OBSERVATIONS ON THE EARLY LIFE HISTORY OF THE MUSSEL BLENNY, *HYPSOBLENNIUS JENKINSI*, AND THE BAY BLENNY, *HYPSOBLENNIUS GENTILIS*, FROM SPECIMENS REARED IN THE LABORATORY

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ABSTRACT

Two egg masses of the mussel blenny, *Hypsoblennius jenkinsi*, with attending males, were collected in Mission Bay, California, and incubated in the aquarium. After hatching, the broods of larvae were reared to the benthic juvenile stage on a diet of the rotifer *Brachionus plicatilus* and brine shrimp. Juveniles of one of the broods were maintained in the aquarium to the adult stage. On day 141 after hatching, one of the females produced a viable egg mass from which larvae hatched in 22 days. A single egg mass of the bay blenny, *Hypsoblennius gentilis*, was collected and incubated in a similar manner, producing larvae that were reared to a length of 6.7 mm. This paper describes the eggs and larvae of *H. jenkinsi*, including growth rate, and provides characters for distinguishing the larvae of this species from *H. gentilis* larvae.

RESUMEN

En Mission Bay, California, se recolectaron dos nidadas de huevos del blenio *Hypsoblennius jenkinsi*, junto con los machos que las atendían, para ser incubadas en al laboratorio. Las larvas eclosionadas se criaron alimentadas con el rotífero *Brachionus plicatilus* y el crustáceo *Artemia salina* hasta que alcanzaron la fase juvenil bentónica. Los juveniles de una nidada lograron alcanzar la fase adulta, y una hembra de 141 días efectuó una puesta de huevos de los cuales eclosionaron larvas a los 22 días. Una puesta de huevos del blenio *Hypsoblennius gentilis* que también se recolectó, fué incubada bajo las mismas condiciones, obteniéndose larvas que alcanzaron 6.7 mm de longitud. En este trabajo se describen los huevos y larvas de *H. jenkinsi*, incluyendo su índice de crecimiento, y se discuten los caracteres distintivos de las larvas de esta especie y de *H. gentilis*.

INTRODUCTION

The family Blenniidae is represented off California and Baja California by three species of the genus *Hypsoblennius: H. gentilis, H. gilberti*, and *H. jenkinsi* (Miller and Lea 1972). The behavior of these species has been studied by Stephens et al. (1970) and Losey (1968), but descriptions of their larvae have not been published. Eggs and larvae of an Atlantic species, *H. hentzi*, were described by Hildebrand and Cable (1938). Balbontin and Perez (1979) described the eggs and larvae of a Chilean species, *H. sordidus*.

Although the species of *Hypsoblennius* are shallow-water demersal spawners, their larvae occur routinely in nearshore CalCOFI plankton collections, both in oblique and surface tows. Larvae of *Hypsoblennius* species are similar in morphology and pigmentation, and identifying them in ichthyoplankton samples has been an intractable problem. Developmental series obtained from eggs of captive adults have been useful in establishing characters for identification of larvae in other fishes. The purpose of this paper is to describe the larvae of *H. jenkinsi* obtained from egg masses of that species and to make comparisons with reared larvae of *H. gentilis*. Information on the reproductive biology of *H. jenkinsi* is also presented.

MATERIALS AND METHODS

Egg masses of *H. jenkinsi* and *H. gentilis* were collected by a diver in Mission Bay, San Diego, and reared in the experimental aquarium at the Southwest Fisheries Center, La Jolla. Brooding males were captured with each egg mass and preserved as voucher specimens after hatching was completed. In all egg collections, the nest was on the inner surface of the shell of the scallop *Hinnites multirugosus*. The shell and brooding male were placed in a plastic bag, taken to the laboratory, and submerged in a 20-liter bucket of filtered seawater. The bag was removed; an airstone was introduced; and the nest was left undisturbed until hatching began. As larvae emerged, they were dipped out with a 1-liter beaker and placed in 100- or 400-liter black fiberglass rearing tanks containing filtered seawater held in water tables at ambient seawater temperatures.

Initially the larvae were fed the rotifer *Brachionus plicatilus*, maintained at a concentration of 50/ml. A liter of a dense algal culture *(Tetraselmnis suesica)* was added daily as food for the *Brachionus*. When the larvae were 10-15 days old, *Artemia* nauplii were

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added at a concentration of about 1 nauplius/ml. Large larvae, juveniles, and adults were fed frozen adult *Artemia*, supplemented with wild zooplankton when available.

Larvae were sampled regularly and preserved in 4 percent Formalin. Some were photographed before preservation to record xanthic pigmentation. Morphometric measurements were made according to the methods described in Sumida et al. (1979), except for the following measurements:

> Greatest body depth = body depth at the cleithral junction.
>
> Pectoral fin length = horizontal distance from the edge of the fin base to the posteriormost margin of the fin blade.
>
> Length of the longest preopercular spine = distance from the base of the spine to its tip.
>
> Snout length = horizontal distance from the anterior edge of head to the edge of the eye.

Meristic counts were taken from specimens cleared and stained using the alcian cartilage staining method of Dingerkus and Uhler (1977) and the trypsin-alizarin red technique of Taylor (1967).

Diameters of field-collected and aquarium-spawned eggs were measured with the ocular micrometer of a stereoscopic microscope. The number of eggs in aquarium spawnings was estimated by counting all eggs in a sample area estimated to be 10 percent of the total egg patch.

The growth curve for *H. jenkinsi* was computed from lengths of Formalin-preserved reared larvae, juveniles, and adults fitted to the Gompertz curve, using a canned program, PAR of BMDP-80 (Dixon and Brown 1979). Pooled lengths were used for larvae less than 40 days old.

Distribution data were taken from fish larvae identification records of CalCOFI collections from 1950 through 1972.

REARING CHRONOLOGY

The first collection of *H. jenkinsi* eggs was made on July 22, 1977. Both valves of the *Hinnites* shell were covered with eggs, estimated to number over 10,000 on one valve. The male measured 73 mm SL. Incubation temperatures ranged from 20.0° to 21.5°C. Subsequent examinations of the shell indicated that about 20 percent of the eggs hatched. The oldest survivors died on day 62, with the largest juvenile reaching 14.1 mm SL.

The second brood was obtained on July 14, 1978. The male measured 44 mm SL. Hatching began on July 16 and lasted for 4 days. Water temperature during incubation and rearing ranged from 19.0° to 23.0°C. Transformation to benthic juveniles was observed on day 53, when larvae had reached 10-13 mm SL. Shells, sponges, and concrete blocks were placed in the rearing tank to provide cover. On day 103 one male and three females, all of about equal size, remained; one, anesthetized with quinaldine, measured 32.0 mm SL.

On day 141 after hatching, a patch of about 450 eggs appeared on the bottom and sides of the rearing tank, covering an area of about 20-25 cm^2. The male fanned the eggs intermittently. A small section of the egg patch was excised from the side of the tank with a scalpel and incubated in a 10-liter pot. Incubation temperatures ranged from 15.2° to 18.0°C. Larvae began to hatch from the eggs after 22 days of incubation (day 163 for the adults). *Brachionus* was added to the rearing pot, but all larvae died within 3 days. On day 240 the male died and was replaced by a field-caught male. Spawning occurred 6 more times, on days 260, 264, 277, 281, 313, and 317 and resulted in clutches of 300-650 eggs, but none of the eggs survived to the hatching stage. The temperatures ranged from 16.0°-19.0°C. The three females died on days 296, 319, and 320 at lengths of 55, 65, and 64 mm SL.

The single egg mass of *H. gentilis* was collected in a *Hinnites* shell on August 9, 1977, along with an 86-mm SL brooding male. Hatching began on August 17 and continued to August 18. Water temperature during incubations was approximately 18.5°C. Larvae fed on *Brachionus* but suffered a high mortality; the last ones died 21 days after initial hatching at lengths of 6.7 mm SL.

DESCRIPTION OF DEVELOPMENTAL STAGES

Eggs

Wild eggs of *H. jenkinsi* reported on here are deposited in a single layer on *Hinnites* valves. They are slightly flattened in the plane of the substrate and are attached by an adhesive disc. The yolk is granular, and the perivitelline space is narrow. Diameters of 29 field-collected eggs from two broods ranged from 0.69 to 0.80 mm ($\bar{x}$ = 0.75 ± 0.029 SD). Diameters of 22 aquarium-spawned eggs from two masses ranged from 0.71 to 0.78 mm ($\bar{x}$ = 0.75 ± 0.023 SD). The aquarium-spawned eggs were used in the following description.

A striking feature of *H. jenkinsi* eggs is the presence

of a clump of violet inclusion bodies and a clump of golden yellow oil globules within the yolk. As reported for the eggs of *H. hentzi* (Hildebrand and Cable 1938), the violet bodies disperse, shrink, and fade with development. They disappear before hatching. The oil globules have a similar fate, although some may persist in newly hatched larvae. After about 3 days of development the outline of the embryo is clearly visible in an equatorial position. After 7 days the embryo extends about two-thirds of the way around the yolk, and the heart is beating. The body axis is now located on the side of the yolk mass facing the substrate, and the head faces upward. By day 17 the body begins to twitch, and by day 19 the eyes are rotating. Hatching occurs at the end of the third week.

The first pigment to develop in the embryo is a covering of scattered melanophores over the upper and lower surfaces of the yolk mass. At the end of the first week the eyes begin to develop melanistic pigment. Midway through embryonic development, melanophores begin to form along the dorsal surface of the gut and on the medial surfaces of the pectoral fin buds. During the third week of the development melanophores appear at the bases of the otic capsules, and a medial series extends along the base of the cranium to the snout. Melanophores cover the medial surface of each pectoral fin. One or two melanophores are present on the ventral surface of the gut just anterior to the anus. A ventral midline series of small, evenly spaced melanophores extends from the anus to the posterior region of the tail. Melanophores are absent on the remaining yolk mass.

Larvae

Morphology. Development of *H. jenkinsi* larvae is illustrated in Figure 1. Body measurements of *H. jenkinsi* and *H. gentilis* are listed in Tables 1 and 2, and proportions are summarized in Table 3. Both species hatch at about 2.5 mm, with large heads, thin tapering bodies, and prominent functional pectoral fins. Both species are similar to the larvae of other species of the genus (Hildebrand and Cable 1938; Balbontin and Perez 1979). Snout-anus length and pectoral fin length are slightly greater in larvae of *H. jenkinsi* than in *H. gentilis*. In *H. jenkinsi*, three major preopercular spines develop, the upper two approximately equal in length (Figure 2). The middle spine is 15 percent of the head length in a 7.6-mm larva and undergoes a reduction to 3 percent of head length at 17.9 mm ($\bar{x}$ = 9.1 ± 4.15 SD for the series). Preopercular spines are absent in *H. jenkinsi* specimens larger than 18.0 mm SL.

TABLE 1
Average Measurements (mm) of Reared Larvae of *Hypsoblennius jenkinsi*

Body length	N	Range	Snout length	Head length	Snout to anus	Eye width	Greatest body depth	Pectoral fin length	Length of longest preopercular spine	Length of cirrus
2.5	1	-	.10	.56	.98	.28	.56	.28	<.02	
2.8	7	2.76- 2.82	.11	.61	1.0	.29	.62	.37	.02	
2.9	7	2.8 - 3.0	.12	.64	1.1	.28	.59	.39	.05	
3.2	6	3.0 - 3.4	.14	.67	1.2	.31	.64	.46	.04	
3.6	5	3.5 - 3.8	.15	.74	1.4	.34	.73	.48	.08	
4.5	6	4.0 - 4.6	.19	1.0	1.6	.44	.92	.82	.06	
4.7	7	4.7 - 4.8	.21	1.1	1.8	.47	.98	.92	.09	
4.9	6	4.9 - 5.0	.23	1.2	2.0	.51	1.1	1.1	.13	
5.2	12	5.0 - 5.2	.21	1.2	2.1	.52	1.1	1.2	.16	
5.7	7	5.3 - 6.3	.25	1.5	2.4	.66	1.3	1.5	.19	
5.8	5	5.6 - 6.0	.22	1.5	2.6	.74	1.4	1.7	.22	
6.2	5	6.1 - 6.6	.23	1.6	2.7	.75	1.6	1.8	.27	
7.6	3	7.2 - 7.9	.20	2.1	3.3	.92	2.1	2.3	.31	
8.9	3	8.6 - 9.6	.30	2.6	4.0	1.1	2.3	2.8	.32	
10.5	4	10.2 -10.8	.38	2.9	4.6	1.2	2.6	3.1	.38	.04
11.3	1		.30	3.1	4.6	1.3	2.6	2.8	.28	.35
12.6	1		.56	3.2	5.5	1.3	3.2	3.7	.48	.12
12.8	1		.40	3.7	5.8	1.5	3.3	4.1	.32	.43
14.1	1		.52	3.8	6.6	1.8	3.8	4.6	.24	.22
15.7	1		.68	4.9	7.3	1.7	4.2	5.1	.20	.69
16.8	1		.75	4.8	7.8	1.7	4.1	4.9	.25	.30
17.9	1		.80	4.8	8.1	1.8	4.8	5.8	.16	.56
18.2	1		.73	5.3	8.5	1.8	5.2	5.7	—	.72
18.6	1		.65	5.3	8.6	1.8	4.9	5.6	—	.52
19.7	1		.89	5.3	9.5	1.9	5.0	6.1	—	.80

Specimens larger than 11 mm are considered early juveniles.
Specimens between dashed lines are undergoing notochord flexion.

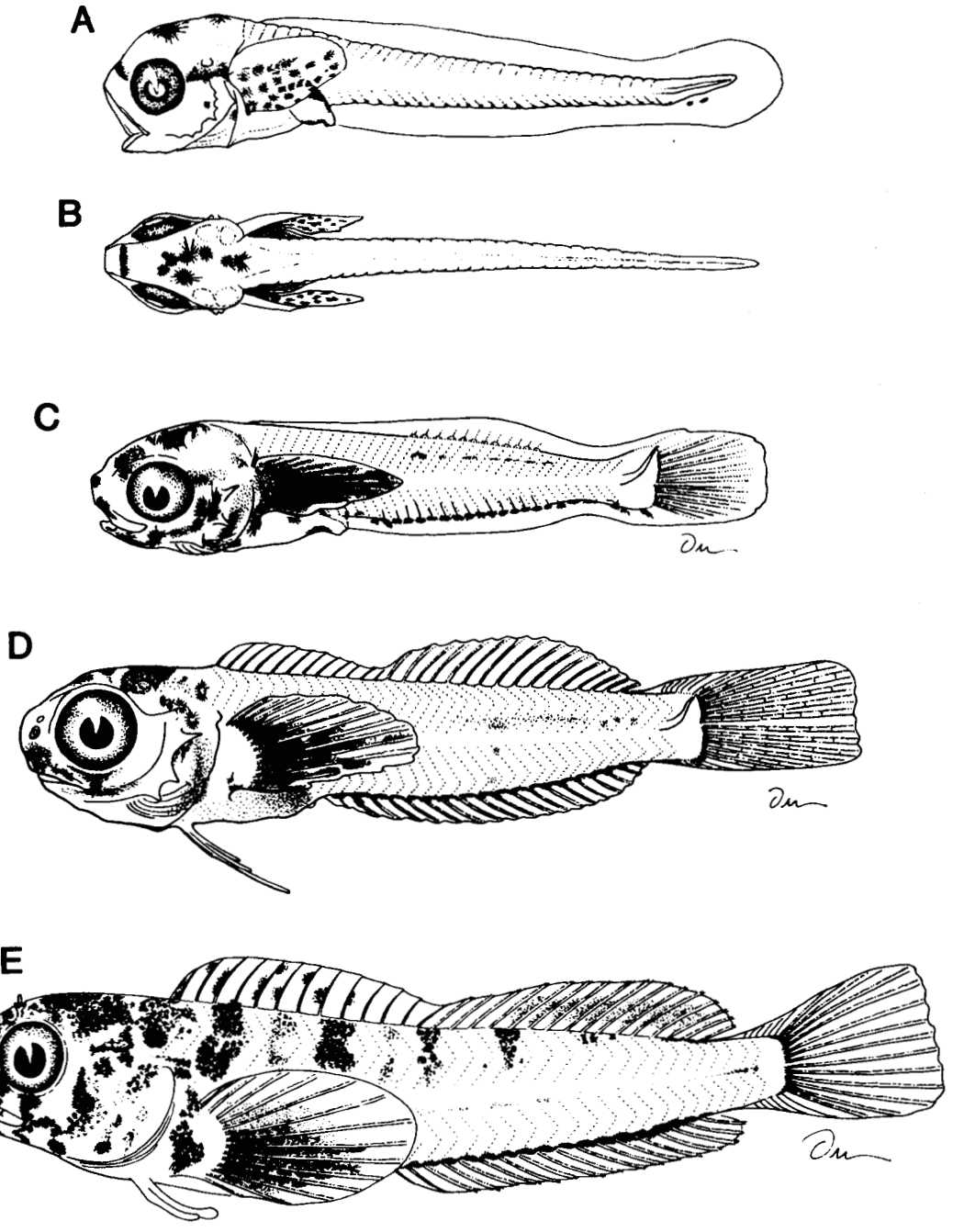

Figure 1. Reared specimens of *Hypsoblennius jenkinsi*: *A.* 4.3-mm larva (day 7); *B.* 4.3-mm larva, dorsal view; *C.* 5.3-mm larva; (day 29); *D.* 10.2-mm larva (day 34); *E.* 18.6-mm juvenile (day 58).

TABLE 2
Average Measurements (mm) of Larvae of *Hypsoblennius gentilis*

Body length	N	Range	Snout length	Head length	Snout to anus	Eye width	Greatest body depth	Pectoral fin length	Length of longest preopercular spine	Length of cirrus
2.5	7	2.4-2.6	.10	.52	.92	.25	.50	.33	—	
2.7	4	2.6-2.8	.12	.57	.96	.28	.55	.36	.02	
3.1	1		.12	.62	1.1	.28	.60	.46	.02	
3.5	4	3.4-3.6	.15	.77	1.4	.34	.76	.53	.08	
3.7	4	3.6-3.7	.20	.84	1.4	.35	.84	.58	.08	
3.9	5	3.8-3.9	.18	.90	1.5	.38	.80	.70	08	
4.1	1		.20	.94	1.5	.36	.86	.90	.06	
4.4	3	4.4	.19	1.0	1.6	.40	.93	.89	.09	
4.6	3	4.6-4.7	.21	1.1	1.8	.45	.87	.96	.12	
4.8	4	4.8	.20	1.1	1.9	.44	1.0	1.1	.12	
6.7	1		.28	1.9	2.9	.80	1.6	2.0	.20	

Specimens between dashed lines are undergoing notochord flexion.

TABLE 3
Comparative Morphometry of *H. jenkinsi* and *H. gentilis*

Body proportion	*H. jenkinsi*	*H. gentilis*
Snout-anus/body length		
A	37.4 ± 1.2 (33-40)	36.1 ± 1.3 (34-38)
B	40.4 ± 2.3 (35-47)	38.8 ± 1.9 (37-43)
C	44.1 ± 1.8 (42-49)	
D	45.6 ± 2.1 (41-48)	
Snout length/body length		
A	4.2 ± 0.6 (3-5)	4.2 ± 0.7 (3-6)
B	4.4 ± 0.6 (3-5)	4.6 ± 0.7 (4-6)
C	3.5 ± 0.7 (3-5)	
D	3.7 ± 0.7 (3-5)	
Head length/body length		
A	21.5 ± 1.2 (19-23)	21.0 ± 1.0 (19-22)
B	23.5 ± 1.8 (20-28)	23.0 ± 1.6 (18-27)
C	27.2 ± 2.2 (23-31)	
D	27.9 ± 1.8 (25-31)	
Eye diameter/body length		
A	9.8 ± 0.6 (9-11)	10.1 ± 0.6 (9-11)
B	10.2 ± 0.8 (9-12)	9.5 ± 0.6 (9-11)
C	12 4 ± 0.8 (11-14)	
D	10.6 ± 1.0 (10-13)	
Greatest body depth/body length		
A	20.7 ± 1.4 (19-24)	20.1 ± 1.0 (18-24)
B	21.6 ± 1.7 (19-26)	21.2 ± 1.9 (18-24)
C	25.5 ± 1.4 (23-30)	
D	25.8 ± 1.7 (23-29)	
Pectoral fin length/body length		
A	12.9 ± 2.9 (11-17)	13.4 ± 1.4 (11-16)
B	22.4 ± 4.0 (16-30)	18.8 ± 3.3 (14-25)
C	29.5 ± 2.0 (26-33)	
D	30.5 ± 2.3 (25-33)	
Longest preopercular spine/head length		
A	7.2 ± 3.9 (3-14)	2.8 ± 1.3 (1-5)
B	10.1 ± 3.9 (1-19)	10.1 ± 2.8 (6-15)
C	16.1 ± 2.4 (13-20)	
D	6.9 ± 5.7 (0-19)	
Cirrus length/head length		
C	2.4 ± 0.7 (2-3)	
D	10.3 ± 3.8 (3-15)	

A = preflexion, B = flexion, C = postflexion, D = juvenile (specimens > 11.0 mm). Values are mean, standard deviation, and range of percentage of body length or head length.

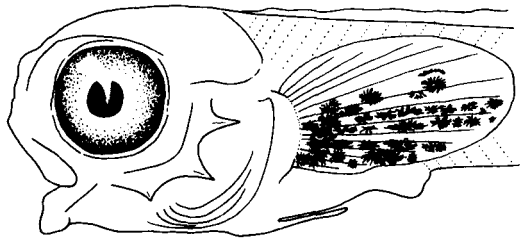

Figure 2. Preopercular spination of *Hypsoblennius jenkinsi* larva, 7.6 mm.

Fin formation. Pectoral fin rays begin to ossify at about 4.0 mm body length in both species, and the adult complements (12-15 for *H. jenkinsi;* 11-12 for *H. gentilis*) are formed during caudal fin flexion (Table 4). Principal caudal fin rays begin ossifying at about 4.0 mm in both species, and the adult complement of 7 superior and 6 inferior rays is present at the completion of notochord flexion. Dorsal, anal, and pelvic fin anlagen appear during caudal fin flexion, and the adult complements are present between 8.0 and 9.0 mm in *H. jenkinsi.*

Pigmentation. Newly hatched *H. jenkinsi* and *H. gentilis* larvae have four areas of melanstic pigmentation: the dorsal surface of the gut, with one or two preanal melanophores along the ventral midline; the medial surfaces of the pectoral fin base and blade; along the base of the cranium from the otic capsules to the snout; and along the ventral midline, with a series of melanophores extending posteriorly from just behind the anus to the tip of the notochord. In *H. jenkinsi* the number of principal postanal ventral midline melanophores ranges from 21-27 ($\bar{x}$= 23.6 ± 1.3 SD for 26 specimens counted). In *H. gentilis* the range was 22-26 ($\bar{x}$ = 24.1 ± 1.2 SD for 23 specimens).

TABLE 4
Meristic Characters of Cleared and Stained Larvae of *H. jenkinsi* and *H. gentilis*

Body length	Source	Vertebrae	Principal caudal rays	Procurrent caudal rays	Dorsal fin	Anal fin	Pectoral fin	Pelvic fin
H. jenkinsi								
4.0	reared	35	5 + 6				12, 12	
4.4	"	10 + 24	5 + 3				11, 11	anlagen
5.0	"	35	5 + 6	0 + 2	12	16	12, 13	anlagen
5.7	"	10 + 24	7 + 6	1 + 2	12	15	13, 13	1, 1
6.1	"	10 + 25	7 + 6	1 + 3	14	17	13, 13	1, 1
7.3	"	10 + 24	7 + 6	5 + 5	XII, 15	I, 17	14, 14	4, 4
8.4	"	10 + 24	7 + 6	7 + 7	XIII, 16	II, 17	12, 12	I,3;I,3
9.8	"	10 + 24	7 + 6	7 + 8	XII, 17	II, 17	13, 13	I,3;I,3
10.3	"	10 + 24	7 + 6	7 + 7	XII, 16	II, 18	14, 14	I,3;I,3
12.1	"	10 + 24	7 + 6	8 + 8	XII, 15	II, 17	13, 13	I,3;I,3
17.1	"	10 + 24	7 + 6	7 + 6	XII, 15	II, 17	14, 14	I,3;I,3
H. gentilis								
3.7	reared	35						
4.1	"	35	2 + 2				11, 11	
4.6	"	10 + 25	4 + 4				9, 9	
4.8	"	10 + 25	4 + 4				11, 11	

Specimens between dashed lines are undergoing flexion.

There are 3-5 small, irregularly spaced melanophores at the tip of the tail.

In both species pigmentation increases during larval development primarily on the head, above the brain, on the nape, snout, jaws, operculum, and isthmus. Pigment descends laterally on the gut wall. During flexion, the irregular group of melanophores at the end of the notochord develops into a line of pigment on the posterior margin of the hypural plates. In postflexion *H. jenkinsi* the pectoral fin blade and median surface of the base remain heavily pigmented except for the dorsal region of the blade, which is unpigmented. *H. jenkinsi* above 18 mm SL develop melanophores on the lateral surface of the pectoral base. In early postflexion larvae of *H. jenkinsi* a series of melanophores develops on the dorsal surface of the vertebral column. At 10-11 mm SL, external dorsal pigment begins to develop. Pigment is arranged in a series of 5 to 7 saddles, beginning at the nape and eventually extending to the middle of the soft dorsal fin, with scattered melanophores on the dorsal margin posterior to the saddles. The saddles extend downward about one-fourth of the body depth. Paler saddles develop between the darker saddles. Concurrent with the dorsal pigment expansion a row of melanophores develops along the lateral line, beginning posterior to the pectoral fin and gradually extending to the tail.

Growth rate. The incubation time for *H. jenkinsi* eggs was determined from the laboratory-spawned egg mass, which began to hatch on day 21 and continued for about 2 days. During the 23-day period temperatures in the rearing tank ranged from 15.2-18.0°C. Hildebrand and Cable (1938) observed hatching of *H. hentzi* in 10-12 days at 24-27°C, and Hubbs (1965) recorded incubation times for *H. jenkinsi* of 14-21 days at 15-18°C and 6-8 days at 24-27°C in temperature-controlled experiments. In the field, eggs in one nest are deposited by several females over a period of time, and consequently hatching occurs over several days (Losey 1968).

The growth rate of the *H. jenkinsi* larvae was computed from lengths of 960 individuals in the two reared groups, fitted to the generalized Gompertz growth curve

$$Y_t = Y_o e^{\frac{\alpha}{\beta}(1-e^{-\beta t})}$$

where t = time in days, y = length in millimeters, α = the instantaneous rate of growth at age 0, and β is the change in growth rate. The resultant growth rate, $Y_t = 1.2845\ e^{3.92(1-e^{-.0177t})}$, is plotted in Figure 3. Sexual maturity, as shown by the laboratory spawning, occurs in the region of the upper break in the curve, at about 40-50 mm SL and 150 days of age. The length reached in 320 days by reared specimens, 60-65 mm, and the maximum length of *H. jenkinsi* reported by Stephens et al. (1970) as 89 mm, indicates that this species approaches its maximum length by the end of its first year.

DISTRIBUTION

Hypsoblennius larvae are not taken in great numbers but are collected over a wide latitudinal range, from CalCOFI line 73, just north of Pt. Arguello, California, to CalCOFI line 150, south of Magdelena Bay, Baja California Sur. They have also been taken in

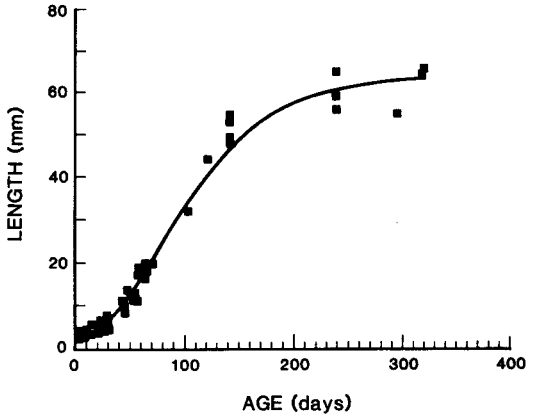

Figure 3. Growth curve for reared *Hypsoblennius jenkinsi*.

oblique tows in the Gulf of California. During October 1972 on CalCOFI Cruise 7210, when surface as well as oblique collections were made over an extended CalCOFI pattern, *Hypsoblennius* larvae were captured in greater numbers at the surface. *Hypsoblennius* larvae usually were collected close to shore but occasionally were taken well offshore, as at stations 107.70 and 133.70. The 781 occurrences of *Hypsoblennius* larvae in CalCOFI oblique tows from 1950–72 and the

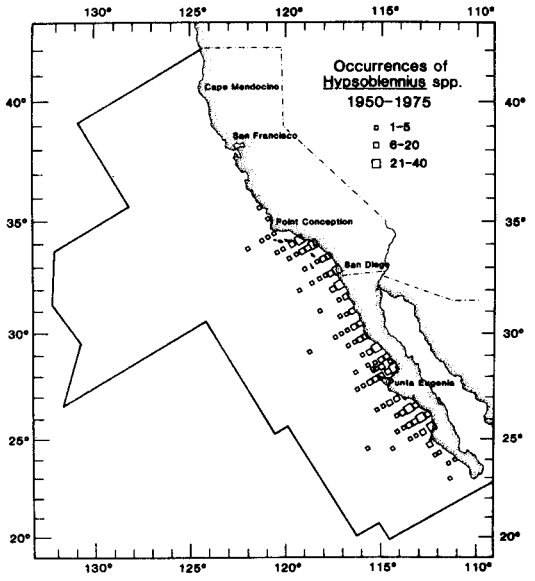

Figure 4. Occurrences of *Hypsoblennius* spp. larvae in CalCOFI plankton collections. Standard CalCOFI sampling pattern bounded by solid line.

TABLE 5
Areal and Seasonal Occurrences of *Hypsoblennius* ssp. Larvae in CalCOFI Collections

Area	% Occurrences	Month	% Occurrences
Lines 60- 77	0.3%	Jan.-Mar.	6.9%
80- 97	30.3	Apr.-June	12.4
100-119	22.2	July-Sept.	54.2
120-137	45.0	Oct.-Dec.	26.5
140-157	2.2		

Values are percent of total occurrences.

13 occurrences in neuston stations in 1972 are plotted in Figure 4 and summarized in Table 5.

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