DEVELOPMENT AND DISTRIBUTION OF LARVAE AND JUVENILES OF *SEBASTOLOBUS* (PISCES; FAMILY SCORPAENIDAE)

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ABSTRACT

The North Pacific scorpaenid genus *Sebastolobus* is composed of three deepwater coastal species of potential commercial importance. They are oviparous and produce bilobed gelatinous egg sacs that float to the surface waters where hatching and larval development occur. Transformation into pelagic juveniles occurs at about 20 mm length. The pelagic stage of *S. alascanus* is relatively short-lived, as they transform into benthic juveniles at 22 to 27 mm length. In the deep-living *S. altivelis* the juveniles remain pelagic for well over a year and grow as large as 56 mm.

Larvae of the two species mentioned are collected regularly on plankton surveys of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) and pelagic and benthic juveniles are common constituents of mid-water and bottom trawls taken in the CalCOFI region. In this paper specimens from these sources are used to describe the larval and juvenile stages of the two species and to show the striking morphological changes which occur during development. Also presented are data on geographic distribution and patterns of seasonal abundance of larvae. Larvae of *Sebastolobus* smaller than 10.0 mm could not be distinguished to species.

Knowledge of the life history of the scorpionfish genus *Sebastolobus* is scanty. Pearcy (1962) described the floating egg masses, the developing embryos, and the newly hatched larvae of *Sebastolobus*. The larvae of *Sebastolobus* occur in the plankton collections of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) and can be differentiated from those of *Sebastes* on the basis of the spination of the parietal ridge (Ahlstrom, 1961). Information on the distribution and abundance of *Sebastolobus* larvae in CalCOFI has hitherto not appeared in the literature, nor has a description of the larval stages. It is the purpose of this paper to fill that void and also to describe the distinctive juvenile stages of *S. altivelis* and *S. alascanus*, which are common constituents of mid-water trawl catches in the eastern North Pacific.

The three known species of *Sebastolobus* inhabit the coastal waters of the North Pacific. *Sebastolobus altivelis* ranges from the southern tip of Baja California to the Aleutian Islands while *S. alascanus* is found from northern Baja California to the Bering Sea and the Commander Islands off the Asiatic mainland. The Asian species, *S. macrochir*, ranges from the coast of Japan northward to the Bering Sea south of Cape Navarin and into the Sea of Okhotsk (Barsukov, 1964). At present the commercial catch of *Sebastolobus* is small, however, data of Best (1964) and Alverson, Pruter, and Ronholt (1964) suggest that these fishes may constitute a substantial resource in the deep coastal waters of the northeast Pacific.

The taxonomic characters of the adult members of this genus have been reviewed by a number of investigators (Starks, 1898; Hubbs, 1926; Matsubara, 1943; Phillips, 1957; Barsukov, 1964; Miller and Lea, 1972). *Sebastolobus* is distinguished from other scorpaenid genera by the unusual pectoral fins, each of which is separated by a notch into dorsal and ventral lobes, by possessing more vertebrae (28 to 31) and dorsal spines (15 to 17), a complete set of circumorbital bones, an uppermost pectoral radial which is free from the scapula, and by a suborbital stay with a broad posterior end anchored firmly onto the preopercular bone. The two North American species may be separated on the basis of the shape and number of rays in the spinous dorsal fin. In *S. altivelis* the third spine is the longest while in *S. alascanus* the fourth or fifth spine is the longest. The former species usually has 15 (rarely 16) spinous dorsal rays while the latter has 16 or 17 (rarely 15) rays. Also, *S. altivelis* usually has 29 (rarely 28) vertebrae and *S. alascanus* has 30 (rarely 31). The Asian species, *S.*

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macrochir, is deeper bodied than the North American species and has a relatively narrower caudal peduncle. Counts of its spinous dorsal rays and vertebrae are close to those of *S. altivelis*.

Hubbs (1926), Barsukov (1964), and Miller and Lea (1972) have given information on the bathymetric ranges of the adults. In summary, *S. altivelis* occurs typically at 550 to 1,300 m with known depth extremes of 200 to 1,550 m. Everywhere along its latitudinal range *S. altivelis* is deeper living than *S. alascanus*, although there is some overlap and the two species are occasionally taken in the same trawls. *Sebastolobus alascanus* commonly occurs at 180 to 440 m, with known depth extremes of 18 to 1,524 m. *Sebastolobus macrochir* occurs commonly at 400 to 640 m.

MATERIALS AND METHODS

Larvae of *Sebastolobus* from 2 yr (1960, 1966) of CalCOFI survey cruises were identified and counted. From these a developmental series that encompassed the entire larval period was established. Larvae of this series were measured with the ocular micrometer of a stereoscopic microscope, according to the methods of Moser (1967, 1972), to produce the tables of morphometrics (Tables 1-3) needed for comparison of body proportions of *S. altivelis* and *S. alascanus*. This series also provided the specimens needed to describe the general morphology and melanophore pattern of the larvae. Measurements of four pelagic juveniles of *S. macrochir* are given in Table 4. An abbreviated series of *S. altivelis* and *S. alascanus* was selected, cleared with a graded series of KOH-glycerin solutions and stained with Alizarin Red-S to produce tables of meristics (Tables 5, 6).

The pelagic juvenile stages of the two species were obtained from the mid-water trawl collections of the Los Angeles County Museum of Natural History (LACM), the Scripps Institution of Oceanography (SIO), and the Southwest Fisheries Center. Demersal juveniles were obtained from otter trawl collections of LACM and SIO. As for larvae, series of juveniles were established for analysis of morphometrics (Tables 2-4), pigment pattern, and meristic characters (Tables 5, 6). In this paper the term "body length" refers to the distance from the snout to the tip of the notochord in larvae which have not yet formed the caudal fin. After dorsad flexion of the tip of the notochord and completion of caudal fin formation "body length" refers to standard length (distance from snout to posterior edge of hypural plate).

TABLE 1.—Measurements (mm) of *Sebastolobus* spp. larvae. Specimens between dashed lines are undergoing notochord flexion.

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-dorsal fin	Snout-anal fin
3.0	1.3	0.50	0.08	0.20	0.60	0.3	0.14			
3.5	1.4	0.80	0.18	0.25	0.52	0.23	0.20			
3.8	1.6	1.0	0.22	0.27	0.68	0.40	0.38			
4.2	1.8	1.2	0.25	0.30	0.86	0.45	0.40			
4.7	1.9	1.2	0.31	0.30	0.80	0.46	-			
5.0	2.0	1.4	0.35	0.33	0.90	0.65	0.50			
5.2	2.1	1.4	0.43	0.40	1.0	0.62	0.55			
5.5	2.3	1.6	0.42	0.35	1.1	0.65	0.58			
5.7	2.3	1.7	0.56	0.40	1.2	0.95	0.85			
5.8	2.4	1.7	0.51	0.39	1.2	1.0	0.78			
5.9	2.6	1.8	0.62	0.47	1.6	1.0	0.75			
6.0	2.7	1.8	0.55	0.51	1.8	1.3	0.85	0.22	2.3	3.4
6.2	2.7	1.9	0.70	0.48	1.6	1.4	0.90	0.20	-	-
6.4	2.7	1.8	0.60	0.45	1.5	1.2	0.85	0.13	-	-
6.7	3.1	1.9	0.82	0.55	1.8	1.4	1.0	0.15	3.9	3.9
6.8	2.8	2.0	0.82	0.52	1.8	1.4	1.1	0.17	-	3.2
6.9	3.3	2.2	0.80	0.58	2.0	1.5	1.2	0.25	2.7	4.1
7.1	3.5	2.5	0.82	0.71	2.4	1.8	1.2	0.80	2.5	4.2
7.3	3.8	2.5	0.95	0.76	2.4	1.8	1.4	0.85	2.7	4.4
7.7	4.2	2.7	1.1	0.75	2.8	2.1	1.5	0.85	2.9	4.5
7.8	4.3	3.1	1.1	0.82	2.6	2.1	1.4	1.2	3.2	4.8
8.3	4.4	3.1	1.1	0.79	2.6	2.0	1.4	1.0	3.1	4.9
8.6	4.8	3.2	1.2	0.92	3.1	2.4	1.7	1.4	3.5	5.3
8.9	5.2	3.3	1.2	1.0	3.1	2.5	1.7	1.4	3.8	5.4
9.2	5.2	3.5	1.2	1.0	3.2	2.7	1.5	1.5	3.8	5.6
9.6	5.4	3.5	1.2	1.1	3.7	2.8	1.8	1.7	4.1	5.8

TABLE 2.—Measurements (mm) of *Sebastolobus altivelis*. Specimens below dashed line have completed transformation into pelagic juvenile stage.

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-dorsal fin	Snout-anal fin
10.1	6.2	3.8	1.2	1.2	3.8	2.8	1.8	1.7	4.2	6.4
10.5	6.5	4.2	-	1.2	3.9	3.0	1.9	1.8	4.4	6.7
11.2	6.9	4.5	1.3	1.4	4.2	3.5	2.1	2.4	5.2	7.3
12.7	7.3	4.6	1.3	1.5	4.7	3.8	2.0	2.5	5.4	7.9
13.4	8.0	5.0	1.5	1.6	4.8	3.7	2.0	2.5	5.4	8.3
14.4	8.8	6.2	1.7	2.1	5.7	5.0	2.7	3.1	6.0	9.6
15.2	10.1	6.1	1.8	1.9	6.3	5.2	2.8	2.9	6.7	10.6
15.4	9.8	6.0	1.7	2.2	6.4	4.7	2.8	2.9	6.9	10.1
15.4	9.9	6.5	1.9	2.2	6.3	5.8	2.9	3.8	6.8	11.0
15.7	10.3	6.8	2.1	2.1	6.9	5.8	2.9	3.8	6.7	10.8
16.0	10.3	6.2	1.8	2.0	7.1	5.4	3.1	3.3	7.0	10.6
16.3	10.3	7.2	2.1	2.2	6.6	6.2	3.0	4.0	6.8	11.2
16.6	10.8	7.4	1.8	2.4	6.6	6.4	3.0	3.4	7.6	11.8
16.7	11.2	6.7	1.9	2.2	7.5	5.8	3.2	3.3	7.1	11.3
17.6	11.5	7.6	2.0	2.5	7.2	6.8	3.2	4.2	7.1	12.2
17.6	11.7	7.0	1.9	2.4	7.3	5.9	3.1	3.8	7.7	12.0
18.2	12.0	7.7	2.1	2.6	7.3	6.3	3.1	4.2	7.8	12.7
18.4	12.5	7.1	2.0	2.5	8.3	6.2	3.6	4.2	7.5	12.8
19.3	13.2	7.9	2.1	2.5	8.5	6.7	3.8	3.8	8.3	13.4
19.4	13.0	8.5	2.3	2.5	8.7	7.6	3.8	4.7	8.4	14.0
20.7	13.8	8.5	2.6	2.3	8.4	7.6	3.7	4.8	8.6	14.7
21.3	14.9	9.2	2.8	2.8	9.0	8.1	3.8	4.8	9.5	15.2
22.6	15.9	9.6	2.5	3.1	9.2	8.8	4.2	5.6	9.5	16.7
23.4	16.6	9.8	2.5	2.7	10.1	9.0	4.4	5.6	9.5	17.4
24.5	17.7	10.8	2.9	3.4	11.0	10.0	4.5	5.8	10.1	18.1
25.8	18.6	10.6	2.9	2.9	11.3	9.3	4.4	5.9	10.1	18.9
26.8	17.7	10.6	2.8	3.8	10.6	11.0	4.8	6.5	10.1	18.8
27.7	20.3	11.5	2.9	3.6	12.2	11.0	5.4	7.1	11.7	22.0
28.3	20.3	12.0	3.2	3.7	12.2	11.5	5.0	7.1	11.5	21.8
29.4	20.4	12.3	3.3	3.8	11.5	11.5	5.2	7.2	12.3	21.1
30.5	21.1	13.0	3.8	3.6	11.7	11.7	5.4	7.6	12.3	23.0
31.4	21.1	12.3	3.2	3.5	13.7	12.2	5.8	7.5	12.3	22.9
32.4	21.1	12.5	3.5	3.6	13.0	12.8	5.8	8.3	12.5	22.2
33.6	23.1	14.0	4.2	4.2	13.5	11.7	5.8	7.5	12.8	25.1
34.6	23.5	13.4	3.8	3.8	14.2	13.5	6.0	8.2	13.7	25.5
36.5	25.0	15.2	4.2	4.8	15.5	14.7	6.7	9.2	14.9	27.5
37.5	25.8	15.0	4.2	4.6	15.9	14.4	6.7	8.3	14.7	27.6
38.5	25.6	15.2	4.0	4.8	16.0	15.7	6.6	9.8	15.2	27.5
39.5	27.9	16.2	5.0	4.8	16.0	15.0	6.7	8.9	16.0	29.9
40.4	27.1	16.4	5.0	4.8	15.2	15.0	6.8	10.8	16.0	30.0
41.6	27.9	16.4	4.3	5.8	15.9	15.2	7.1	10.1	16.2	29.6
42.3	28.1	16.9	4.6	5.2	17.4	15.2	7.2	10.0	15.9	29.4
43.5	30.1	16.9	5.2	5.4	16.0	14.7	6.7	9.5	17.4	32.4
44.4	30.0	17.9	-	4.8	16.4	16.4	7.1	9.5	17.2	32.2
45.1	29.5	18.2	4.8	5.4	17.6	16.0	7.8	10.1	17.2	32.0
46.2	30.7	17.9	5.0	4.9	17.7	17.1	8.1	11.5	17.1	33.5
47.1	30.2	18.1	5.0	5.6	17.1	15.2	7.0	10.3	17.7	33.0
48.5	32.0	18.6	5.4	5.8	18.6	16.9	7.8	10.5	17.7	34.7
49.5	32.2	19.8	5.0	5.8	18.6	18.1	8.3	11.8	16.4	36.2
51.3	37.0	20.6	6.7	5.8	18.8	17.4	8.0	11.3	18.9	40.0
53.5	35.7	20.6	6.2	7.5	18.6	16.9	8.2	11.0	18.7	37.8
56.0	37.6	21.4	5.8	7.7	19.2	19.8	8.3	12.3	20.3	40.6
*42.0	26.8	16.6	4.6	5.6	12.0	12.7	6.0	9.3	16.4	29.0
*47.4	29.6	17.7	4.7	6.9	13.9	13.5	6.8	10.1	18.1	31.7
*48.1	31.4	19.1	5.2	7.3	14.4	15.2	7.0	11.5	17.9	33.5
*50.3	33.0	19.2	5.4	7.3	14.0	13.8	7.1	11.8	18.8	35.3
*51.0	33.0	19.5	4.7	7.2	15.0	16.2	7.5	11.2	18.7	35.2
*53.0	33.4	20.5	5.4	8.6	14.6	15.5	7.0	12.1	19.9	37.7
*54.0	35.4	19.7	5.9	7.3	15.5	17.7	7.8	12.6	20.6	38.4
*56.0	35.2	21.1	5.6	7.7	15.5	16.4	7.4	12.6	20.8	38.1
*57.5	37.2	21.4	5.6	8.0	15.3	16.7	8.1	12.5	21.1	40.3
*58.6	37.9	22.6	6.0	8.7	16.5	16.9	8.2	12.7	21.6	40.6
*60.0	38.0	22.0	6.0	8.4	16.2	15.1	8.1	12.8	21.5	41.6

*Benthic juvenile.

TABLE 3.—Measurements (mm) of larvae and juveniles of *Sebastolobus alascanus*.

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-dorsal fin	Snout anal fin
10.3	6.2	4.2	1.5	1.2	4.0	3.2	1.6	1.9	4.3	6.8
11.2	7.4	5.0	1.8	1.3	4.1	3.2	1.7	2.1	5.0	7.7
11.7	7.2	5.0	-	1.3	3.9	3.1	1.8	2.1	5.1	7.7
12.5	7.7	4.7	1.7	1.5	4.5	3.6	1.8	2.4	5.4	8.3
13.2	7.3	5.0	1.6	1.8	4.6	3.9	1.9	2.7	5.8	8.2
14.0	8.1	5.7	1.8	2.1	4.9	4.1	1.9	2.5	6.2	8.8
14.4	8.4	5.6	1.4	1.8	5.2	4.2	2.1	2.6	5.7	9.1
15.2	9.2	6.2	1.8	2.0	5.2	4.4	2.1	2.9	6.3	10.0
16.0	9.3	6.2	2.0	2.0	5.2	4.8	2.2	2.9	7.1	10.0
16.4	9.8	6.7	1.8	2.5	5.7	4.7	2.3	3.2	7.1	10.5
16.9	10.0	6.8	1.9	2.3	5.9	4.8	2.4	3.1	7.3	10.8
17.6	10.6	6.7	2.1	2.2	6.1	4.9	2.3	3.5	7.1	11.3
18.6	12.7	-	-	2.8	6.8	5.4	2.8	3.8	8.5	13.2
19.8	12.0	7.7	2.0	2.8	7.1	5.9	2.9	4.0	8.3	13.0
20.0	12.0	8.1	2.2	2.9	7.1	6.4	2.8	4.2	8.4	13.0
20.3	12.8	8.2	1.8	3.1	7.2	6.2	7.8	4.0	8.1	13.5
21.0	13.5	8.6	1.9	3.1	7.5	6.5	3.0	4.6	8.1	14.4
21.4	12.8	8.3	2.4	2.9	7.1	6.2	2.8	3.8	8.6	14.4
21.9	12.8	8.5	2.1	3.1	7.1	6.2	2.8	4.2	8.8	14.9
22.3	14.2	9.6	-	2.8	7.9	6.5	3.2	4.4	9.1	15.4
22.9	14.4	9.8	2.6	3.2	7.5	6.7	3.1	4.6	9.3	15.5
23.2	14.7	9.5	2.5	2.9	7.9	7.2	3.0	5.0	9.6	16.0
23.4	14.9	9.0	2.2	3.3	8.0	7.1	3.2	5.0	9.3	16.4
24.0	14.4	9.8	2.2	3.2	8.0	6.8	3.3	5.0	9.8	15.9
24.3	15.5	10.0	2.8	3.2	8.6	7.3	3.3	5.0	9.8	16.9
25.1	15.9	10.0	3.0	3.3	8.4	7.0	3.4	5.0	10.1	17.2
25.5	16.0	10.1	2.8	3.5	8.8	8.2	3.7	5.5	10.1	17.6
26.4	17.9	10.6	3.2	3.5	9.0	8.0	3.7	5.7	11.3	19.1
27.2	17.9	11.2	3.0	-	8.3	8.1	3.3	5.4	10.8	19.3
*22.5	13.0	8.7	2.1	3.2	7.2	6.3	2.9	4.6	9.6	14.7
*25.3	16.9	10.3	3.5	3.2	8.1	6.8	3.3	5.0	11.2	18.9
*37.8	22.0	12.7	2.9	5.0	10.1	9.6	4.2	8.2	13.5	24.3
*39.0	24.0	14.1	4.0	5.1	9.9	9.8	4.0	8.8	15.0	26.7
*40.8	25.1	14.8	3.8	5.3	10.0	9.7	3.8	8.8	15.3	27.3
*42.3	27.7	15.4	4.3	5.8	10.1	10.0	4.2	9.0	16.3	29.6
*43.6	26.3	15.4	4.1	5.8	9.5	10.6	4.4	9.4	16.1	29.5
*44.7	26.2	15.9	4.3	5.8	11.2	10.5	4.8	8.1	16.9	29.7
*46.2	28.1	16.2	4.4	6.4	10.8	10.8	4.7	9.9	16.7	31.2
*48.8	29.1	16.8	4.7	6.5	11.4	11.4	4.7	10.5	18.0	32.9
*50.3	29.4	17.4	4.8	7.0	12.4	12.2	5.0	10.6	18.0	33.0
*51.0	30.6	17.5	5.0	6.8	11.8	11.5	5.2	10.5	17.5	33.6
*59.2	36.6	20.6	5.4	8.4	13.0	13.5	5.6	12.1	20.8	40.0
*60.0	36.8	21.6	5.7	9.0	14.3	14.3	5.9	13.0	21.5	39.7

* Benthic juvenile.

TABLE 4.—Measurements (mm) of pelagic juveniles of *Sebastolobus macrochir*.

Standard length	Snout-anus distance	Head length	Snout length	Eye diameter	Body depth	Pectoral fin length	Pectoral fin base depth	Pelvic fin length	Snout-dorsal fin	Snout-anal fin
21.0	14.5	9.2	2.5	3.1	9.1	9.2	3.8	5.4	10.0	15.0
25.5	17.9	10.8	3.0	4.5	11.2	11.2	4.7	7.1	11.3	18.2
27.2	18.6	11.8	3.8	4.3	12.5	11.0	4.8	7.7	12.2	19.1
29.8	19.2	13.2	3.0	5.0	13.2	13.2	5.7	8.5	13.5	20.8

TABLE 5.—Meristics from cleared and stained larvae and juveniles of *Sebastolobus* spp. (above dashed line) and *Sebastolobus altivelis* (below dashed line).

Length (mm)	Primary caudal fin rays		Secondary caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	Superior	Inferior	Superior	Inferior	Left	Right	Left	Right	Superior	Inferior	Upper limb	Lower limb			Left	Right	
6.2	-	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-
6.8	-	-	-	-	3	3	14	2	-	-	-	3	-	-	-	-	-
7.0	8	7	-	-	5	5	14	12	-	-	-	2	-	-	-	-	-
7.7	8	7	4	4	7	7	23	24	2	1	3	9	III-5	XV-9	I-5	I-5	28
8.1	8	7	-	2	7	7	23	23	-	-	3	9	III-3	XV-9	I-5	I-5	28
8.3	8	7	3	4	7	7	23	23	2	1	2	8	III-5	XV-9	I-5	I-5	27
8.8	8	7	4	5	7	7	23	24	2	2	3	10	III-5	XV-9	I-5	I-5	29
9.3	8	7	3	4	7	7	24	24	2	1	3	10	III-5	XV-9	I-5	I-5	29
10.1	8	7	6	8	7	7	23	23	1	2	5	12	III-5	XV-9	I-5	I-5	29
10.6	7	7	6	7	7	7	23	23	1	2	5	13	III-6	XV-10	I-5	I-5	29
11.2	8	7	6	7	7	7	23	23	1	2	5	13	III-5	XV-9	I-5	I-5	28
11.5	8	7	7	7	7	7	23	23	1	2	5	13	III-5	XV-9	I-5	I-5	29
12.0	8	7	6	7	7	7	23	23	2	2	5	13	III-5	XV-8	I-5	I-5	28
13.0	8	7	6	7	7	7	23	24	2	2	6	13	III-5	XV-10	I-5	I-5	29
13.7	8	7	6	7	7	7	23	23	2	2	5	13	III-5	XV-9	I-5	I-5	29
14.4	8	7	7	7	7	7	23	24	2	2	6	14	III-5	XV-9	I-5	I-5	29
15.0	8	7	7	7	7	7	23	23	2	2	6	13	III-5	XV-9	I-5	I-5	29
16.6	8	7	7	7	7	7	23	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
17.6	8	7	8	7	7	7	23	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
18.1	8	7	7	7	7	7	24	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
19.4	8	7	7	7	7	7	22	22	2	2	6	14	III-5	XV-9	I-5	I-5	29
20.6	8	7	8	8	7	7	23	23	2	2	7	14	III-5	XV-9	I-5	I-5	29
25.8	8	7	8	9	7	7	24	23	2	2	6	15	III-5	XV-9	I-5	I-5	29
30.5	8	7	6	7	7	7	24	24	2	2	7	15	III-5	XVI-9	I-5	I-5	29
40.4	8	7	7	7	7	7	23	23	2	2	7	15	III-5	XV-9	I-5	I-5	29
50.0	8	7	7	7	7	7	23	23	2	2	7	14	III-5	XV-8	I-5	I-5	29

TABLE 6.—Meristics from cleared and stained larvae and juveniles of *Sebastolobus alascanus*.

Length (mm)	Primary caudal fin rays		Secondary caudal fin rays		Branchiostegal rays		Pectoral fin rays		Hypural elements		Gill rakers (right arch)		Anal fin rays	Dorsal fin rays	Pelvic fin rays		Vertebrae
	Superior	Inferior	Superior	Inferior	Left	Right	Left	Right	Superior	Inferior	Upper limb	Lower limb			Left	Right	
7.5	8	7	3	4	7	7	21	21	2	2	3	9	III-5	XVI-8	I-5	I-5	30
11.0	8	7	3	5	7	7	22	22	1	2	4	9	III-5	XVI-9	I-5	I-5	30
11.7	8	7	6	6	7	7	22	22	2	2	4	10	III-5	XVI-8	I-5	I-5	30
12.5	8	7	7	8	7	7	21	21	2	2	5	12	III-5	XVI-10	I-5	I-5	30
13.2	8	7	8	7	7	7	21	22	2	2	5	12	III-5	XVI-9	I-5	I-5	30
14.4	8	7	9	9	7	7	22	22	2	2	5	13	III-5	XVI-9	I-5	I-5	30
15.2	8	7	8	8	7	7	22	22	2	2	5	12	III-5	XVI-9	I-5	I-5	30
16.4	8	7	9	9	7	7	21	21	2	2	7	13	III-5	XVII-9	I-5	I-5	30
17.6	8	7	9	9	7	7	21	21	2	2	6	13	III-5	XVI-9	I-5	I-5	30
18.6	8	7	9	9	7	7	22	22	2	2	6	13	III-5	XVI-9	I-5	I-5	30
19.8	8	7	8	8	7	7	22	22	2	2	6	13	III-5	XVI-9	I-5	I-5	30
20.3	8	7	9	8	7	7	22	22	2	2	5	13	III-5	XVI-9	I-5	I-5	31
21.4	8	7	8	8	7	7	22	22	2	2	6	13	III-5	XVI-9	I-5	I-5	30
22.3	8	7	8	8	7	7	22	22	2	2	6	12	III-5	XVI-9	I-5	I-5	30
24.3	8	7	9	8	7	7	21	21	2	2	7	14	III-4	XVI-9	I-5	I-5	30
25.5	8	7	9	9	7	7	22	22	2	2	6	14	III-5	XV-10	I-5	I-5	30
26.4	8	7	9	9	7	7	21	21	2	2	7	12	III-5	XV-9	I-5	I-5	30
27.2	8	7	10	10			21	21	2	2	7	13	III-5	XVI-10	I-5	I-5	30

DESCRIPTION OF DEVELOPMENT

Distinguishing Features

Early *Sebastolobus* larvae (up to 6 mm) can be distinguished from those of all other genera of eastern Pacific Scorpaenidae on the basis of pigmentation. *Sebastolobus* larvae of this size range are unique in having two large melanistic blotches about midway along the tail, one at the dorsal midline and one at the ventral midline (Figure 1A, B). These are sometimes expanded to form a solid band on the tail. Early larvae of all other eastern Pacific scorpaenid genera have a series of melanophores along the ventral midline of the tail, and in some species of *Sebastes* an opposing row is present at the dorsal midline. The large tail blotches of *Sebastolobus* disappear in larvae between 5.0 and 6.5 mm. Soon after the loss of these large tail blotches in *Sebastolobus* the larvae develop prominent crestlike parietal ridges that terminate in double spines, the posterior (nuchal) spine being longer and more prominent than the anterior (parietal) spine (Figure 1F). Of the other eastern Pacific scorpaenid genera, only the larvae of *Scorpaenodes* have parietal ridges and spines like *Sebastolobus*. If two spines are present on the parietal ridges of other genera, the anterior spine is always longer and more prominent than the posterior. *Sebastolobus* larvae may be distinguished from those of *Scorpaenodes* on the basis of a melanistic shield, which covers the dorsolateral surface of the gut in the former and is absent in the latter. Larvae of *Sebastolobus* smaller than 10.0 mm could not be distinguished to species. Larvae larger than this can be identified to species by a combination of characters. The pectoral fins of *S. altivelis* larvae are relatively longer and are wider at the base than in *S. alascanus*. Also, larvae of *S. altivelis* are deeper bodied than those of *S. alascanus*. Details of the structural and pigmentary characters that differentiate the larvae and juveniles of the two species are given below.

General Morphology

Sebastolobus larvae hatch and are freed from their transparent gelatinous egg masses at about 2.6 mm (Pearcy, 1962). The smallest larvae in our plankton collections are about 3.0 mm long and still have the elliptical yolk sac with a posteriorly positioned oil droplet (Figure 1A). When the larvae reach approximately 3.5 mm, the yolk sac has been resorbed and the jaws and feeding apparatus are well formed (Figure 1B). Flexion of the notochord begins in larvae about 6.0 mm long and is completed in larvae about 7.5 mm (Figure 1E, F). Larvae larger than 10.0 mm and pelagic and benthic juveniles can be identified to species on the basis of characters mentioned above (Figures 2-7). In both species, transformation into the pelagic juvenile stage is initiated within the size range of 14.0 to 20.0 mm. All specimens larger than 20.0 mm have some juvenile pigmentation. The largest pelagic juvenile of *S. alascanus* encountered was 27.2 mm, whereas the smallest benthic juvenile was 22.5 mm. In contrast, in the protracted pelagic juvenile stage of *S. altivelis*, individuals may attain 56.0 mm in length. The smallest benthic juvenile of this species in the collection was 42.0 mm. Pelagic juveniles of *S. macrochir* are similar in shape and pigmentation to those of *S. altivelis*. Although the largest pelagic specimen available was only 30 mm long, it is probable that pelagic juveniles of *S. macrochir* grow larger than this and have a protracted mid-water life as in *S. altivelis*.

Relative body depth (maximum body depth/standard length) changes markedly during development and is an important taxonomic character in the pelagic juveniles (Figure 8). It is 15% at the beginning of the larval period, almost doubles by the onset of notochord flexion, and averages 28% during flexion. It increases further to 35% in larvae 7.5 to 10.0 mm. Relative body depth remains at about this percentage in larvae and pelagic juveniles of *S. alascanus* but decreases sharply to an average of 25% (range of 22 to 32%) in benthic juveniles. Late-stage larvae and pelagic juveniles of *S. altivelis* are much more robust and deeper bodied, averaging 41% (range of 36 to 45%) in the 10- to 40-mm size range. Pelagic juveniles 40 to 50 mm long begin to show a decrease in body depth (mean 38%; range of 36 to 41%), 50- to 55-mm specimens show a further decrease (mean 35%; range of 34 to 37%) and the decrease is precipitous in benthic juveniles (mean 28%; range of 27 to 30%). Body depth in 21- to 30-mm pelagic juveniles of *S. macrochir* averaged 37.5% of the body length (range of 34 to 42%).

The gut has an unusual shape in early larvae up to about 5.5 mm. The narrow, dorsally positioned esophagus runs posteriad from the head for some distance before entering the principal mass of the gut. The effect of this is to produce a space between

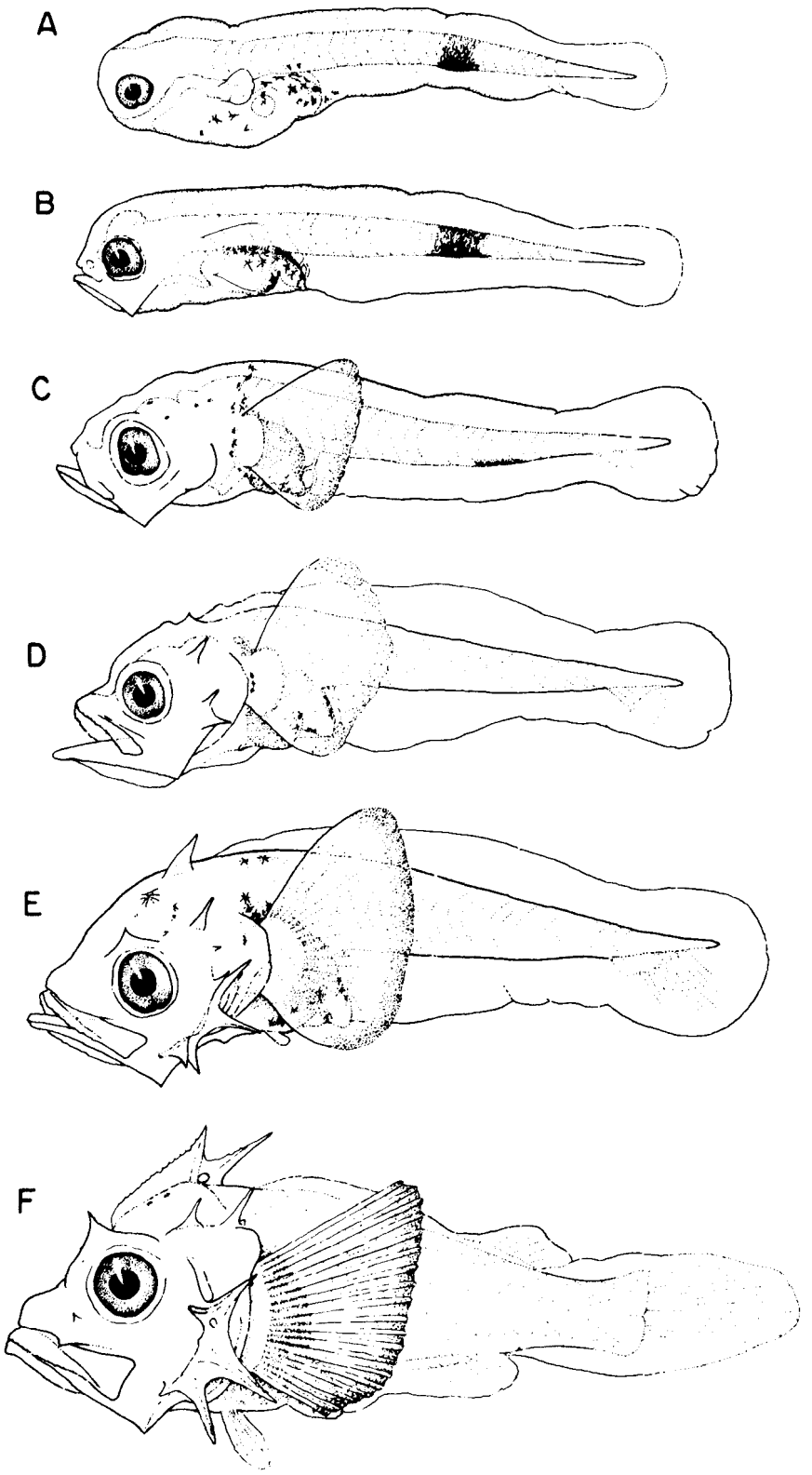

FIGURE 1.—Larvae of *Sebastolobus* spp. from CalCOFI plankton samples. A. 3.0 mm; B. 3.5 mm; C. 5.2 mm: D. 5.7 mm: E. 6.2 mm; F. 7.7 mm.

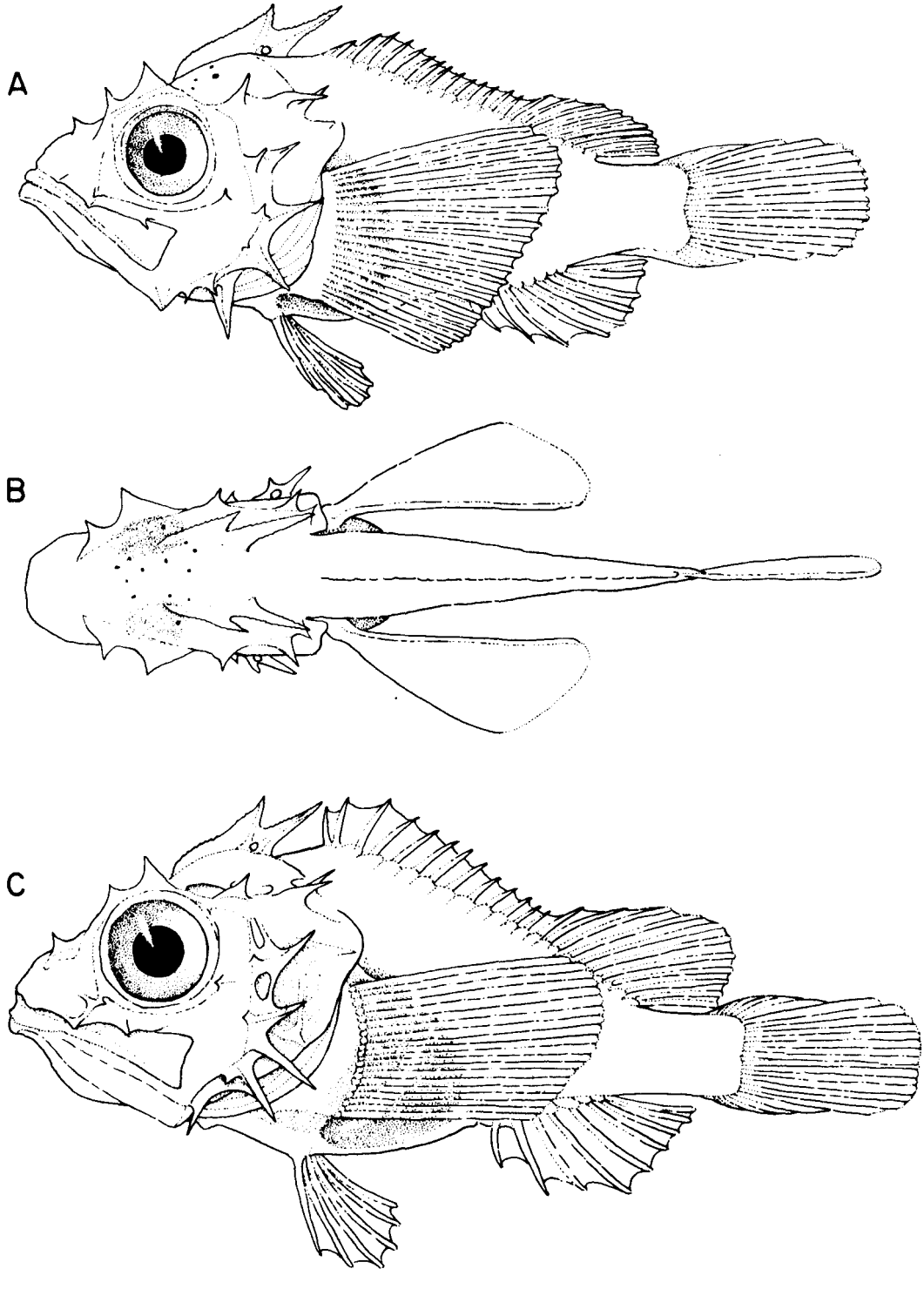

FIGURE 2.—Larvae of *Sebastolobus altivelis* from CalCOFI plankton samples. A. 11.2 mm; B. 11.2 mm, dorsal view; C. 15.4 mm.

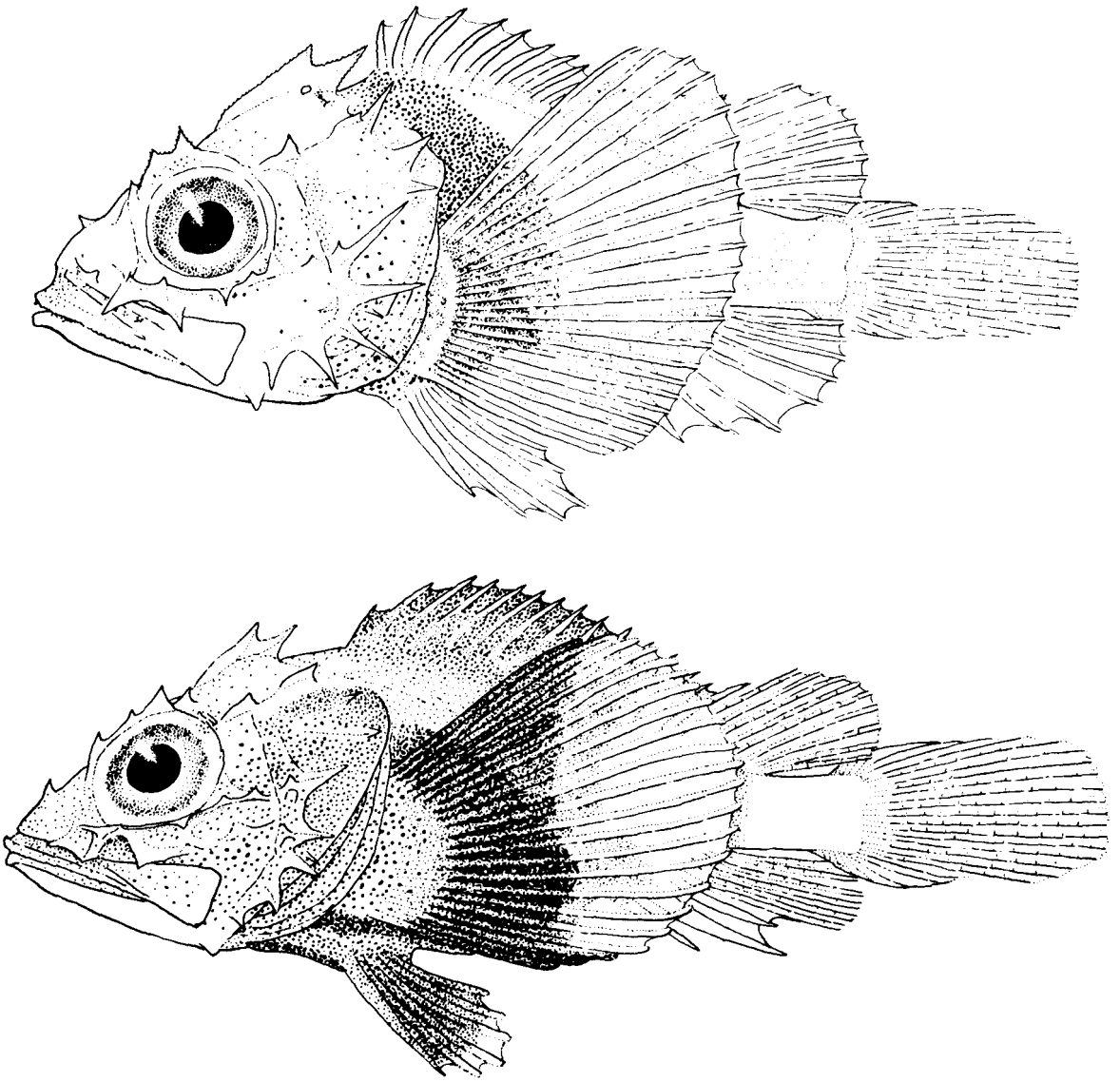

FIGURE 3.—Developmental stages of *Sebastolobus altivelis* from mid-water trawl samples. Above, 16.3-mm transforming specimen. Below, 26.8-mm pelagic juvenile.

the head and the gut (Figure 1B). The space gradually diminishes as the gut enlarges and is absent in larvae larger than 6.0 mm. Relative gut length increases markedly during development. Snout-anus distance averages 41% of the body length up to the stage of notochord flexion, 46% during flexion, and 56% in post-flexion larvae up to 10 mm in length. In larvae and transforming specimens of 10- to 20-mm *S. altivelis* there is an increase to a mean of 64% and in 20- to 56-mm pelagic juveniles there is a further increase to a mean of 68%. In early benthic juveniles snout-anus length averages 64% of body length. The gut is slightly shorter in *S. alascanus;* snout-anus length averages 61% of body length for the larvae and for the pelagic and early benthic juveniles.

The head is moderate in size in early larval stages but enlarges markedly with development. Head length increases from 23% of body length at hatching to an average of 31% during notochord flexion and is 37% in 7.5- to 10.0-mm larvae. Relative head length in larvae and pelagic juveniles of *S. altivelis* in the 10.0- to 40.0-mm size range averages 41%. A slight decrease to a mean of 39%

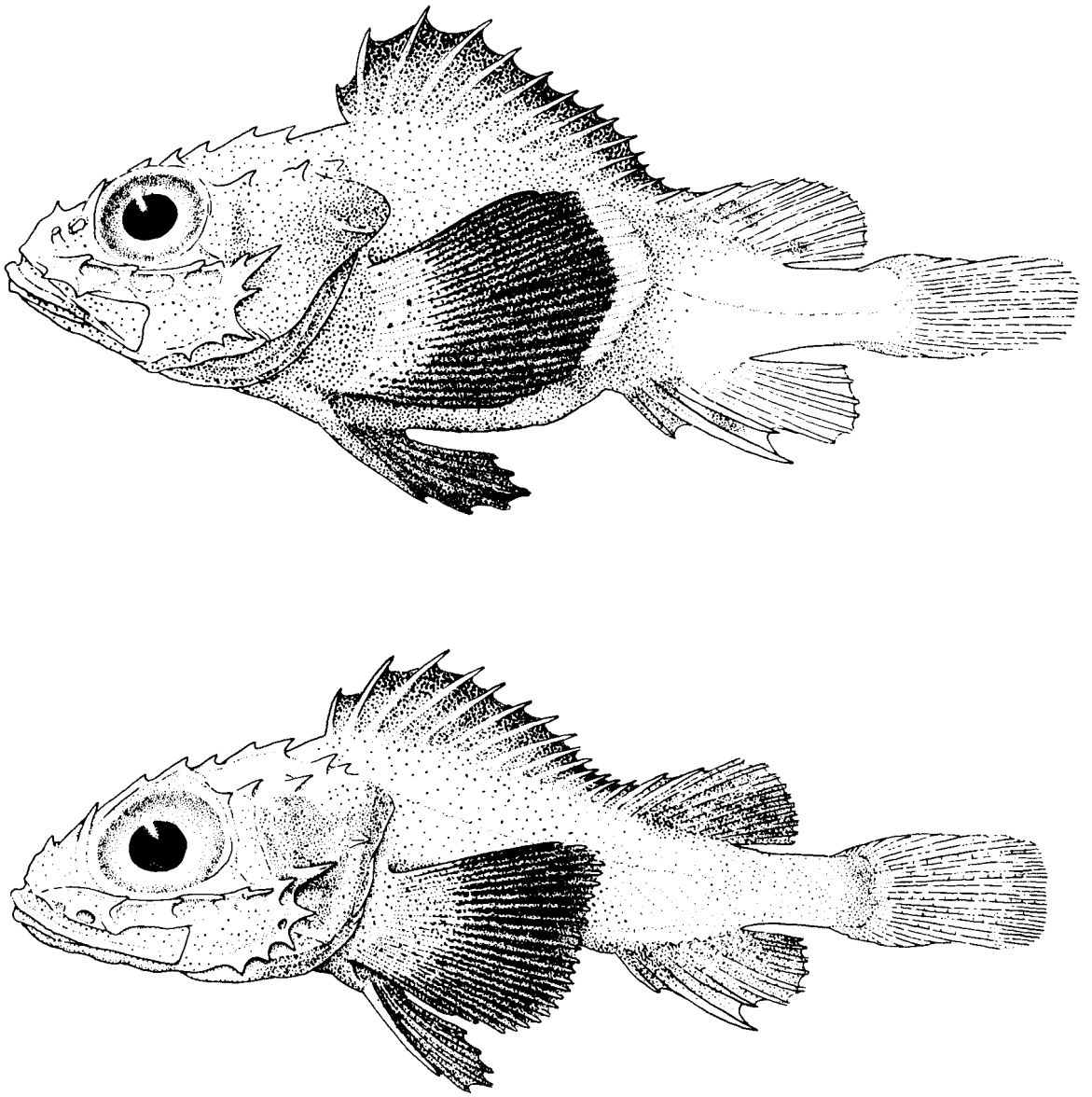

FIGURE 4.—Developmental stages of *Sebastolobus altivelis*. Above, 53.5-mm late pelagic juvenile from mid-water trawl. Below, 53.0-mm benthic juvenile from bottom trawl.

occurs in 40.0- to 56.0-mm specimens and early benthic juveniles average 38%. Virtually the same changes in relative head size occur in *S. alascanus*.

The eyes of early-stage *Sebastolobus* larvae are relatively smaller than in *Sebastes* larvae of comparable size. Eye diameter averages 26% of the head length for larvae up to the beginning of notochord flexion, 27% during flexion, and 28% in post-flexion larvae up to 10.0 mm in length. *Sebastes* larvae average 33 to 35% during comparable stages. Eye diameter in larvae and pelagic juveniles of *S. altivelis* 10.0- to 56.0-mm range) averages 31% of the head length, while in those of *S. alascanus*, eye diameter is slightly larger (mean 33%). In early benthic juveniles of both species, relative eye diameter increases sharply to a mean of 38% of head length. The snout is relatively short in pre-flexion larvae of *Sebastolobus* where snout length averages 27% of head length.

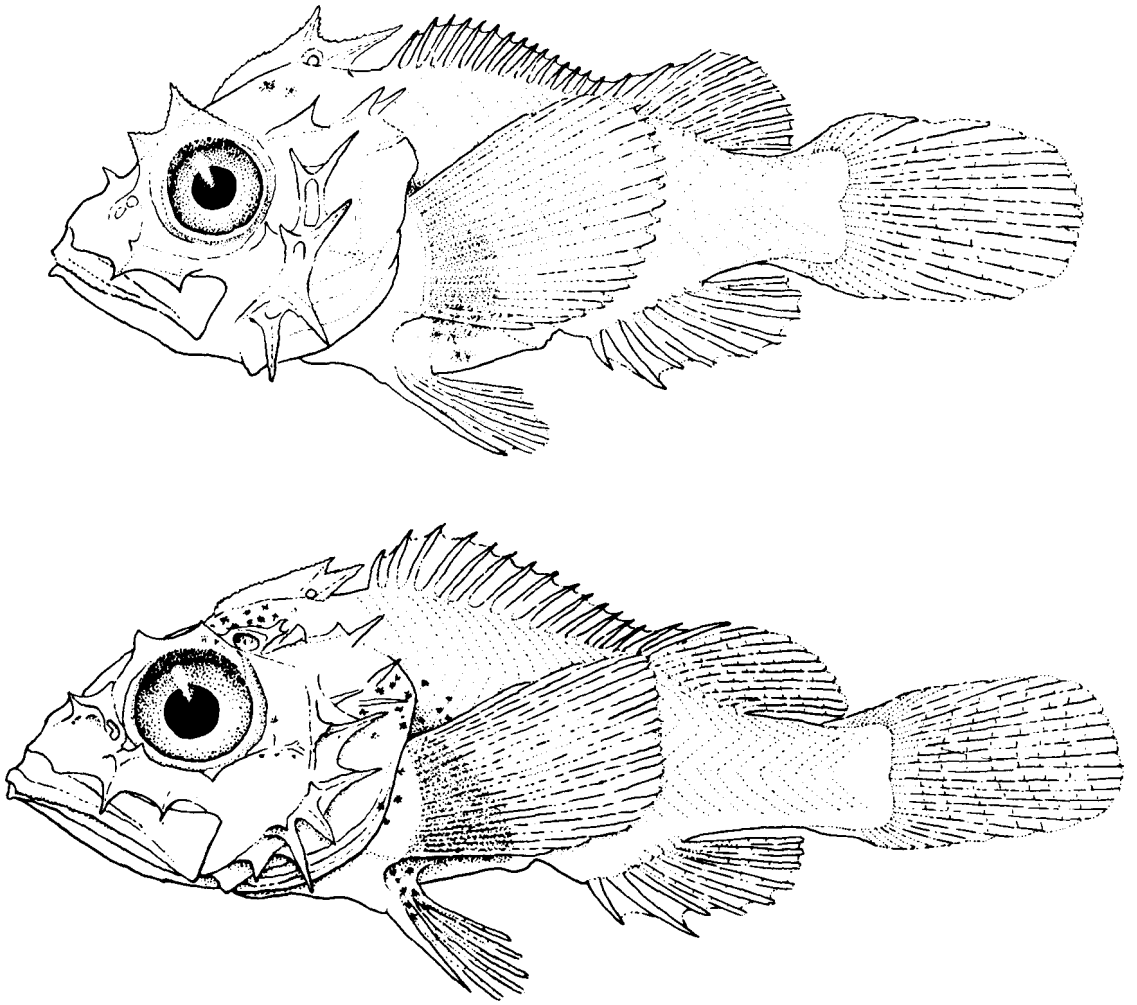

FIGURE 5.—Developmental stages of *Sebastolobus alascanus*. Above, 10.3-mm larva from mid-water trawl. Below, 16.0-mm transforming specimen from mid-water trawl.

This increases to an average 36% in 6.0- to 10.0-mm larvae. Later stages of *S. altivelis* average 28%. *Sebastolobus alascanus* in the 10.0- to 20.0-mm range average 31%, but this is reduced to 27% in the remaining stages.

Fin Development

The pectoral fins of *Sebastolobus* are undifferentiated buds in newly hatched larvae, however, when the larvae reach a length of 3.0 mm the base and blade portions of each fin are beginning to differentiate. From this stage until the initiation of notochord flexion at 6.0 mm the rayed portion of the fin enlarges rapidly to form the large fan-shaped structure characteristic of *Sebastolobus*. At this stage the fin length is about 17% of the body length. This increases to an average of 22% during notochord flexion and 27% in post-flexion larvae up to 10 mm length.

In specimens larger than 10 mm the relative length of the pectoral fin differs considerably between *S. altivelis* and *S. alascanus* (Figure 9). In specimens of *S. altivelis* in the 10- to 20-mm size range, the pectoral fin length averages 34% of the body length (range of 29 to 39%). The pectorals reach their maximum relative length in 20- to 40-mm pelagic juveniles where they average 39% of the body length (range of 35 to 41%). In pelagic juveniles 40 to 50 mm long the average is 35% (range of 32 to 37%), and the fins are still shorter in early benthic juveniles 42 to 60 mm long where they average 29% of the body length (range of 25

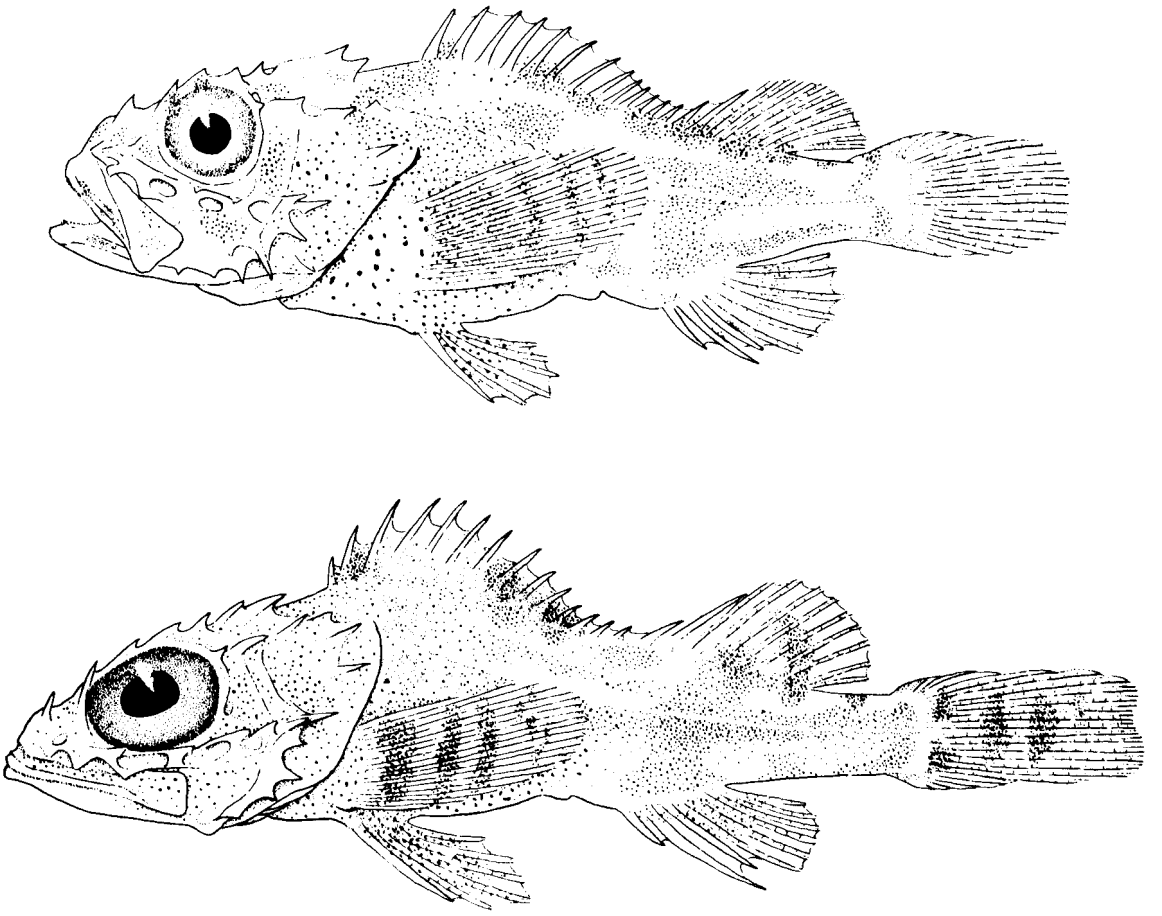

FIGURE 6.—Juveniles of *Sebastolobus alascanus*. Above, 25.3-mm newly transformed benthic juvenile from bottom trawl. Below, 50.3-mm benthic juvenile from bottom trawl.

to 33%). The pectoral fins of *S. alascanus* are considerably shorter than those of *S. altivelis* at comparative sizes. In specimens 10 to 20 mm long fin length averages 29% of body length (range of 26 to 31%). In 10- to 27-mm pelagic specimens pectoral fin length averages 29% of the body length (range of 26 to 32%). In early benthic juveniles 22 to 60 mm long, fin length is reduced to an average of 24% (range of 23 to 28%). The pectoral fin in pelagic juveniles of *S. macrochir* is even longer than in *S. altivelis*. In 21- to 30-mm specimens fin length averaged 43% of the body length (range of 40 to 44%).

The depth of the pectoral fin base is a particularly useful character in distinguishing the larvae of *Sebastolobus* from those of *Sebastes* and is also useful in separating the two species of *Sebastolobus* (Figure 10). In larvae of *Sebastes* examined (e.g., *S. paucispinis*) the depth of the fin base is about 9 or 10% of the body length through notochord flexion; thereafter it gradually diminishes, relative to body length, to about 5 or 6% in the smallest pelagic juveniles. In *Sebastolobus* there is an opposite trend of relative increase from an average of 11% (range of 10 to 15%) in pre-flexion larvae, to 18% (range of 15 to 20%) in subsequent stages of *S. altivelis* up to about 40 mm in length. In larger pelagic juveniles of *S. altivelis* the depth of the pectoral fin base begins to decrease in relation to body length. In 40- to 50-mm specimens the average is 16.5% (range of 15 to 18%) and in 50- to 56-mm pelagic juveniles it is 15% (range of 15 to 16%). It is further reduced to 14% (range of 13 to 15%) in 42- to 60-mm benthic juveniles. The pectoral fin base in *S. alascanus* is significantly shallower

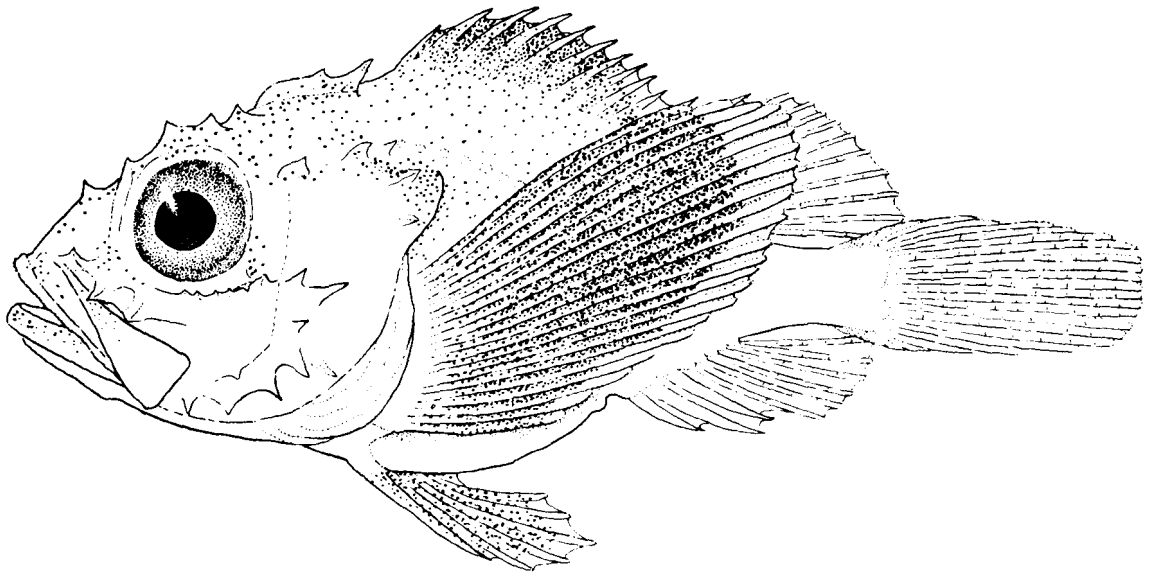

FIGURE 7.—Pelagic juvenile of *Sebastolobus macrochir* from off Kamchatka (27.2 mm).

than in *S. altivelis*. In *S. alascanus* larvae and pelagic juveniles 10 to 30 mm long the fin depth averages 14% of the body length (range of 12 to 16%). In 22- to 60-mm benthic juveniles this is reduced to an average of 10% (range of 9 to 11%).

Ossification of the pectoral fin rays begins in 6.0-mm larvae of *Sebastolobus* (Table 5). The full complements of pectoral rays, 23 to 24 for *S. altivelis* and 21 to 22 for *S. alascanus*, are present in 7-mm larvae (Tables 5, 6).

The pelvic fin buds appear in larvae of about 6.0 mm and elongate to about 12% of the body length by the completion of notochord flexion. Fin length increases to about 17 to 18% of the body length in post-flexion larvae up to 10 mm in length. In *S. altivelis* this increases further to about 24% in pelagic juveniles 20 mm long, and averages 24% (range of 21 to 27%) for the remainder of the pelagic phase. There is a slight decrease to 22% (range of 21 to 24%) in benthic juveniles up to 60 mm long. The pelvic fin is slightly shorter in *S. alascanus* averaging 19% (range of 18 to 20%) in 10- to 20-mm specimens, and 21% (range of 18 to 33%) in larger pelagic juveniles and in benthic juveniles up to 60 mm long. The full complements of one spinous ray and five soft rays are beginning to ossify in 7-mm larvae of *S. altivelis* and *S. alascanus*.

The hypural thickening of the caudal fin first appears in larvae about 3.5 mm long. The hypurals begin to ossify in 7-mm larvae of both species and the full complements of two superior and two inferior elements are ossified in 12-mm larvae of both species. The full complements of eight superior and seven inferior principal caudal rays are beginning to ossify in 7-mm larvae of *Sebastolobus*. The procurrent caudal rays also begin to ossify in 7-mm larvae. The full complements of 6

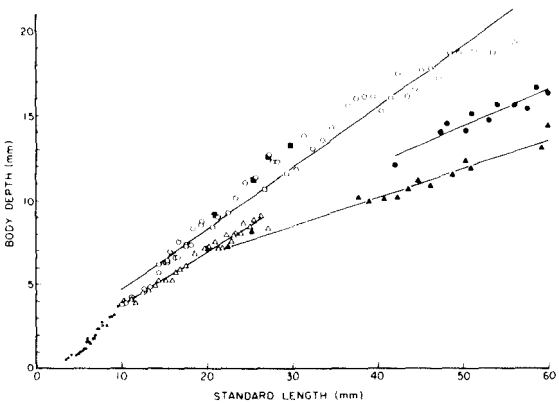

FIGURE 8.—Relationship of body depth to body length in developmental stages of *Sebastolobus*. Small dots = larvae less than 10 mm not identifiable to species. Large open circles = larvae and pelagic juveniles of *S. altivelis*. Large dots = benthic specimens of *S. altivelis*. Open triangles = larvae and pelagic juveniles of *S. alascanus*. Solid triangles = benthic specimens of *S. alascanus*. Solid squares = pelagic specimens of *S. macrochir*. Lines fitted by method of least squares. No regression line drawn for *S. macrochir*.

to 9 superior and 7 to 9 inferior procurrent rays are present in 10-mm larvae of *S. altivelis* and the full complements of 8 to 10 superior and inferior elements are present in 12- to 13-mm larvae of *S. alascanus*.

The dorsal and anal fins begin to develop in 6-mm larvae of *Sebastolobus* and the full complements of rays are ossifying in 7-mm larvae of both species. In *S. altivelis* the usual number of spinous dorsal rays is 15 and in *S. alascanus* the usual number is 16. Both species have 8 to 10 soft dorsal rays with a usual number of 9.

Pigmentation

The melanophore pattern of embryos and yolk-sac larvae of *Sebastolobus* has been described by Pearcy (1962). At the beginning of the larval stage (3.5 mm) the melanophore pattern is distinctive. Large median melanistic blotches oppose each other about midway back on the tail (Figure 1A, B). In some specimens, the blotches are expanded to form a band. Also, melanophores cover the dorsolateral surfaces of the posterior region of the gut. The melanistic tail blotches are transitory; they are lost in some larvae as small as 4.2 mm and one or both are absent in most larvae between 5.0 and 6.0 mm in length. The dorsal spot was absent in all larvae larger than 6.0 mm and the ventral spot was absent in all larger than 6.4 mm. In contrast, the gut pigment is augmented throughout the larval period, extending forward to the axillary region and internally anterior to the cleithrum in larvae about 5.0 mm long. When the larvae reach 6.0 mm the pigment extends onto the ventral surface of the gut and dorsally as deeply embedded pigment at the nape. With continued development the melanophores form a solid sheath on the peritoneum surrounding the gut.

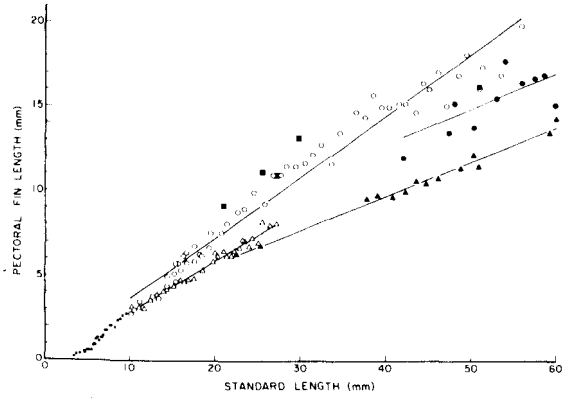

FIGURE 9.—Relationship of pectoral fin length to body length in *Sebastolobus*. Symbols as in Figure 8.

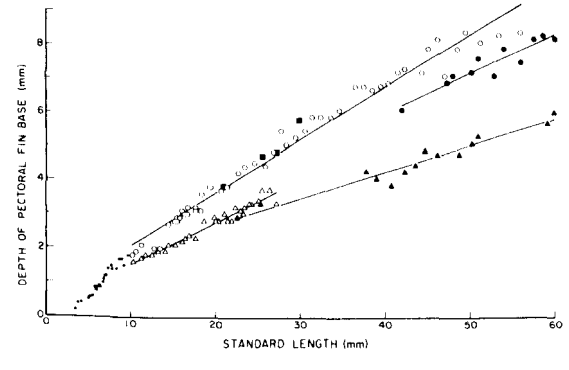

FIGURE 10.—Relationship of depth of pectoral fin base to body length in *Sebastolobus*. Symbols as in Figure 8.

Melanophores appear at the posterior margin of each pectoral fin in some larvae as small as 4.0 mm. About half the larvae examined between 4.0 and 5.0 mm have this posterior margin of fine melanophores and the pigment is present in all larvae in the 5.0- to 11.0-mm range. The melanophores are then lost, and almost all larvae larger than 11.0 mm have pigmentless fins.

Melanophores appear on the posterior lobes of the brain in 5.2- to 7.0-mm larvae and are present in all larvae larger than this. They also appear above the anterior lobes of the brain in larvae between 7.0 and 9.0 mm in length and in most larvae larger than 9.0 mm.

Juvenile pigmentation begins to appear in some specimens of *S. altivelis* of the 14- to 20-mm size range. On the head, patches of melanophores appear on the opercle, cheek, snout, and jaws. In most specimens larger than 22 mm, the patches are confluent, and the head is generally dusky with darker areas at the opercle and along the upper jaw.

A patch of melanophores appears superficially over each side of the gut in specimens as small as 14 mm. These patches expand to form a solid melanistic sheath in some specimens of the 14- to 20-mm size range. The posterior margin of the sheath is an arc running from the vent to the nape and stands out sharply against the pigmentless region of the trunk posterior to the sheath. With continued development the pigment sheath expands posteriad and is a striking feature of the pelagic juveniles. In the 20- to 30-mm size range the sheath extends posteriad to a vertical from the

first or second anal fin spines. In the 30- to 40-mm size range the sheath extends posteriad to the 2nd or 3rd anal spine in most specimens and to the soft dorsal fin in some. In most pelagic juveniles of the 40- to 50-mm size range the dusky sheath extends back to the soft dorsal and it does so in all specimens of the 50- to 60-mm size range. When the juveniles become benthic, the dusky sheath extends posteriad to the caudal fin.

The fins become deeply and characteristically pigmented in juveniles of *S. altivelis*. The anterior portion of the spinous dorsal fin becomes melanistic in specimens as small as 18 mm. In juveniles of the 20- to 25-mm size range the anterior one-half to two-thirds of the fin is melanistic. In the 25- to 30-mm range three-fourths or more of the fin is black. In pelagic juveniles larger than this the pigment has spread onto the soft dorsal fin, and covers both the soft dorsal and soft anal fins in benthic juveniles.

The bases of the pectoral fins begin to be covered with melanophores in specimens as small as 14 mm. In specimens as small as 18 mm the melanophores extend onto the basal region of the rays. With further growth this black basal zone enlarges posteriad and becomes a highly characteristic feature of the pelagic juveniles. The posterior margin of this zone contrasts sharply with the distal clear region of the fin. In juveniles of the 19- to 25-mm size range the width of the black basal zone averaged 20% of the fin length. Enlargement of this zone is shown by the average relative widths for successive size ranges (25 to 30 mm, 38%; 30 to 35 mm, 46%; 35 to 40 mm, 54%; 40 to 45 mm, 65%; 45 to 50 mm, 72%; 50 to 55 mm, 76%). Towards the end of the pelagic juvenile stage a pale translucent layer covers the basal region of the pectoral fin and thus gives the black zone the appearance of a band. The huge pectoral fins, each with their broad black band, are distinctive features of the pelagic juveniles of *S. altivelis*. When the juveniles become benthic the black zone extends to the tips of the fins. Like the pectoral fins, the pelvic fins also develop a black-pigment zone that enlarges with development. In 20- to 25-mm juveniles the basal one-quarter to three-quarters of each fin may be black, although in the majority of specimens the basal one-half is black. In the 25- to 30-mm range most specimens have three-fourths or more of the fin black and in juveniles larger than 30 mm either the fin is entirely black or the extreme tips of the rays are pigmentless.

Juvenile pigment begins to appear in *S. alascanus* in the 14- to 20-mm size range. The first head pigment to appear is a melanistic blotch on the posterior region of the opercle. This gradually spreads anteriorly onto the cheek and in late-stage pelagic juveniles the entire head is speckled with melanophores. A blotch begins to form over each side of the gut in larvae as small as 15 mm. These enlarge dorsad onto the spinous dorsal fin and posteriad as an irregular mottled sheath that contrasts markedly with the solidly pigmented sheath of *S. altivelis* juveniles. In the largest pelagic juveniles the mottling on the dorsal fin and trunk extends posteriad to a vertical from the vent. When the juveniles become benthic the mottling spreads onto the remainder of the body and median fins. Melanophores appear on the bases of the pectoral fins in specimens of the 14- to 20-mm size range. A faint band of melanophores appears on the rays in some specimens of this size range but never becomes highly developed and covers only the basal one-third of the fin in the largest pelagic juveniles. Likewise a faint band of pigment develops on each pelvic fin in specimens as small as 16 mm and only covers the basal half of the fin in the largest pelagic juveniles. When the juveniles become benthic the pectoral fins develop a pattern of four narrow irregular bands.

DISTRIBUTION

The genus *Sebastolobus* has an exceptionally wide latitudinal distribution in the eastern Pacific. *Sebastolobus altivelis* ranges from the Aleutian Islands southward to Cape San Lucas, Baja California, and *S. alascanus* inhabits waters from the Bering Sea to northern Baja California (Barsukov, 1964; Miller and Lea, 1972). The extensive north-south range of *Sebastolobus* is probably related to habitat depth rather than eurythermy. They are deep-living species throughout their latitudinal range and, as such, experience little change in habitat temperature towards the southern end of their range. Alverson et al. (1964) reported that significant catches of *Sebastolobus* are taken at depths shallower than 150 fathoms in the trawl fishery from Oregon to southeastern Alaska, but that the percentage contribution of *Sebastolobus* increased with depth. At the maximum depth range sampled, 500 to 600 fathoms, *Sebastolobus* accounted for about 70% of the total fish catch. Southward of Oregon the shoaler elements of the *Sebastolobus* populations are gradually eliminated and, off

southern California, adults of even the shallower-living species, *S. alascanus*, are generally restricted to waters deeper than 150 fathoms.

Curtailment of spawning or mortality of fertilized eggs off southern California is evident from the distribution of *Sebastolobus* larvae in the CalCOFI sampling area (Figures 11, 12). In 1966, there were no occurrences south of line 97, which runs seaward from the Mexican border, and in 1969 *Sebastolobus* occurred on only two stations below this line. It is apparent that the CalCOFI sampling pattern did not encompass the offshore limits of larval distribution and that larvae occur well seaward of the 200 to 250 mile coastal zone sampled during these years.

The seasonal abundance of *Sebastolobus* larvae for 1966 and 1969 is shown in Table 7. In 1966 larvae were taken from April to October in central and southern California. Numbers of larvae and occurrences were highest in April and diminished in subsequent months. No larvae were

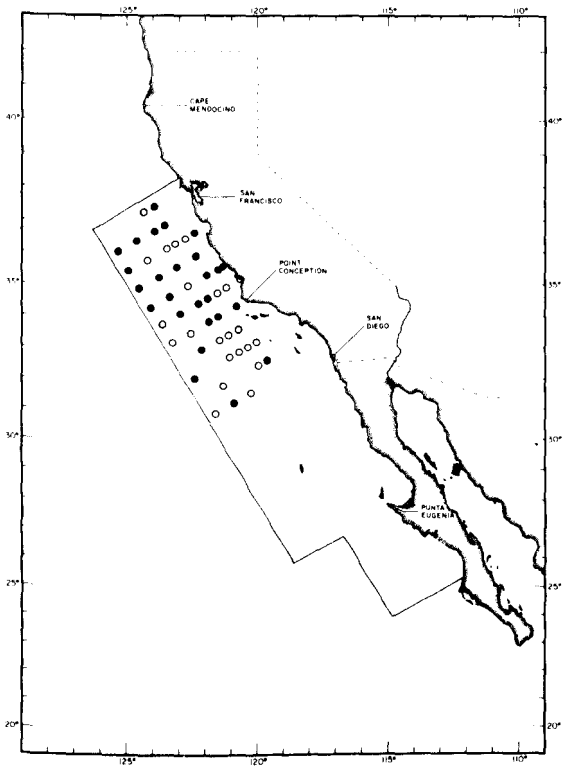

FIGURE 11.—Stations at which larvae of *Sebastolobus* were collected during CalCOFI survey of 1966. Dots indicate stations where numbers of *Sebastolobus* larvae exceeded mean number (7.2) for all positive stations. Area of frequent occupancy is outlined (see Ahlstrom, 1961, for complete grid).

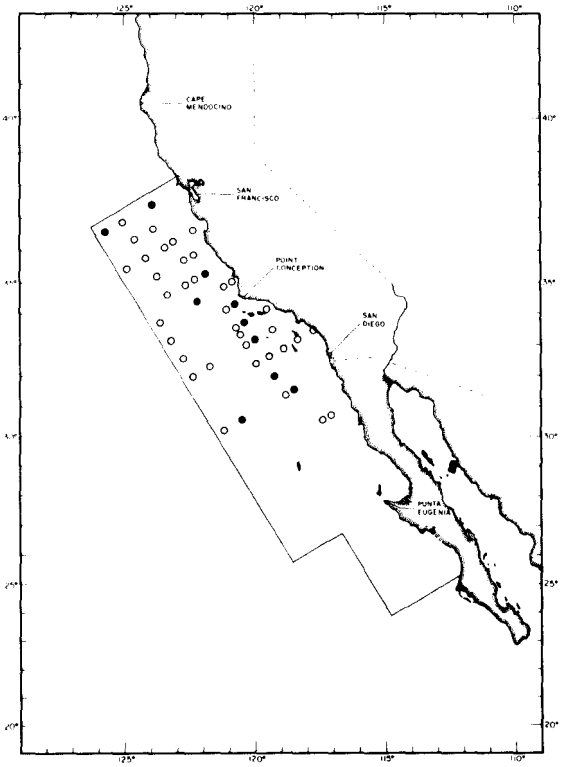

FIGURE 12.—Stations at which larvae of *Sebastolobus* were collected during CalCOFI survey of 1969. Symbols as in Figure 11.

taken south of southern California in 1966. In 1969, larvae appeared earlier in the year, from January to December off central California, from January to October off southern California, and from June to September off northern Baja California. Again, numbers of larvae and occurrences peaked in April off central and southern California. Data for the two species are lumped together in Table 7. Of the larvae identifiable to species, those over 10 mm, 6% were *S. alascanus* in 1966 and 12% were *S. alascanus* in 1969. Thus, the data in Table 7 pertain largely to *S. altivelis*.

Although *Sebastolobus* larvae are taken in plankton tows over a large proportion of the year, the spawning season is relatively short. Table 8 shows the seasonal change in the size of *Sebastolobus* larvae. The mean size increases steadily throughout the year and small, recently spawned larvae, less than 5 mm, do not occur after June in 1966 and May in 1969. This indicates a spawning season of 4 or 5 mo.

Information on the growth rate of the pelagic juveniles of both species of *Sebastolobus* was obtained by examining mid-water trawl samples

TABLE 7.—Standard numbers and occurrences of *Sebastolobus* larvae taken during 2 yr of the California Cooperative Oceanic Fisheries Investigations. Dashes indicate region not occupied.

		Month																					
		Jan.		Feb.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
	Year	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.	No.	Occ.
Central California CalCOFI Lines 60–77	1966	-	-	0	0	227	19	0	0	89	14	67	10	0	0	0	0	13	3	-	-	-	-
	1969	3	1	12	4	81	10	10	2	0	0	17	5	38	9	0	0	14	4	-	-	3	1
Southern California CalCOFI Lines 80–93	1966	-	-	-	-	58	10	34	7	3	1	10	3	37	4	39	8	17	3	-	-	-	-
	1969	3	1	3	1	-	-	3	1	0	0	19	6	13	4	-	-	3	1	-	-	-	-
Northern Baja California CalCOFI Lines 97–107	1966	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1969	-	-	-	-	-	-	0	0	10	2	13	3	0	0	6	2	-	-	-	-	-	-

from the Los Angeles County Museum, Scripps Institution of Oceanography, and the Southwest Fisheries Center. A total of 260 samples from the years 1950 to 1969 were examined. Most of the samples were taken in the deepwater basins off southern California, but two samples of *S. alascanus* were taken as far north as Crescent City, Calif., and one sample of *S. altivelis* was from the vicinity of Guadalupe Island, Baja California.

The composite monthly size frequencies of mid-water trawl specimens of *S. altivelis* are shown in Figure 13. Two major size classes are present from May through September. One class is formed by larvae and transforming specimens, less than 20 mm in length, from the January-May spawning season. The other class is formed

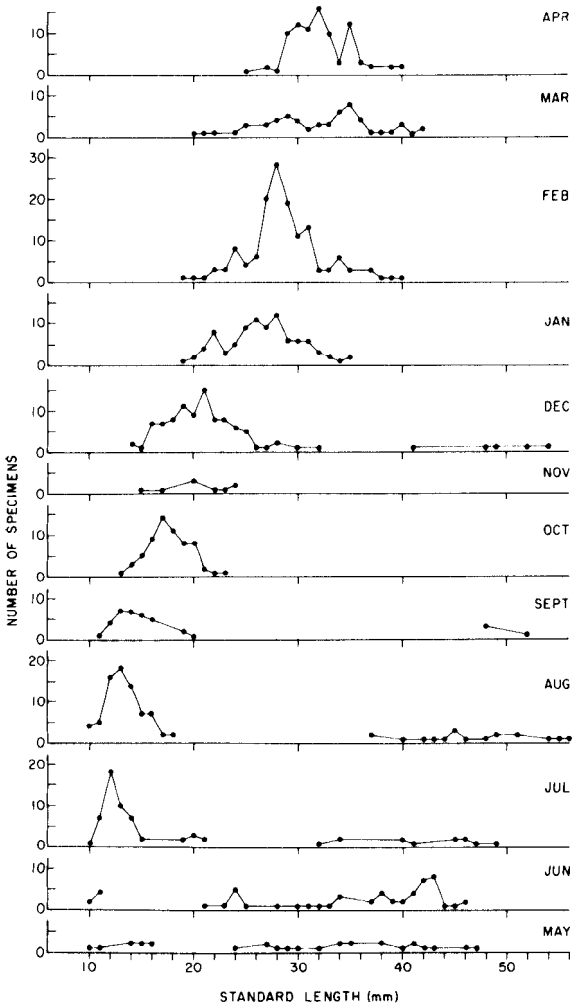

FIGURE 13.—Composite monthly size frequencies for larvae and pelagic juveniles of *Sebastolobus altivelis* from mid-water trawls.

TABLE 8.—Mean lengths with standard deviations in mm (A) and size ranges in mm (B) of *Sebastolobus* larvae taken during 2 yr of the California Cooperative Oceanic Fisheries Investigations.

	Month									
	Jan.		Feb.		Apr.		May		Jun.	
Year	A	B	A	B	A	B	A	B	A	B
1966	-	-	-	-	4.3 ± 1.07	2.2 - 6.9	6.2 ± 1.16	4.2 - 7.8	7.4 ± 1.17	5.1 - 10.0
1969	3.1 ± 0.65	2.8 - 3.4	3.0 ± 0.47	2.8 - 3.4	3.6 ± 0.76	2.6 - 4.7	4.2 ± 0.98	3.1 - 5.2	8.6 ± 0.68	8.1 - 8.9

	Month									
	Jul.		Aug.		Sep.		Oct.		Dec.	
Year	A	B	A	B	A	B	A	B	A	B
1966	8.7 ± 1.15	6.2 - 11.2	11.6 ± 1.42	9.2 - 15.2	14.0 ± 1.57	9.2 - 17.7	16.4 ± 1.37	14.4 - 19.3	-	-
1969	10.8 ± 1.15	8.9 - 13.2	11.8 ± 1.58	9.2 - 18.2	17.0 ± 1.10	16.2 - 17.9	16.3 ± 1.43	15.2 - 18.6	15.0	15.0

by large pelagic juveniles from the previous year's spawning season. A single size class of transforming specimens is present in October and November, however, the absence of the large pelagic juveniles is probably due to inadequate sampling, since they are present in December. From January through April a single class of pelagic juveniles is present. In summary, the early life history of *S. altivelis* is as follows: larvae are produced in a 4- or 5-mo spawning season that peaks in April. Transformation into pelagic juveniles begins as early as July and by the end of December most have completed transformation. The prolonged pelagic juvenile stage lasts until the following summer when the juveniles begin to settle to the bottom. This process probably extends over a 6- to 8-mo period with some juveniles remaining pelagic until December. The total period spent in the pelagic environment from spawning to settling is about 20 mo. The means of the composite monthly length frequencies are plotted in Figure 14 to give an estimation of growth of this species.

The composite monthly length frequencies for mid-water trawl-caught specimens of *S. alascanus* are shown in Figure 15. In contrast to *S. altivelis*, only a single size class is present each month. From July to December a single class of larval and transitional specimens less than 20 mm long is present. Some pelagic juveniles are present in December and by January most of the specimens have completed transformation. Successive samples from February to May contain only pelagic juveniles. In summary, the planktonic and early pelagic life history of *S. alascanus* is similar to that of *S. altivelis*. A probable 4- or 5-mo spawning period that peaks in April gives rise to larvae that appear in mid-water trawl samples in summer. Transformation into the pelagic juveniles begins as early as August and most have completed transformation by the end of December. A class of pelagic juveniles is present from December through May, however, the size ranges for these months overlap the range at which *S. alascanus* juveniles begin to settle to the bottom, and it is

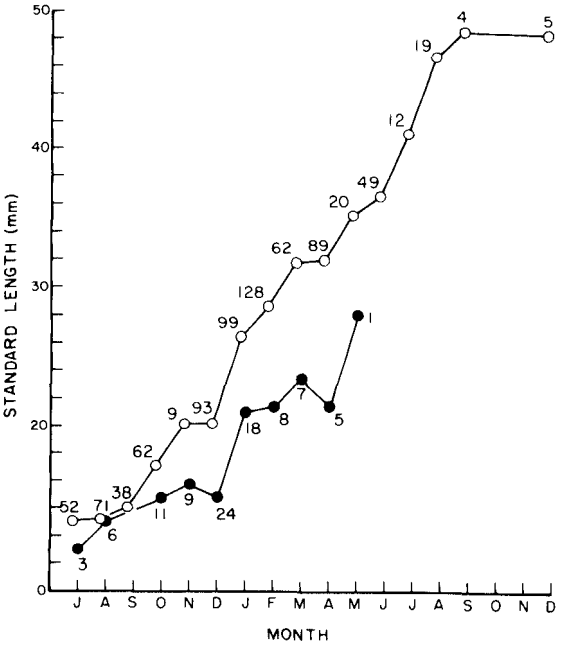

FIGURE 14.—Means of composite monthly size frequencies of larvae and pelagic juveniles of *Sebastolobus altivelis* and *S. alascanus* from mid-water trawls.

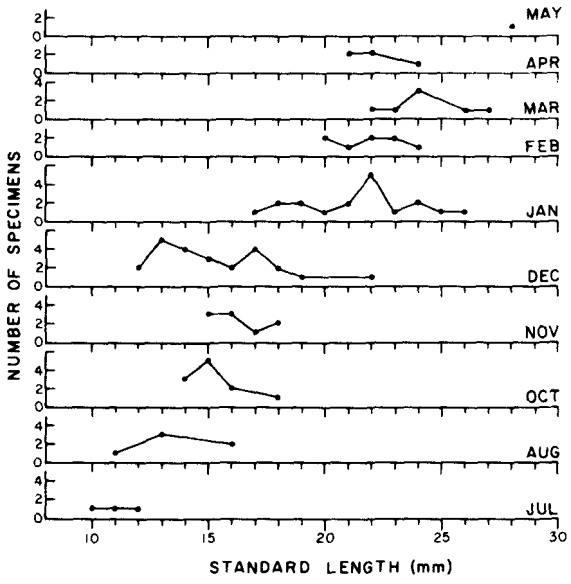

FIGURE 15.—Composite monthly size frequencies for larvae and pelagic juveniles of *Sebastolobus alascanus* from mid-water trawls.

probable that settling begins as early as January. Most have become benthic by May or June. The pelagic juvenile stage in this species is short-lived compared with *S. altivelis* and the total period spent in the pelagic environment from spawning to settling is about 14 or 15 mo. The means of the composite monthly frequencies are plotted in Figure 14.

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