

The Early Life History of the Rockfish, *Sebastes thompsoni* (Scorpaenidae), in the Sea of Japan

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Abstract Larval and juvenile stages of the rockfish, *Sebastes thompsoni*, are described and illustrated with particular reference to the development of head spines. Notochord flexion occurred between 4.6 and 7.8 mm SL. Transformation occurred between 16 and 22 mm SL. Preflexion and flexion larvae of *S. thompsoni* were distinguished from related species by pigmentation of the dorsal and ventral midlines of the tail. Larvae and juveniles occurred in the coastal water around Honshu Island in the Sea of Japan where they were under the influence of the Tsushima warm current. The timing of their habitat shift from a pelagic life style to an association with drifting seaweed and food items of larvae and juveniles are also described and discussed.

The genus *Sebastes* is one of the important components of the shelf and slope fish fauna of temperate and subarctic regions (Boehlert and Yamada, 1991), with about 18 species being distributed in the Sea of Japan (Nagasawa, 1991). Among these species, *Sebastes thompsoni* is an important resource for commercial fisheries in the coastal region of Honshu Island. Although preextrusion larvae and juveniles of *S. thompsoni* have been described briefly (Shiogaki, 1988) and pelagic juveniles associated with drifting seaweeds reported (Ikehara, 1977; Yamada, 1980), the early life history is poorly known. The aim of this study is to describe a developmental series of *S. thompsoni* with particular attention to the development of head spines, horizontal distribution, and the habitat shift from a free pelagic life style to an association with drifting seaweed. Food items of larvae and juveniles are also described and discussed.

Materials and Methods

Specimens examined in this study were came from the collections in the Japan Sea National Fisheries Research Institute. Samples were mainly obtained with 130 cm ring nets (130RN) (surface tows) and 70 cm bongo nets or 80 cm ring nets (oblique tows, from 100 m deep to surface), from 1986 to 1992: April 1986 (surface tows), May 1986 (surface tows),

April 1987 (surface tows and oblique tows), May 1987 (both tows), April 1988 (both tows), May 1988 (both tows), April 1989 (both tows), May 1989 (both tows), April 1990 (both tows), May 1990 (both tows), March 1991 (oblique tows), April 1991 (oblique tows), May 1991 (oblique tows), March 1992 (oblique tows), April 1992 (oblique tows), May 1992 (oblique tows). The fish associated with drifting seaweed were collected with large dip nets in June 1989. Samples were mainly taken during the period from March to June, in the area between Sado Strait and Tsushima Strait. All samples were fixed with 5% buffered formalin sea water, fish larvae and juveniles being subsequently sorted and preserved in 5% buffered formalin solution. Our approach to identification, methods for making counts, measurements and terminology for developmental stages follow Richardson and Laroche (1979) and Nagasawa (1993). Terminology of head spination follows Moser and Ahlstrom (1978). For observations of general development and head spines, specimens were stained lightly with saianin 5-R or cleared and stained following Dingerkus and Uhler (1977), respectively. Observations, measurements, and illustrations were made with the aid of a camera lucida and micrometer attached to a binocular dissecting microscope. For gut contents analysis, the entire gut was removed from each specimen and placed in a drop of lactic acid. The gut was then teased apart

by probes to release any organisms, which were identified and counted using a phase contrast microscope.

Results

Description of development

Distinguishing features.—Preextrusion larvae of *Sebastes thompsoni* are characterized by three rows of melanophores along both the dorsal and the ventral midlines of the tail, and also a few melanophores on the lateral midline (Shiogaki, 1988). These characters are also observed in preflexion and early flexion larvae. Larvae of *S. inermis* are similar to those of *S. thompsoni* (Kojima, 1988), but observations of reared larvae of *S. inermis* revealed only a single row of melanophores along both the dorsal and ventral midline of the tail. This character is therefore useful for separation of larvae of the two species. Late flexion and postflexion larvae of *S. thompsoni* are characterized by a distinct row of melanophores along the lateral midline. The bodies of transforming larvae and early pelagic juveniles of *S. thompsoni* are pigmented uniformly and the combination of fin ray counts are useful for identification. Late pelagic juveniles have already five pigment bands as in the adults. Fin ray counts are as follows: D; XIII, 13–15, A; III, 7, P₁; 15–17, P₂; I, 5.

General development and morphology.—In the study material, the smallest larva (4.30 mm in standard length [SL]) was regarded as a newborn preflexion larva. Preflexion larvae had large heads, large well-formed eyes and functional jaws (Fig. 1A). The gut was short and bulbous, posteriorly with a short posteroventral orientation. Yolk and an oil globule were observed in the anterior region of the liver in some specimens. Notochord flexion occurred between 4.6 and 7.8 mm SL. Transformation from postflexion larvae to pelagic juveniles included a structural change of the dorsal and anal fin “prespines” to sharp, hard spines (Laroche and Richardson, 1981), occurring between 16 and 22 mm SL.

Allometry of some body parts are shown in Figure 2. Relative body depth increased markedly in the early larval stages (4.3–16 mm SL), less so in transforming larvae and pelagic juveniles (Figs. 1, 2). The relative snout to anus distance also increased markedly during the early larval stages, but gradually

during transformation and pelagic juvenile stages. Relative head length increased markedly during the early larval stages, but decreased gradually during the transformation and pelagic juvenile stages. Relative eye diameter with respect to SL was 10–12% and almost constant during the larval and pelagic juvenile stages. However, relative eye diameter with respect to head length was variable and it decreasing markedly during the larval stages.

Fin development.—Pectoral fins were already present in preflexion larvae and the rayed portions are fan-shaped membranes (Fig. 1A). The rays appear in flexion larvae as small as 5.2 mm SL and postflexion larvae of 11.9 mm and larger have the full complements of 15–17 (mainly 16) pectoral rays.

Pelvic fins are not observed in preflexion larvae, but appeared in flexion larvae as small as 5.5 mm SL (Fig. 1A, B). In flexion larvae smaller than 7.9 mm SL, the pelvic fins were visible only as fleshy buds (Fig. 1B). Rays began to differentiate in larvae of 8 mm SL or larger. Postflexion larvae larger than 11 mm had the full compliment of I, 5 pelvic rays (Fig. 1C, D).

Caudal fin rays were not observed in preflexion larvae, although the finfold was well-developed, being continuous with the dorsal and anal finfolds (Fig. 1A). Rays appeared in flexion larvae larger than 4.7 mm SL and in those larger than 6 mm SL, serving to support the caudal finfold (Fig. 1B). Slits in the fin fold between the caudal peduncle and dorsal or anal regions appeared in postflexion larvae 9.1 mm SL and larger. The finfold of the caudal peduncle region disappeared in postflexion larvae larger than 11 mm (Fig. 1C, D). Branching of the caudal rays occurred in postflexion larvae larger than 14 mm (Fig. 1E), and the full compliment of 7+7 principle caudal rays being established in pelagic juveniles larger than 30 mm SL.

Dorsal and anal fin rays were not observed in flexion larvae, but correspondig fin folds were well-developed and continuous with the caudal portion. In flexion larvae larger than 4.6 mm SL, dorsal and anal fin bases appeared and portions of the soft ray pterygiophores of both fins started to differentiate (Fig. 1B). In flexion larvae larger than 7.6 mm, some soft rays appeared in both fins. In postflexion larva of 9.1 mm, some dorsal spine buds were observed (Fig. 1C). In larger postflexion larvae, the finfold between the anus and first anal spine became smaller, disappearing by 11 mm SL. In postflexion larvae larger than 11.3 mm SL, the total dorsal and

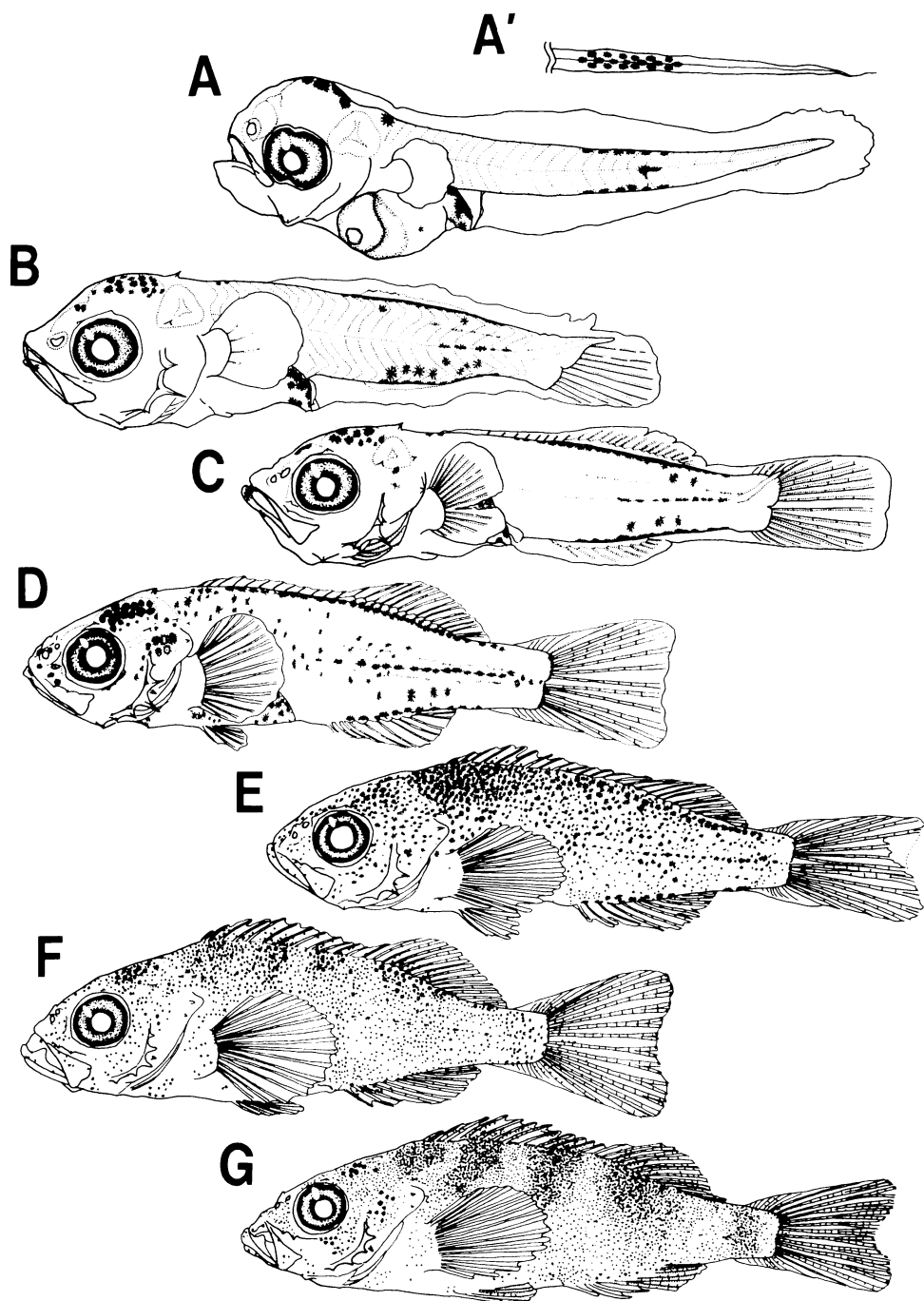


Fig. 1. Developmental series of *Sebastes thompsoni*. A) Preflexion larva 4.3 mm NL; A') pigmentation of the dorsal midline of specimen A; B) flexion larva 6.4 mm SL; C) postflexion larva 9.1 mm SL; D) postflexion larva 11.9 mm SL; E) postflexion larva 16.1 mm SL; F) transforming larva 18.2 mm SL; G) pelagic juvenile 28.1 mm SL.

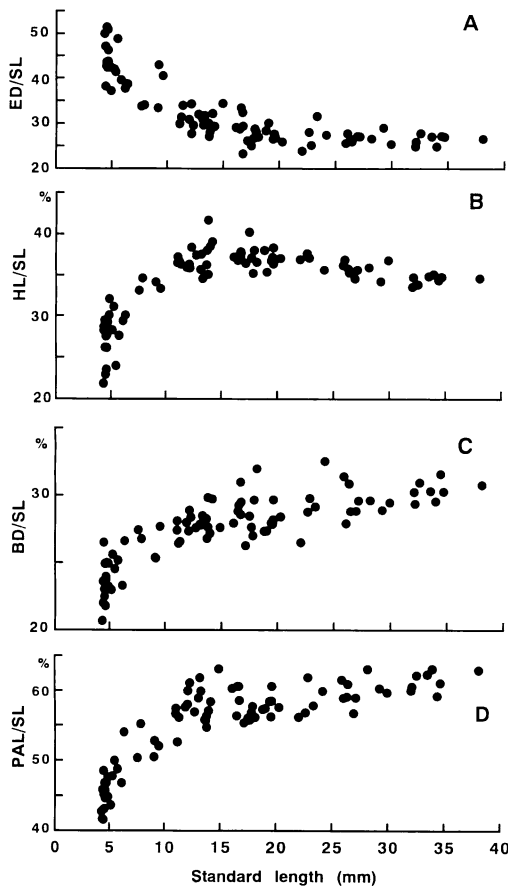


Fig. 2. Allometry of larvae and juveniles of *Sebastes thompsoni*. A) Relationship between the ratio of eye diameter (ED) to head length (HL) and standard length (SL); B) relationship between the ratio of HL to SL and SL; C) relationship between the ratio of body depth at pectoral fin base (BD) to SL and SL; D) relationship between the ratio of preanal length (PAL) to SL and SL.

anal fin ray counts were as in adults (Fig. 1D, E), although the last spines of both fins remained at the "prespine" until about 22 mm SL.

Pigmentation.—In preflexion larvae, the dorsal surface of the gut was covered with a mantle of melanophores and the lateral and ventral surface of the rectum lightly pigmented (Fig. 1A). In some specimens, a few melanophores occurred on the lateral surface of the looped portion of the gut. Six to twenty-six melanophores occurred on the brain case and some on the nape. The fin membranes were not pigmented. Three rows of melanophores occurred

on the dorsal and ventral midlines of tail from the 16th or 17th to 21–22nd myomeres, in addition to a few (usually 1 or 3) melanophores on the lateral midline of the tail.

In flexion larvae, some melanophores appeared on the tip of the upper and lower jaws, with melanophores being added to the dorsal surface of the brain, resulting in its being almost covered in larvae larger than 6.1 mm SL (Fig. 1B). The pigmented region on the dorsal midline extended anteriorly and posteriorly from the 11–14th to 20–23rd myomeres. The ventral midline was also covered with melanophores. Development of melanophores on the lateral midline had formed distinct horizontal pigment band. Internal pigment was observed along the dorsal portion of the notochord around the 19–23rd myomeres.

In postflexion larvae smaller than 14.9 mm SL, the basic pigmentation pattern was similar to that of flexion larvae, with melanophores being added continuously (Fig. 1C, D). The dorsal and ventral midlines were more heavily pigmented, with melanophores extending anteriorly. The row of melanophores on the lateral midline was also conspicuously developed and extended anteriorly. Internal melanophores along the dorsal and ventral portions of the notochord were observed. Melanistic pigment appears on the opercle, postorbital, preorbital and throat regions beside the caudal fin base, being added gradually to the lateral region.

In postflexion larvae larger than 14.2 mm SL, melanophores were spread over the body (Fig. 1E), being distributed densely on the dorsal surface and more sparsely on the lateral and ventral surfaces. The internal pigment along the notochord was hidden. Some melanophores appeared on the membranes of the dorsal and caudal fins.

In transforming larvae, five bands of melanistic pigment started to develop ventrally from the elongate patch of melanophores that lying along the dorsal fin base and dorsal portion of the caudal peduncle (Fig. 1F). The first of these extended anteroventrally from the dorsal fin origin to the opercle region. The second band extended similarly from the base of the 5–8th dorsal spine to the pectoral fin base. The third and fourth bands extended ventrally from the base of the 10–12th dorsal spine, and the base of the soft dorsal fin, respectively. The fifth band appeared on the caudal peduncle. The dorsal fin membrane above these melanistic bands and the membranes of the spinous anal fin and caudal fin base were also pigmented.

In pelagic juveniles, each melanistic band became further developed, taking on adult characteristics (Fig. 1G).

Head spination.—In this species, spines of the head region were not well developed throughout the larval and juvenile periods, each spine being small (Fig. 1).

Although, new-born preflexion larvae lacked head spines, two spines appeared prior to notochord flexion: the pterotic spine and the third posterior preopercular spine (Table 1). The pterotic spine, the only spine on the pterotic bone and remains to adulthood. The third posterior preopercular spine is the first-appearing of the posterior preopercular series, other spines in this series appearing in flexion or postflexion larvae. All of these spines remain in adults, the sequence of spine appearance for the series being 3-2-4-1,5.

In flexion larvae, eight spines appeared: parietal, postocular, lower posttemporal, second anterior preopercular, fourth anterior preopercular, second posterior preopercular, fourth posterior preopercular and first lower infraorbital. The parietal spine was a prominent spine at the posterior terminal of the parietal ridge, which was slightly serrated in postflexion and transforming larvae. The postocular spine formed directly above the eye and was conspicuous in postflexion larvae, but became smaller after transformation. The lower posttemporal spine appeared on the ventral margin of the posttemporal bone, remaining conspicuous in postflexion larvae, but disappearing at transformation. The posttemporal bone also bears the upper posttemporal spine, which appeared above the lower posttemporal spine on the posterior edge of the posttemporal bone at the end of the postflexion larval period. This spine became conspicuous in transforming larvae, but was reduced in pelagic juveniles and inconspicuous by the end of the pelagic juvenile period. The second and fourth anterior preopercular spines were lateral projections on each of the posterior preopercular spines. In this species, the anterior preopercular spines disappeared by the end of the postflexion larval period. The first lower infraorbital spine was a downward-projecting spine that appeared on the ventral edge of the lacrymal. The second lower infraorbital spine appeared posteriorly on the ventral edge of this bone in early postflexion larvae. The two spines became strongly obliquely-directed with growth, being very conspicuous in adults and providing a diagnostic character for the subgenus *Mebarus*.

In postflexion larvae, 10 spines appeared: nuchal,

upper posttemporal, upper opercular, lower opercular, interopercular, first posterior preopercular, 5th posterior preopercular, first upper infraorbital, second lower infraorbital, and supracleithral spines. The nuchal spine was subjacent to the posterior end of each parietal spine, being fused to the parietal spine without a small hole in postflexion larvae about 12 mm SL, and separated again in larger postflexion larvae. The spine was lost during transformation. The upper opercular spine appeared on the upper posterior edge of the opercle in early postflexion larvae. In advanced postflexion larvae, the lower opercular spine also appeared on the ventral portion of the upper opercular spine. The two spines became more conspicuous as development proceeded, being retained in adults. The interopercular spine appeared as a supporting, rod-like projection at the upper margin of the interopercle bone, with its upper edge of this spine facing the subopercle. Although was not very conspicuous, the spine retained in adults. The first upper infraorbital spine was a small, upward-projection that appeared on the upper edge of the lacrymal bone just above the first lower infraorbital spine. Although it appeared in early postflexion larvae, it had disappeared by the end of the postflexion larval stage.

Nasal and cleithral spines appeared during transformation, former as a dorsal projection of the nasal bone. It became conspicuous with continuing development, being retained in adults. The cleithral spine appeared on the upper posterior margin of the cleithrum, as a spatular projection, which become strongly with growth, being conspicuous in adults.

Distribution

According to fragmentary information, larvae and pelagic juveniles were collected along Honshu Is., from Tsushima Strait to Tsugaru Strait (Nagasawa, 1991). The ichthyoplankton surveys using surface tows of the 130RN and covering a wide region from Tsushima Strait to Sado Island, were conducted in April and May 1989 (Fig. 3) and 1990 (Fig. 4).

In the April 1989, larvae and pelagic juveniles were widely distributed along the coastal region (Fig. 3), but were not collected offshore (northwest off Oki Islands). The percent occurrence (number of stations where larvae or juveniles were collected/number of stations sampled \times 100), excluding the offshore region was 21%. In the area from Tsushima Strait to Wakasa Bay, 71% of positive stations were

Table 1. Sequence of head spine development of *Sebastes thompsoni*. Presence of spine indicated by +, Terminology follows Moser and Ahlstrom (1978)

Spine	Standard length (mm)																								
	4.3	4.6	5.1	5.8	6.1	6.4	7.4	7.9	9.1	9.5	11.1	11.4	12.1	13.3	14.2	16.7	17.7	18.8	19.6	22.0	26.3	32.1	34.7	38.1	
	Preflexion L.		Flexion Larvae						Postflexion Larvae						Transforming Larvae				Pelagic Juveniles						
Parietal				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Nuchal											+	+	+	+	+	+	+	+	+						
Preocular																								+	+
Postocular					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pterotic		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+						
Lower posttemporal								+	+	+	+	+	+	+	+	+	+	+	+						
Upper posttemporal															+	+	+	+	+		+	+			
Upper opercular										+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Lower opercular													+	+	+	+	+	+	+	+	+	+	+	+	+
Inter opercular												+	+	+	+	+	+	+	+	+	+	+	+	+	+
2nd anterior preopercular				+	+	+	+	+	+	+	+	+	+	+	+										
4th anterior preopercular					+	+	+	+	+	+	+	+	+												
1st posterior preopercular										+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2nd posterior preopercular				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3rd posterior preopercular		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4th posterior preopercular					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5th posterior preopercular										+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
1st upper infraorbital									+	+	+	+	+												
1st lower infraorbital								+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2nd lower infraorbital												+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nasal																									
Supracleithral											+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cleithral																	+		+		+	+	+	+	+

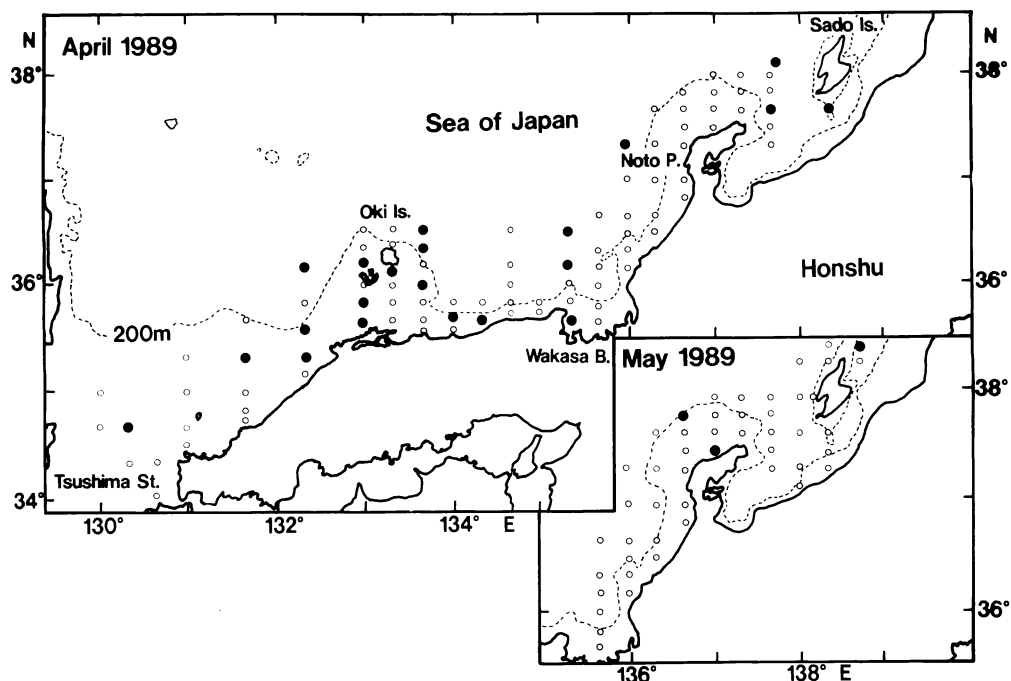


Fig. 3. Distribution of larvae and juveniles of *Sebastes thompsoni* collected by surface tows in April 1989 and May 1989; (○) negative stations, (●) positive stations.

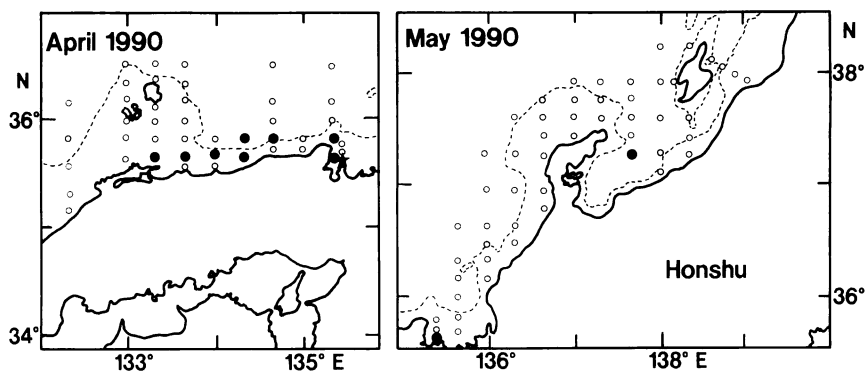


Fig. 4. Distribution of larvae and juveniles of *Sebastes thompsoni* collected by surface tows in April 1990 and May 1990; (○) negative stations, (●) positive stations, (★) station of an extraordinary catch.

located on the continental shelf. However no larvae were collected in the region on the continental shelf around Noto Peninsula in this month. The estimated density at each station in the April 1989 survey was only 0.01–0.31 per 10 m² of sea surface. In the May 1989, larvae were collected in restricted areas around the Noto Peninsula and Sado Island. In both months, larvae of *S. thompsoni* were uncommon over the continental shelf around Noto Peninsula. All

larvae in both surveys were collected in areas under the influence of the Tsushima warm current.

In April 1990, larvae were collected at 9 sampling stations (20% of the total stations), 8 of these being on the continental shelf in the area from Oki Strait to Wakasa Bay (Fig. 4). An extraordinary catch of 489 specimens was made at the station in Wakasa Bay (shown by star in Fig. 4). The estimated density of this station was 5.81 per 10 m² of sea surface and the

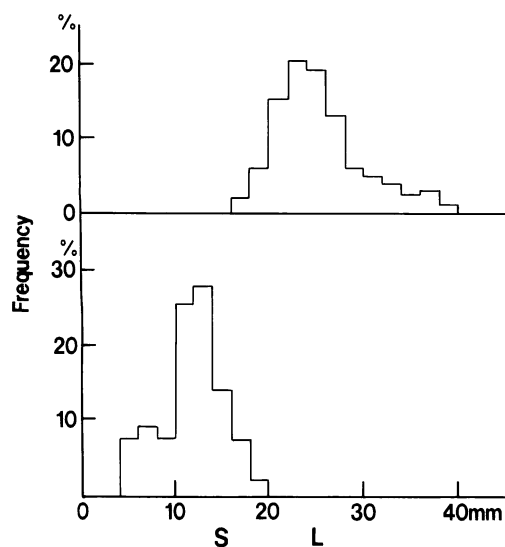


Fig. 5. Frequency distribution of standard length of larvae and juvenile of *Sebastes thompsoni*. Top—pelagic juveniles associated with drifting sea weed; bottom—larvae and juveniles collected by surface tows.

larvae ranging from 13.6 to 20.2 mm SL. Many sardine eggs (*Sardinops melanostictus*) were collected at the same time, indicating that the fish larvae and eggs had accumulated in a slick or local eddy.

In June 1988, 13 drifting seaweed clumps were collected between Sado Island and Oga Peninsula (Akita Prefecture). Although, one hundred and twenty-one pelagic juveniles or transforming larvae were collected from 8 clumps (62% of total drifting clumps of seaweed sampled), few smaller larvae were collected on these occasions. The number of fish associated with each seaweed clumps ranged from 1

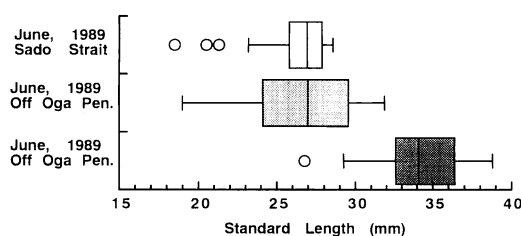


Fig. 6. Distribution of standard lengths of pelagic juveniles of *Sebastes thompsoni* collected from 3 drifting clumps of seaweed (see text). Boxplots show median with shared range from 25th to 75th quartile; lines indicate range of remaining points; open circles indicate outlying points.

to 42, more than 30 specimens being collected from three separate clumps.

Timing of habitat shift

Larvae collected by surface tows were smaller than 20 mm SL (excluding the specimens included in the extraordinary catch—see above), with few pelagic juveniles being collected (Fig. 5). The size range of larvae collected by oblique tows of 70 cm bongo nets in the same survey fell within 4.3–9.2 mm SL. This range was more restricted than obtained from surface tows, suggesting that *S. thompsoni* utilizes open surface water as a prerecruitment habitat before recruitment to drifting seaweed.

The length distribution of the larvae and juveniles associated with drifting seaweed ranged 16–40 mm SL, with more than 90% of the specimens being larger than 20 mm SL (Fig. 5). In contrast, the lengths of the larvae collected by surface tows ranged 4.3–20 mm SL, with frequencies larger than 16 mm SL reducing rapidly. These results revealed

Table 2. Percentage composition by number of food organisms in the gut of *Sebastes thompsoni*

SL (mm)	<7	7–10	10–15	15–20	20–25	25–30	30–35	35–40
No. of fish examined	4	5	17	4	16	6	6	15
No. of fish with food	4	5	17	4	16	6	6	15
Food organisms (% in number)								
Nauplii	75							
Copepodites <0.7 mm	23	18	9					
<i>Paracalanus</i> sp.	2	82	69	98	93	99	99	98
<i>Podon</i> spp.			8					+
<i>Evadne nordmanni</i>			5	1	1	+	1	2
Euphausiid calyptopys				1	5	+		
Others			10		1	+	+	

+: Presence confirmed but percentage less than 1%.

that habitat shift from a pelagic life style to an association with drifting seaweed, occurred during transformation (16–20 mm SL) of this species, with more than 90% of the total specimens in the extraordinary catch in Wakasa Bay were also this stage.

The standard lengths of larvae and juveniles associated with drifting seaweed overall had a rather wide range, but SL ranges of fish from each clump were narrower (Fig. 6), as was that of the larvae caught in Wakasa Bay. The narrow range of SL of transforming larvae which accumulated in the surface water before their habitat shift to drifting seaweed, may be responsible for the narrow size range of pelagic juveniles and transforming larvae associated with drifting seaweed.

Feeding

Seventy-five larvae and juveniles of *S. thompsoni* were used for gut content analysis. Food items were observed in the guts of all specimens examined. In preflexion and flexion larvae smaller than 7 mm SL, 75% of food items were copepod nauplii and 23% were copepodites smaller than 0.7 mm SL (Table 2). In post flexion larvae 7–10 mm SL, major component become *Paracalanus* sp., Copepodites <0.7 mm being minor component and nauplii being absent. In postflexion larvae 10–15 mm SL, *Paracalanus* sp. were also the predominant food items. However, in some specimens, *Podon* spp. or *Evadne nordmanni* were major components. In postflexion and transforming larvae 15–20 mm SL, dietary components were almost entirely *Paracalanus* sp., with only a few specimens of *Evadne nordmanni* and euphausiid calyptopys were observed. In pelagic juveniles larger than 20 mm SL, the major component continued to be *Paracalanus* sp., in spite of the change in habitat to that of drifting seaweed. In summery, larvae and pelagic juveniles fed on zooplankton, the size of the prey increasing with larval during the period from preflexion to postflexion. During and after transformation, prey size did not increase, although the fish had mouths large enough for larger prey. Pelagic juveniles associated with drifting seaweed did not feed on epiphytal organisms.

Discussion

Matsubara (1943) proposed the subgenus *Mebarus* in which he included *Sebastes paradoxus*, *S. wakiyai*,

S. taczanowskii, *S. joyneri*, *S. thompsoni*, and *S. inermis*. Of these, *S. paradoxus* is a junior synonym of *S. wakiyai* (Chen, 1985), and *S. wakiyai* and *S. taczanowskii* should be referred to other subgenera. Chen (1985) retained *S. joyneri*, *S. thompsoni*, and the *S. inermis* complex (recognizing three separate forms in this complex) in *Mebarus* and further added *S. atrovirens* from the eastern North Pacific. Barsukov (1991) disagreed with the latter move and he divided the *S. inermis* complex into three species. Of Chen's *Mebarus* species, the early life history of only *S. inermis* has been studied. The size of larvae at parturition in *S. inermis* is 4.5 mm TL (Harada, 1962), being almost the same in *S. thompsoni*. Transformation occurs at 17–20 mm SL in *S. thompsoni* and at about 16 mm in *S. inermis* (Harada, 1962). Although the general morphology and pigmentation of larvae of *S. thompsoni* is similar to that of *S. inermis*, the head spines of the former are smaller. Kendall (1991) classified postflexion larvae of 34 species of *Sebastes* including the Northwest Pacific species into 11 groups, both *S. thompsoni* and *S. inermis* being included in the Group 5. The other members, excluding *Sebastiscus marmoratus*, are Northeast Pacific species, with transformation sizes larger than those of *S. thompsoni* and *S. inermis*. In addition, the head spines of the Northeast Pacific species are larger than those of *S. thompsoni* (Washington et al., 1984; Matarese et al., 1989). In the former, only *S. dallii* has a row of melanophores on the dorsal midline portion of the tail during the preflexion and flexion larval period (Moser and Butler, 1981). This species has lateral postanal melanophores and internal pigment above the notochord throughout the larval period. In addition, Kendall (1991) classified pelagic juveniles into 6 groups, based on pigment patterns. Although *S. thompsoni* was included in his Group 4, it should be removed to Group 3, owing to the presence of 5 bands of pigment on the body. *S. dallii* was included in Group 3. Postflexion larvae of Northeast Pacific species, *S. saxicola* were not classified by Kendall (1991), but their general appearance is also similar to that of *S. thompsoni* (Matarese et al., 1989). Pelagic juvenile of *S. saxicola*, included in Group 3 by Kendall (1991), have two distinct lower infraorbital spines as does *S. thompsoni*. If the ontogenetic similarities of these species reflect their phylogenetic relationships, *S. thompsoni* or the subgenus *Mebarus* might be closely related to *S. dallii* or *S. saxicola*. Further information on the early ontogenetic stages of *Sebas-*

tes is required for any phylogenetic analysis.

Gut contents of larvae and juveniles of some species of *Sebastes* from Japanese waters have been reported (Harada, 1962; Kuwahara and Suzuki, 1983; Nagasawa, 1993), the major food items in early larvae being copepod nauplii and in advanced larvae, generally copepodites (*Paracalanus* sp. being dominant). In larvae of *S. thompsoni*, a similar phenomenon was observed. Although feeding studies in juveniles larger than 20 mm have been few, Harada (1962) mentioned that *Paracalanus parvus* predominated in the stomach contents of larvae and juveniles of *S. inermis* 10–20 mm SL, with the proportion of *Centropages abdominalis* (larger than *P. parvus*) increasing in larvae larger than 20 mm SL. In *S. thompsoni* pelagic juveniles larger than 20 mm SL, *Paracalanus* sp. remained the dominant item, as in smaller specimens. Such a contrast in juvenile feeding between the two species may be associated with their different habitats, with the functional aspects of feeding organs also being relevant. Because the number of gill rakers on the first gill arch of *S. thompsoni* is greater (the rakers therefore being more dense) than in *S. inermis* (Matsubara, 1943), the some advantage may be conferred on the when feeding on smaller prey animals.

The association of pelagic juveniles of *Sebastes* with drifting seaweed has been previously recorded (Uchida and Shojima, 1958; Senta, 1962, 1965; Ida et al., 1967; Mitchell and Hunter, 1970; Boehlert, 1977; Ikehara, 1977). In the Northwest Pacific, *S. thompsoni*, *S. inermis*, *S. schlegeli*, *S. hubbsi* and *S. vulpes* have been collected with drifting seaweed. Among these species, the pelagic juveniles of *S. thompsoni* were peculiar in that they were not collected in other habitats. In contrast, other species were collected in such habitats as *Zostera* belts, *Sargassum* belts, and water masses without drifting seaweed (Harada, 1962; Senta, 1965; Nagasawa, unpubl. data). Therefore, *S. thompsoni* may be the only Northwest Pacific species that lives in close association only with drifting seaweed during the pelagic juvenile period.

Pelagic juveniles or transforming larvae of *S. thompsoni* congregate around drifting seaweed after encountering them. In this process, accumulation of larvae in a slick or local eddy may be a transitional phase, for they would then be easily be able to congregate under the drifting seaweed, the latter also being prone to such accumulation.

Moser and Ahlstrom (1978) described three early

life history strategies employed by Northeast Pacific rockfishes. One of them, employed by *S. diploproa*, is similar to that of *S. thompsoni*. Larvae of the former are released in the spring and appear in the surface water upon reaching a length of ca. 10 mm SL. Subsequently, they are recruited to drifting seaweed where they grow to 30–50 mm SL (Mitchell and Hunter, 1970; Boehlert, 1977; Moser and Ahlstrom, 1978). Pelagic juveniles of both *S. thompsoni* and *S. diploproa* utilize drifting seaweeds as shelter (Mitchell and Hunter, 1970; Yamada, 1980). In spite of this similarity, the species differ in pigmentation at this stages (Moser and Ahlstrom, 1978; Matarese et al., 1989), pelagic juvenile of *S. diploproa* having a solid background pigmentation with faint bars, and fins with contrasting dark and clear areas for disguise. The dissimilarity may be associated with size differences in the fronds of the drifting kelp. Because the fronds of drifting kelp in the Sea of Japan are smaller than those of *Macrocystis pyrifera*, the pelagic juveniles of *S. thompsoni* have a more complicated pigmentation helping to disguise them.

S. thompsoni is distributed from the southern part of Hokkaido to Tsushima Strait and the coastal region of southern Korea in the Sea of Japan, and to Tokyo in The Pacific Ocean (Amaoka, 1984). Most of these areas are under the influence of the Tsushima warm current. As the pelagic stage of *S. thompsoni* is extended by aggregation around drifting seaweed, the species is transported downstream by the Tsushima warm current during the larval and juvenile periods. This strategy has the advantage to extending their distributional area, and the drifting seaweed providing clues for orientation, in addition to shelter (Nagasawa, 1991). Considering this, *S. thompsoni* may have evolved from a shallow water species, such as *S. inermis*, that inhabited *Zostera* or *Sargassum* belts during the larval and juvenile periods.

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ウスメバルの初期生活史

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各種ネット採集で得られた標本に基づいてウスメバル仔稚魚の形態発育史を記載するとともに、分布、食性などについての知見を取りまとめた。本種仔魚は脊索長 4.5 mm 前後で産出され、4.6–7.9 mm にかけて脊索後端が屈曲する。背鰭および臀鰭の最終棘条の棘化を指標とする変態は体長 16–20 mm で起こり、体長 22 mm 以上ではすべての個体が浮遊期稚魚となっていた。頭部の各棘要素は仔稚魚期を通して比較的小さい。前屈曲期から変態期（体長 4.5–18 mm）の仔魚は主に表層で浮遊生活をおくる。体長 20–40 mm の浮遊期稚魚は流れ藻に随伴する。流れ藻への移動・蟄集は主に体長 16–20 mm の変態期に行なわれるものと判

断されるが、このプロセスには潮目等が仔魚の集積場所として機能している可能性が示唆された。前屈曲期から屈曲期にかけてのウスメバル仔魚は主にかいあし類のノープリウスを、後屈曲期以降の仔稚魚は *Paracalanus* sp. を主に摂餌し、流れ藻に随伴する浮遊期稚魚についてもこの傾向は変わらなかった。日本海におけるウスメバル仔稚魚の出現域は対馬海峡から津軽海峡にかけての本州沿岸域に広く認められるが、沖合の冷水域には出現しない。

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