is present on only two of these larvae.

On day 38, nine larvae were collected from near the tank bottom and preserved. They appear emaciated, are 6.4 mm SL preserved and are still at a preflexion stage of development (Figure 1). Two of the nine larvae have dorsal midline pigment, three have lower jaw pigment, and six have nape pigment. The hindgut pigment seems to have expanded laterally somewhat.

The last larvae died on day 51, but were not preserved until day 53, so they are disintegrated and can only be used for limited observations of pigment patterns, which have not changed substantially since day 38. The gut pigment may have expanded laterally beyond its extent earlier. Nape pigment is seen on most of the specimens, but lower jaw and dorsal midline pigment is not evident.

Sebastes auriculatus: Brown rockfish were reared at Friday Harbor through metamorphosis (62 days) in 1988. Larvae were preserved at 3-5 day intervals through day 35, and then at day 62. The larvae grew from 5.5 mm live total length (5.3-5.6 mm SL preserved) at day 0 to 13.9 mm (10.4 mm SL preserved) at day 62. The day 62 larvae were illustrated (Figure 2). Throughout

development the larvae are quite similar in appearance to those reared and illustrated by Stahl-Johnson (1985). The 62-day larvae are larger and more advanced than any cultured by Stahl-Johnson (1985).

At extrusion the larvae have pigment on the tip of the upper jaw, and pigment all along the lower jaw including the angular. Several large melanophores are on the crown of the head and are continuous with similar spots on the nape. There is a gap in the dorsal midline series over the gut region, with the dorsal series forming a continuous line starting variously within three myomeres anterior or posterior to the anus. There are about 15 melanophores in the dorsal series, which is most intense posteriorly where the melanophores are larger. The postanal ventral midline series of melanophores originates at the hindgut and terminates concurrently with the dorsal series on about the second-to-last myomere. There are one or two lateral melanophores near the posterior end of the dorsal and ventral series on some of the larvae. The dorsal and posterior aspects of the gut cavity are heavily pigmented, and there are large melanophores ventrally on the yolk sac as well. Laterally the yolk sac is unpigmented. There is a spot just anterior to the anus. The most distinctive feature in comparing these larvae with those of S. caurinus examined here is the presence of pigment along the lower jaw in S. auriculatus; only the tip of the lower jaw is pigmented in S. caurinus examined here. Stahl-Johnson (1985) noted differences in the number of preanal dorsal melanophores between these species, but with the larvae examined here, individual variation seemed to be as great as

between species differences.

No substantial changes in development or pigment were noted in 3-day larvae. At 7 days the larvae are 5.8-6.1 mm SL preserved and much of the yolk has been used. Pigment has been added to the lower jaw, and there is lateral trunk pigment on all of the larvae examined, including melanophores internally in a series along the dorsal surface of the notochord near the posterior ends of the dorsal and ventral series in some specimens. One of five specimens has a preanal dorsal midline melanophore, besides the one on the nape.

By day 10 the larvae are 6.1-6.5 mm SL preserved and some pigment is present on the lateral surface of the gut cavity, but an unpigmented area still exists there.

Larvae held at two light regimes were preserved on day 7 and day 10, to see if light level influenced pigment development. No differences in pigment related to light level were seen in these larvae. Larvae were maintained in the dark regime only after day 10.

At day 15 the larvae have not grown in length beyond the day 10 larvae. The pigment pattern has changed little, but the pigment is more intense than previously. There is still a gap in the preanal region between the nape pigment and the rest of the dorsal midline series. There is more lateral gut pigment, but it still does not cover the entire lateral aspect of the gut. There is a slight thickening of the finfold tissue where the caudal fin will form.

There is considerable variation in size and stage of



development among the larvae preserved at day 20. In preserved SL they range from 6.2 to 7.5 mm. The smallest specimens are not different from the 10 and 15 day larvae, but in the largest specimen there is evidence of about nine principal caudal fin rays, although the notochord is still straight. The pterotic and second and third posterior preopercular spines are present on the largest specimen. No appreciable changes in pigment were seen.

The larvae at day 25 were the same size and appearance as the larger larvae on day 20.

The larvae preserved at day 30 were 6.6-7.8 mm SL preserved and varied from preflexion to mid flexion in stage of development. The largest larva observed here is similar in stage of development to the 7.4 mm, 18-day larva illustrated by Stahl-Johnson (1985), however, those seen here lack the opercular pigment, and do not have as much preanal dorsal midline pigment or lateral trunk pigment as shown on that illustration. The parietal spines are barely visible.

The larvae at 35 days are not much larger than those at day 30 (7.0-7.8 mm SL preserved), and have not changed much in development. These larvae are not as advanced as the 9.0 mm, 24-day larva illustrated by Stahl-Johnson (1985). Some preanal dorsal pigment is present in all three of the larvae available. It is most prevalent just posterior to the nape pigment, still leaving a gap between this pigment and the postanal dorsal midline pigment. The preanal pigment is not located in the dorsal septum, but is just to either side of it. The large pigmented patch on the opercular region of the 7.4-mm larva illustrated by Stahl-Johnson

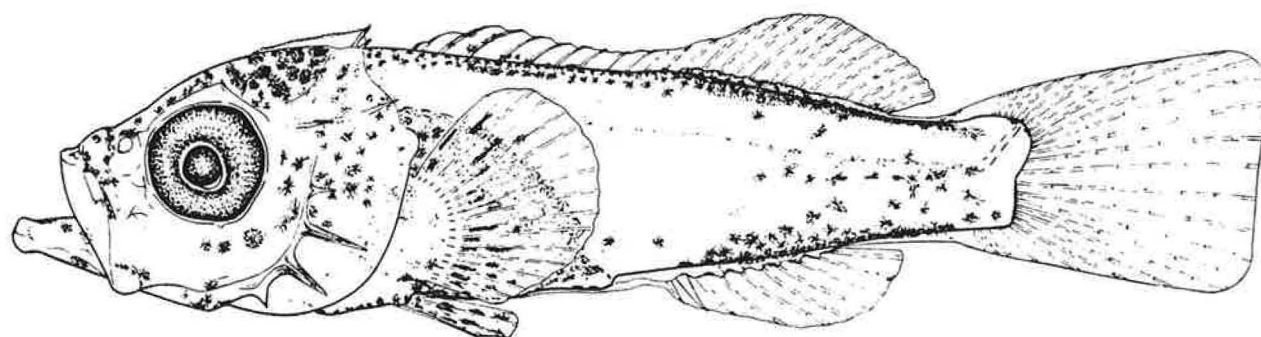


Figure 2. Late flexion larva of Sebastes auriculatus, 10.4 mm SL, 62 days old, extruded 7 June 1988, from an adult held at the Seattle Aquarium and reared at Friday Harbor, Washington by Michael Canino.

(1985) is not present on any of these larvae, nor is there a melanophore at the base of the caudal fin.

At day 62 the three preserved larvae had grown to 9.7, 10.4 and 12.0 mm SL preserved. The 10.4 mm specimen was illustrated (Figure 2). All three specimens are at a postflexion stage of development and the larger two have full complements of median fin rays (the last spines are still soft rays). The head spine complements are nearly complete, but the coronal and preocular spine are not visible. The parietal spines are at the end of long serrate ridges, and the nuchal spines are considerably smaller than the parietals and pointed more posteriorly. The third and fourth posterior preopercular spines are massive and pigmented, but not elongate or serrate. The pigment pattern has changed from that seen earlier, but these remain heavily pigmented. The upper and lower jaws are pigmented, as is the top of the head and the opercular region. The intense area of pigment just anterior to the opercle shown on the 9.0 mm larva by Stahl-Johnson (1985) was not evident in the larvae examined here. Internally there is pigment along the spinal nerve that is particularly heavy just posterior to the head and near the posterior end of the spinal column. The gut area is entirely covered with melanophores. The dorsal and ventral body margins are covered with melanophores, except ventrally in the area between the anus and the origin of the anal fin where there is a series of melanophores somewhat removed from the body margin. The body margin melanophores extend onto the pterygiophores, particularly of the second dorsal fin. There is some pigment in the dorsal fin membrane also. There is some

lateral body pigment on the postanal trunk and the caudal peduncle. The rays of the pectoral and pelvic fins are heavily pigmented. The hypural margins are variously pigmented.

Sebastes aurora: Aurora rockfish were extruded from adults collected off the Oregon coast in 1985. The embryos were at a pre-hatch stage of development and may have been dead when they were preserved. They were maintained for 34 hr in culture. The embryos already possess the unusual postanal band of pigment illustrated in preflexion larvae of this species (Moser et al. 1985).

Sebastes caurinus: Copper rockfish were reared at Friday Harbor with limited success in 1987 and 1988. In 1987 one batch of larvae survived for 10 days, the other for 16 days. In 1988 one batch survived for 14 days, the other for 18 days. The larvae from the 18-day batch in 1988 grew from 6.3 mm live total length (5.3-5.6 mm SL preserved) at day 0 to 8.0 mm (6.7-6.9 mm SL preserved) at day 18. Larvae from the other batches did not show appreciable growth, and were quite emmaciated in later samples. All of these larvae are similar in appearance to the extrusion and preflexion larvae of this species illustrated by Stahl-Johnson (1985). Most of the extrusion larvae examined here do not have lower jaw pigment or pigment on top of the head. There is a melanophore on the nape in almost all individuals, but dorsal midline pigment on the rest of the preanal myomeres is variably present. There is more pigment in this area on larvae of one female than another female, indicating that this trait is variable

within the species, and is passed to the larvae from the parents. There are a variable number of postanal dorsal midline melanophores, from about 10 to 20. Stahl-Johnson (1985) noted 18-32 dorsal midline melanophores, with the first one occurring on myomere one to eight on larvae less than 24 hr old. The postanal ventral midline melanophores are larger and form a more continuous row than the dorsal series. The ventral series terminates about one myomere posterior to the termination of the dorsal series. The melanophores in these series are centered in the dorsal and ventral septa. The dorsal and posterior aspects of the gut cavity are heavily pigmented, and there is one melanophore just anterior to the anus. The gut is heavily pigmented along its ventral midline.

At 10-12 days the pigment pattern has changed little. There is still considerable individual variation in the number of preanal dorsal midline melanophores, but there is generally a gap between the melanophore on the nape and the next melanophore in the dorsal midline series.

At 14-18 days the nuclei of the melanophores in the dorsal and ventral midline series are not as rigidly confined to the septa as they were previously. The dorsal aspect of the gut cavity is even more heavily pigmented than previously, but there is still a gap in most specimens between the melanophore on the nape and the next melanophore in the dorsal midline series. There is some thickening in the finfold where the caudal fin will form in the 18-day larvae, but they are still in the preflexion stage of development. A pigment spot has been added to the angular in these larvae.



Sebastes ciliatus: Dusky rockfish larvae were extruded from a pregnant female collected during a groundfish assessment cruise aboard the Japanese research vessel Tomi Maru on 31 May 1988, and preserved immediately. The larvae were in an advanced state of embryonic development at extrusion, but had not yet hatched, although a few hatched prematurely at extrusion. Those that hatched are about 5.5 mm SL preserved. The yolk sac is about 0.7 mm diameter, and the oil globule is situated anteroventrally in it. The eyes are densely pigmented and the mouth is open. Gut pigment consists of a few discrete melanophores arranged in an almost linear fashion along the sides and posterior area of the hindgut. The postanal ventral midline series of melanophores is quite long, consisting of about 25-30 individual melanophores, and extending from about 3 myomeres posterior to the anus to about 20-22 myomeres posterior to the anus. On some larvae this series is nearly continuous with one or two melanophores in the area where the base of the caudal fin will develop, other specimens lack melanophores in this area. These larvae are similar to the preflexion larvae of this species illustrated by Harling et al. (1971), except they showed a series of two melanophores dorsally near the end of the notochord, which is not present on any of the specimens examined here.

Sebastes crameri: Darkblotched rockfish larvae were extruded from a female collected during a groundfish assessment cruise aboard the David Starr Jordan off the Oregon coast on 1 March 1989,

and maintained alive for 60 hr aboard ship. Samples of the larvae were preserved at 0, 36, and 60 hr. Upon extrusion the larvae had not yet hatched, but were in an advanced state of embryonic development, and some hatched as they were extruded. They were about 4.1 mm SL preserved at extrusion, and did not change in length or appearance during the 60 hr they were maintained. The yolk sac is large, about 0.7 mm diameter with a large oil globule situated in the anteroventral portion of the yolk sac. The eyes are pigmented and the mouth open. Gut pigment consists of a heavy covering of the hindgut area with melanophores that are in various states of contraction among individuals. Some pigment extends onto the yolk sac adjacent to the hindgut. There is a rather short row of about 8-12 postanal ventral midline melanophores that extends from about 4 myomeres posterior to the anus to about 15 myomeres posterior to the anus. Melanophores in the area of the future base of the caudal fin range from zero to three. These larvae are very similar to, but not quite as advanced as, the preflexion larvae of this species illustrated by Westrheim et al. (1968).

Sebastes diploproa: Splitnose rockfish were extruded from adults collected off Oregon in 1985. The embryos from one female are well advanced and appear more similar to the preflexion larvae of this species illustrated by Westrheim et al. (1968) than to those illustrated by DeLacy et al. (1964). These larvae were maintained for 24 hr in culture.

Sebastes elongatus: Greenstriped rockfish were extruded from adults collected off Oregon in 1985. The embryos were all at a late pre-hatch stage of development and were maintained for 79 hr in culture. Although these embryos were not yet ready to be extruded naturally, their pigment patterns match closely illustrations of preflexion larvae of this species in the literature (Westrheim et al. 1968, Moser et al. 1977).

Sebastes flavidus: Yellowtail rockfish larvae were extruded from a female collected off the Oregon coast on 27 February 1989, and reared aboard ship for 16 days, until yolk exhaustion. No evidence of feeding was observed. Extrusion larvae of S. flavidus have been illustrated previously (DeLacy et al. 1964), and those reported here are quite similar. At extrusion only some of the larvae hatched immediately; some of those preserved were still within the chorion. The larvae were 3.9 mm SL preserved at extrusion, and the yolk fills most of the body cavity with the oil globule is located in the forward part of the gut cavity. The mouth is open and the eyes are heavily pigmented. There are about 10 postanal ventral midline melanophores and one in the area where the caudal fin will form. Rather heavy pigment covers the dorsal and posterior aspect of the gut wall, and there are a few spots ventrally along the midline of the gut cavity. One melanophore is generally in the area between the anterior part of the hindgut and the posterior part of the yolk sac.

By an age of 3 days, the ventral gut pigment is more extensive with about four highly dendritic melanophores covering

the ventral aspect of the gut, and there are one or two melanophores in the area where the caudal fin will form. There are 11 melanophores in the postanal ventral midline series. The 3-day larvae look quite similar to the larvae of this species illustrated by DeLacy et al. (1964).

Virtually no change in appearance of the larvae was noted through day 12 (Figure 3), except that the yolk volume gradually decreased.

By day 14 the larvae were noticeably emmaciated and little yolk remained; the last surviving larva was preserved on day 16.

Sebastes helvomaculatus: Rosethorn rockfish were extruded from adults collected off the Oregon coast in 1985. The embryos were well advanced and may have hatched before they were extruded. They were maintained for 17 hr in culture. They are similar in appearance to published illustrations of preflexion larvae of this species (Westrheim et al. 1968).

Sebastes jordani: Shortbelly rockfish were extruded from adults collected off the Oregon coast in 1985. The embryos were at a pre-hatch stage of development and were maintained for 20 hr in culture. The embryos were 4.6 mm SL (Figure 4) and appear similar to published illustrations of slightly more advanced preflexion larvae (Moser et al. 1977). The yolk sac is large, about 0.8 mm diameter, and the oil globule is situated ventrally. There is a small melanophore on the nape. The hindgut is densely covered with melanophores on its posterior surface, and these

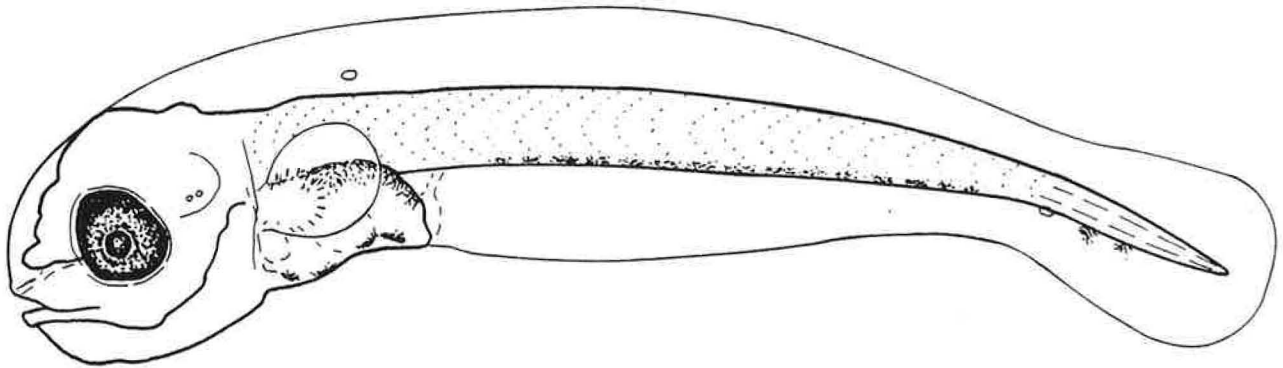


Figure 3. Preflexion larva of Sebastes flavidus, 4.6 mm SL, 12 days old, extruded from an adult collected 27 February 1989, off the coast of Oregon, reared by H.G. Moser and A.W. Kendall, Jr.

extend forward along the dorsal margin of the gut cavity in the region of the swim bladder. There is a postanal dorsal ventral midline series of melanophores, with some melanophores extending into the myosepta between the dorsal and ventral rows. The ventral series is longer than the dorsal series; it is composed of about 12 melanophores forming a continuous line reaching from about 4 myomeres posterior to the anus to about 15 myomeres posterior to the anus. The dorsal series starts about 8 myomeres posterior to the anus and extends as far posterior as the dorsal series. There appear to be about 20 melanophores in the dorsal series, but the nuclei of many of these melanophores are lateral to the dorsal midline.

Sebastes maliger: Quillback rockfish were obtained from a pregnant female collected by trawl near Friday Harbor in March 1987. The larvae were preserved after about 1 day. The larvae appear to be near full term. They are 5.4 mm SL preserved (6.2 mm total length live). Pigment is quite similar to the illustrations of the species in the literature (DeLacy et al. 1964, Westrheim et al. 1968), however the pigment on these specimens was faded by the time they were observed in detail, so some may have been overlooked. There is little or no pigment on the head. There is a prominent melanophore on the nape at about the level of the cleithrum, further posterior than the nape pigment on other species. Dorsal midline melanophores are present and are closer together posteriorly than anteriorly. The first one is at about the level of the anus and there is a considerable gap between it

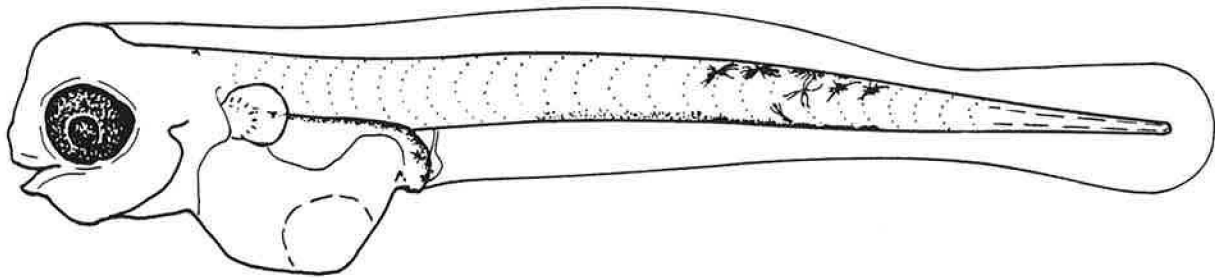


Figure 4. Preflexion larva of Sebastes jordani, 4.6 mm SL, extruded from an adult collected 25 May 1985, off the coast of Oregon and maintained aboard ship for 20 hr. Illustration from Matarese et al. 1989.

and the next melanophore in the dorsal series. Toward the end of the series there is about one melanophore per myomere. There are about 12-15 melanophores in this series. There are a few spots scattered ventrally on the gut, not alined in a series. Pigment on the posteriodorsal aspect of the gut cavity is continuous with the postanal ventral midline series of melanpophores. There is also pigment on the poserior aspect of the hindgut. The melanophores in the postanal ventral midline series are situated in the septum and too close together to count accurately. The series reaches posterior to the second or third from last myomere, slightly further than the dorsal series.

Sebastes melanops: Black rockfish were obtained from pregnant females collected by angling near Newport, Oregon in 1981 and 1984 and held in the laboratory where larvae were released spontaneously. Larvae were maintained for 68 days in 1981, and one grew to a late flexion stage of development. In 1984 the larvae were not fed and were maintained for only 6 days. By the time the larvae were examined in detail (August 1989), the pigment had faded considerably. The larvae are 3.8 mm SL preserved at extrusion (Figure 5). Pigment at extrusion consists of dorsolateral gut pigment, a postanal ventral midline series of melanophores that is most intense posteriorly, and one or two melanophores near the base of the future caudal fin. One of these melanophores is at the base of the notochord and the other is in the finfold. By the fourth day after extrusion, pigment covers the gut cavity, with some of the pigment extending onto the body adjacent to the gut. Pigment



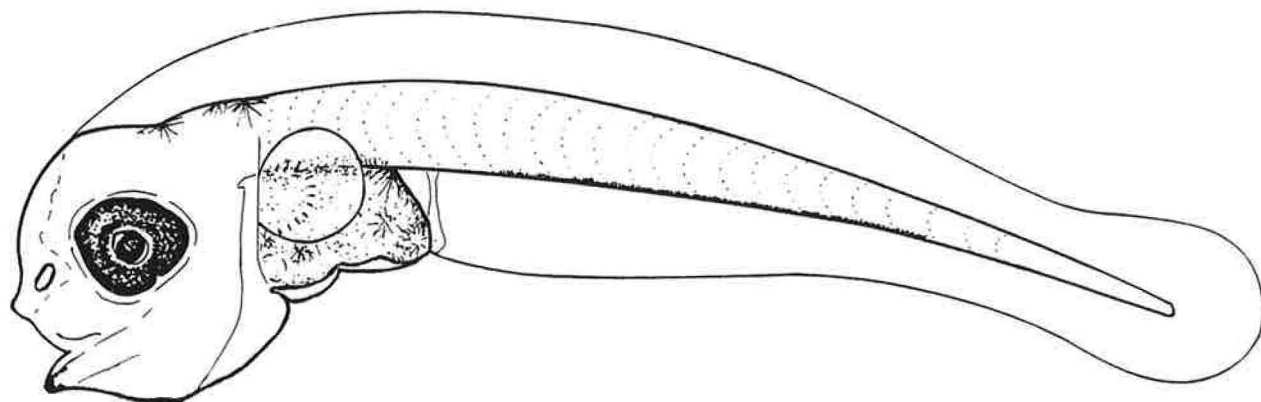


Figure 5. Preflexion larva of Sebastes melanops, 4.0 mm SL, 6 days old, extruded 1 February 1984, from an adult collected off Oregon and reared at Newport, Oregon by G.W. Boehlert and M. M. Yoklavich. Illustration from Matarese et al. 1989.

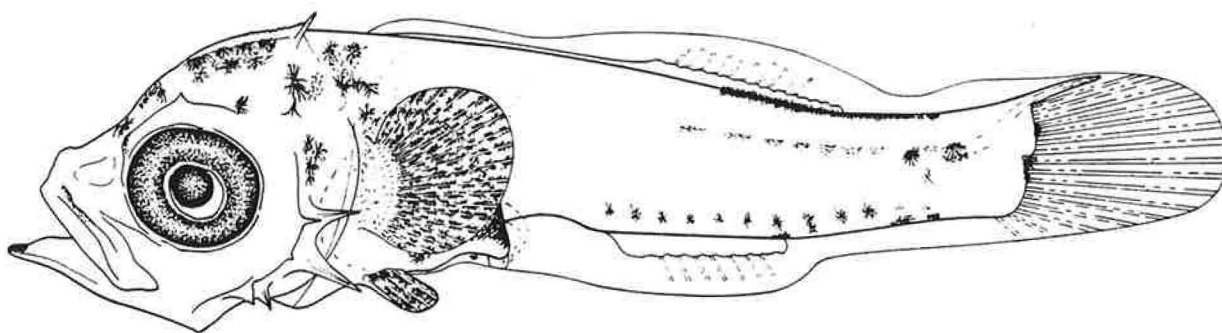


Figure 6. Late flexion larva of Sebastes melanops, 7.7 mm SL, 68 days old, extruded from an adult collected 8 February 1981, off Oregon and reared at Newport, Oregon by G.W. Boehlert and M.M. Yoklavich.

is forming on the nape and middorsally on the optic lobes of the brain. There is also some pigment at the tip of the lower jaw. The postanal ventral midline series starts about six myomeres posterior to the anus, and tends to be broken into two areas, with pigment in the posterior area more intense. The anterior melanophores are closer together, forming a continuous line, but the posterior melanophores are larger with some space between them.

By 19 days at 16 C the larvae are 4.3 mm SL preserved, and are considerably deeper bodied than early extrusion larvae. The finfold is thickening in the area where the caudal fin will form. Pigment is present and generally heavier in the areas mentioned previously. Several melanophores line the lower jaw. The top of the head is rather heavily pigmented and this extends posteriorly onto the nape where there is usually a large embedded midline melanophore as well as other pigment in the area. There are several superficial melanophores on the gut wall and there is also internal pigment in the gut area. There is still about a six myomere gap between the anus and the beginning of the postanal ventral midline series of melanophores. There are about nine melanophores in the postanal ventral midline series, and the melanophores are closer together in the posterior region of the series. There is a dorsal midline melanophore opposing the last ventral melanophore in some of the specimens. There is a melanophore in the area where the caudal fin is beginning to form. The medial and proximal base and the blade of the pectoral fin are heavily pigmented.

At 31 days the larvae reared at 10 C are 4.7-5.7 mm SL

preserved. The pterotic and second and third posterior preopercular spines are present in the larger two specimens. Little change in pigment was noted except that a series of about eight small melanophores is present dorsally in the musculature posteriorly in the trunk dorsal to the posterior end of the ventral midline series. Ray formation seems to have begun in the caudal fin.

At 68 days the last surviving larva was 7.7 mm SL preserved and at a late flexion stage of development (Figure 6). Evidence of the development of about 4 dorsal spines, 10 dorsal soft rays and 7 anal rays is seen. There are seven dorsal and seven ventral principal caudal rays; two secondary caudal rays are evident. The pelvic spine and all five rays are present. About 18 pectoral rays are present. The parietal spines are prominent, the central three anterior and posterior preopercular spines are present, the supraocular spines are present, and the pterotic spines are visible. Pigment includes melanophores on the lower jaw, covering the crown of the head, on the nape and upper opercular area, and covering the gut cavity. The pectoral and pelvic fins are heavily pigmented. There is a series of seven melanophores in the musculature internal to the base of the anal fin. There are five melanophores along the ventral midline of the caudal peduncle that extend into the body. Dorsally there is a continuous line of pigment along the midline from the posterior two-thirds of the second dorsal fin to the midpoint of the caudal peduncle. There are melanophores internal in this area along the dorsal part of the spinal column. There are melanophores along the posterior ends of

the hypurals in the center of the caudal fin. This pigment pattern is quite similar to that shown for a 10.6 mm SL postflexion larva by Laroche and Richardson (1980).

Sebastes mystinus: Blue rockfish were obtained from pregnant females collected by angling in February 1984 near Newport, Oregon and held in the laboratory where larvae were released spontaneously. Larvae were held without food and survived for 9 days. The larvae were 3.8 mm SL preserved at extrusion, and have a large yolk sac and oil globule. They appear to have been extruded somewhat prematurely, although the eyes are pigmented and the mouth is open. The gut pigment is mainly in the region of the hindgut. The postanal ventral midline series of melanophores is short, starting about 6 myomeres posterior to the anus and ending before the caudal peduncle. The preflexion S. mystinus larva presented in Matarese et al. (1989) that was reared at Moss Landing Marine Laboratory, California is at a slightly more advanced stage of development than the extrusion larvae observed here.

By day 6 the larvae are 3.9 mm SL preserved, gut pigment has extended anteriorly to cover most of the ventral surface of the yolk sac up to the oil globule, and nearly all of the larvae have pigment on the tip of the lower jaw. The postanal ventral midline series of melanophores forms a continuous line starting at the third myomere posterior to the anus and ending near the last myomere. The gut is coiling on the left side of the yolk sac.

On day 9, the larvae are 4.4 mm SL preserved, and have used up most of the yolk, although the oil globule is still present.

Pigment is as on the 6-day larvae, except the dorsal gut pigment extends forward to cover the posterior two-thirds of the gut cavity, there is nape pigment on some, and some pigment interior in the otic region ventrally on the midline in the region of the hindbrain. Also the tips of the pectoral fin blades are pigmented.

Sebastes nebulosus: China rockfish larvae extruded from females held at the Seattle Aquarium were reared for 34 days at Friday Harbor. Larvae of S. nebulosus were previously unknown. The larvae grew from a live total length of 5.9 mm on day 0 to 7.9 mm on day 34. A lateral and a ventral view of an 11 day, 5.7 mm SL preserved larva, which is at the yolk exhaustion stage, is shown here (Figure 7). The larvae are quite heavily pigmented, in comparison to most other Sebastes larvae. There is pigment on the lower jaw, on top of the head and laterally in the area of the ear, on the dorsal midline at the posterior of the head and from about myomere 5 to myomere 23, and on the postanal ventral midline from the anus to the third from last myomere. There is also pigment on the dorsal, posterior, ventral, and anterior part of the gut. The pigment over the hindgut is particularly intense.

By an age of 32 days the larvae had reached 7.15 mm live total length (7.0 mm SL preserved) and the notochord was beginning to flex (Figure 8). There are five fin rays in the dorsal and in the ventral part of the caudal fin. The pterotic spines and third posterior preopercular spines are present. The larvae continue to be heavily pigmented. Besides the tip of the lower jaw, the mandible has some pigment, and the area of the angular is

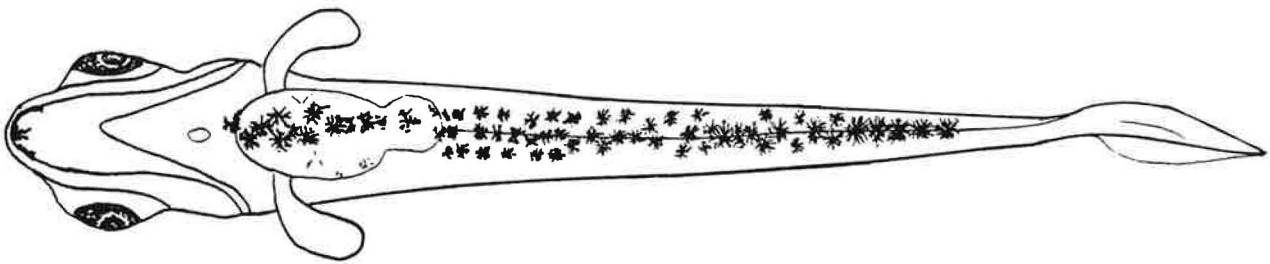
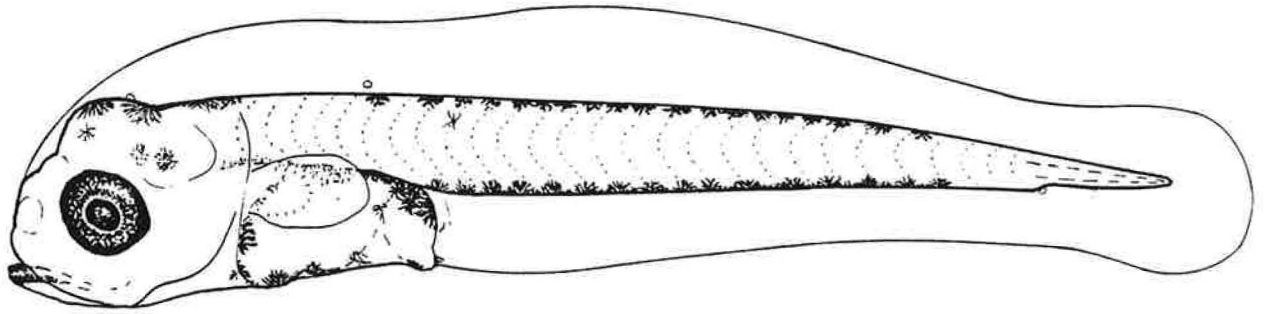


Figure 7. Preflexion larva of Sebastes nebulosus, 5.7 mm SL, 11 days old, extruded 4 May 1988, from an adult held at the Seattle Aquarium and reared at Friday Harbor, Washington by Michael Canino. Upper: lateral view; lower ventral view.

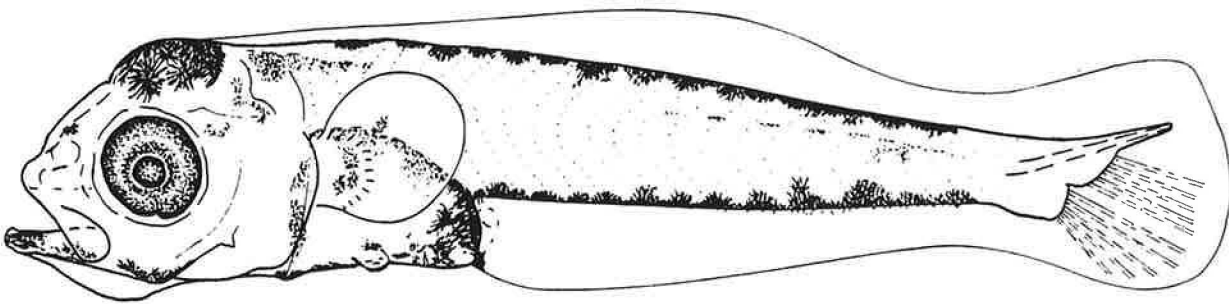


Figure 8. Flexion larva of Sebastes nebulosus, 7.0 mm SL, 32 days old, extruded 4 May 1988, from an adult held at the Seattle Aquarium and reared at Friday Harbor, Washington by Michael Canino.

pigmented. There is a medial spot on the snout just posterior to the nares, and the top of the head is covered with melanophores. There is a double row of internal pigment along the nape in the area of the first three or four myomeres. The posterior end of this pigment overlaps the beginning of the dorsal midline pigment by one or two myomeres. The dorsal midline pigment then continues posteriorly ending about two myomeres anterior to the end of the body. There is also a discontinuous line of melanophores internally along the dorsal side of the notochord along its posterior third. This line is most intense near the tail, in the area where the second dorsal and anal fins will insert. The postanal ventral midline melanophores form a continuous line from the anus to the same area that the dorsal series terminates. Some of the melanophores in both the dorsal and ventral series near their posterior ends also extend somewhat into the finfolds, and onto the lateral body surface. There is light pigment on the medial surface of the base and on the blade of the pectoral fin and the pelvic fin bud is pigmented. Gut pigment covers the dorsal aspect of the gut cavity and is intense over the hindgut. There is a line of melanophores along the ventral midline of the gut region and there is internal pigment along the anterior margin of the gut cavity.

Sebastes nigrocinctus: Tiger rockfish larvae were extruded from a female collected in the Vancouver area and reared for several days in 1988 and 1 day in 1989. Preflexion larvae of this species were previously unknown. The illustration presented here



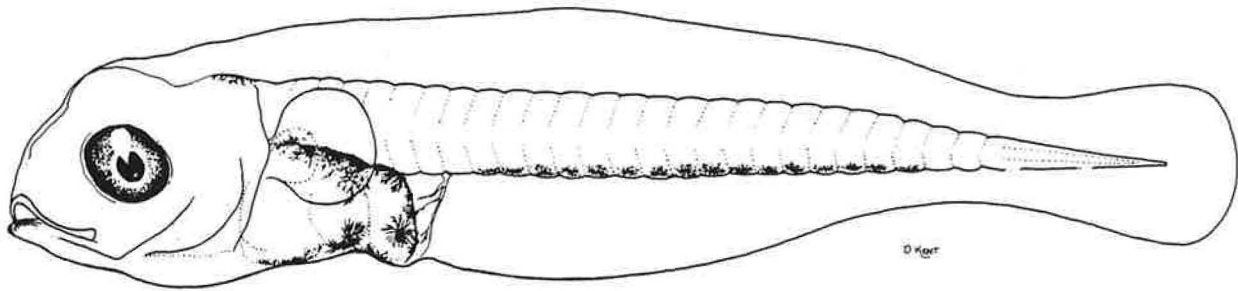


Figure 9. Preflexion larva of Sebastes nigrocinctus, 5.6 mm SL, 1 day old, extruded 18 May 1988, from an adult held at the Vancouver Public Aquarium and reared there by Jeff Marliave. Drawing by Danny Kent, Vancouver Public Aquarium.

is of a 1 day old specimen and was drawn by Danny Kent at the Vancouver Public Aquarium (Figure 9). The larvae ranged in size from 5.1 to 5.6 mm when they were 1 day old. The larvae have pigment on the lower jaw, on the dorsal midline at the posterior of the head, and a series of postanal ventral midline melanophores starting 3 myomeres posterior to the anus and extending posterior for 16 myomeres to the end at the third-from-last myomere. There is a shield of heavy pigment on the dorsal surface of the gut that continues on the posterior surface of the hindgut. There is also considerable pigment on the ventral surface of the gut including an expanded melanophore just anterior to the anus.

Sebastes polyspinis: Northern rockfish larvae extruded from a female collected in the Gulf of Alaska by Craig Rose (NWAFC) in July 1985 were preserved immediately to be used for descriptions. The larvae appear to be very near full-term. They had already hatched and the yolk occupies only about half of the gut area. They are 6.1 mm SL preserved (Figure 10). The gut pigment consists of expanded melanophores covering the posterior and lateral aspects of the hindgut. This pigment extends somewhat onto the wall of the gut cavity anterior to the hindgut, and also extends dorsally in the area of the swim bladder. The postanal ventral midline series is long, beginning about 4 or 5 myomeres posterior to the anus and ending about 2 myomeres anterior to the tail. It forms a continuous line in most specimens, so it is not possible to count the individual melanophores. There is also pigment on the dorsal and ventral edge of the body near the tip of the notochord

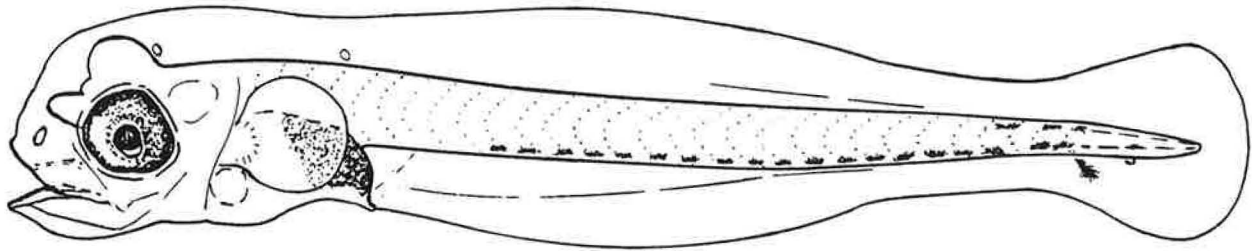


Figure 10. Preflexion larva of Sebastes polyspinis, 6.1 mm SL, at extrusion, from an adult collected July 1985, in the Gulf of Alaska and preserved immediately. Illustration from Matarese et al. 1989.

consisting of one or two dashes both dorsally and ventrally. A melanophore is aligned obliquely in the ventral finfold near where the center of the caudal fin will develop.

Sebastes proriger: Redstripe rockfish were extruded from adults collected off Oregon in 1985. The embryos were at a late pre-hatch state of development and were maintained for 78 hr in culture. Their pigment patterns closely resemble those of illustrated preflexion larvae (Westrheim et al. 1968).

Sebastes ruberrimus: Yelloweye rockfish larvae extruded from females held at the Seattle Aquarium were reared for 30 days at Friday Harbor. Larvae were held under two different light regimes to investigate the effect of light level on development of larval pigment, since some reared Sebastes larvae have appeared more melanistic than those collected in the wild (Stahl-Johnson 1985). The larvae grew from 4.2 mm live total length (4.0 mm SL preserved) on day 0 to 6.2 mm (5.6 mm SL preserved) on day 30. Extrusion larvae of S. ruberrimus have been illustrated before (DeLacy et al. 1964, Westrheim et al. 1968, Harling et al. 1971), but later stages were previously unknown. At extrusion the larvae still have a fairly large yolk sac and the oil globule is in the posterior part of the yolk sac (Figure 11). Gut pigment is over the dorsal surface of the posterior half of the gut and the posterior surface of the hindgut. This pigment extends anterior from the hindgut to cover the posterior part of the yolk sac including most of the area of the oil globule. The postanal ventral midline series begins

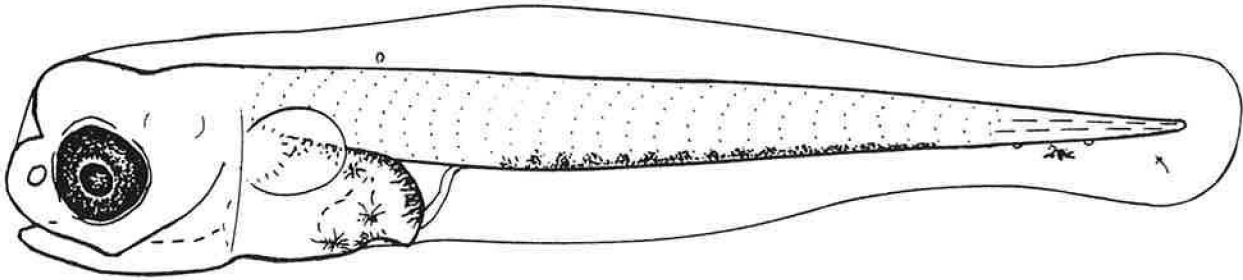


Figure 11. Preflexion larva of Sebastes ruberrimus, 4.0 mm SL, 0 days old, extruded 7 June 1988, from an adult held at the Seattle Aquarium and reared at Friday Harbor, Washington by Michael Canino.

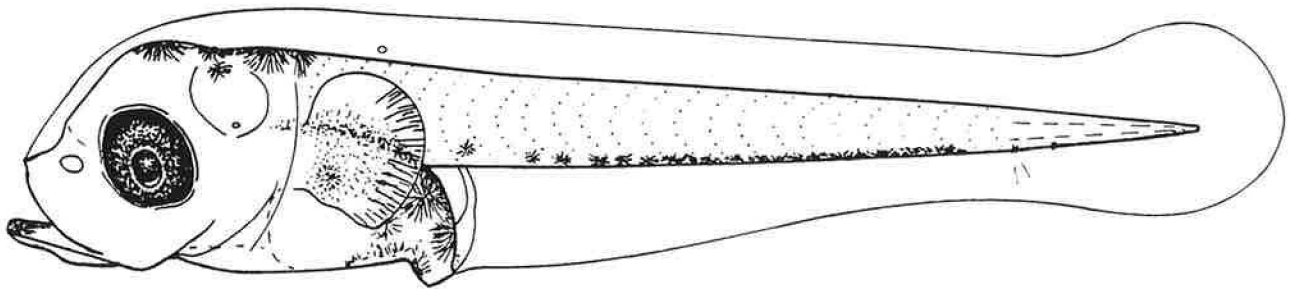


Figure 12. Flexion larva of Sebastes ruberrimus, 5.6 mm SL, 30 days old, extruded 7 June 1988, from an adult held at the Seattle Aquarium and reared at Friday Harbor, Washington by Michael Canino.

about one myomere posterior to the urinary duct and ends about two myomeres anterior to the tail. It is composed of about 15 rather large melanophores. There is a melanophore ventrally in the finfold near where the caudal fin will develop.

By day 7, the yolk and oil globule are much reduced in size. The tip of the lower jaw is pigmented, and a melanophore is present on each optic lobe, and on the nape of most larvae. The gut pigment has spread anteriorly to cover the posterior half of the gut cavity.

By day 15, the pectoral fin blade is pigmented on some larvae, and melanophores have been added internally along the ventral surface of the notochord over the anterior region of the gut cavity. Little change in pigment was seen on the 20- and 25-day larvae; pigment was consistently present on top of the head and on the pectoral fin blade, and the gut pigment was more intense.

The oldest larvae available are 30 days old, appear quite robust, and still have a small amount of yolk left (Figure 12). There is some indication of caudal fin development, in the form of thickening of the finfold in the area where the fin will develop, but the notochord has not begun to flex. The pigment pattern seen in 15-day larvae has not changed appreciably by day 30. There was considerable variation in the degree of contraction of melanophores among individual larvae throughout the developmental series, but no differences in pigment between larvae held at different light levels could be seen.

Sebastes zacentrus: Sharpchin rockfish were extruded from adults collected off Oregon in 1985. The embryos were at a late prehatch state of development and were maintained only 5 hr in culture. These embryos are very similar in appearance to preflexion larvae of this species illustrated by Efremenko and Lisovenko (1970), Westrheim et al. (1968), and one of the illustrations of this species presented by Harling et al. (1971). The other illustration of this species by Harling et al. (1971) is obviously of a misidentified specimen (see Laroche and Richardson 1981).





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