

EARLY LARVAE OF THE DIAMOND TURBOT,  
*HYP SOPSETTA GUTTULATA*<sup>1</sup>MAXWELL B. ELDRIDGE  
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**A developmental series of larvae of *Hypsopsetta guttulata* collected in San Francisco Bay is described. These larvae are very similar to *Pleuronichthys turbots* and distinguishing characters which separate larval forms of *Hypsopsetta* from *Pleuronichthys* are discussed. Occurrences of *H. guttulata* eggs and larvae indicate an extended spawning period from early June through mid-October.**

## INTRODUCTION

The most abundant pleuronectid larva collected to date in a current study of the fish eggs and larvae of Richardson Bay, California, presented a problem. At first the larvae, especially the specimens with the yolk-sac absorbed, appeared to be one of the *Pleuronichthys* species, of which two (*P. decurrens* and *P. verticalis*) were known to be in the San Francisco Bay. Many identifying characters for *Pleuronichthys* spp. established by Budd (1940), however, did not agree with my specimens. The most obvious were the small size of yolk-sac larvae and the presence of oil globules in the yolk. The dilemma was presented to E. H. Ahlstrom of the NMFS Southwest Fisheries Center, who was able to identify the series of specimens as larvae of the diamond turbot, *Hypsopsetta guttulata*.

The diamond turbot is not tabulated separately in commercial landings but is included with turbot of the genus *Pleuronichthys*. Together they constitute a minor part of the commercial catch. The diamond turbot is often caught by coastal sport fishermen. This reflects the fish's habitat; it is commonly found in shallow bays and tidal flats and on muddy or sandy bottoms (Baxter 1960). This species ranges from Cape Mendocino to Cape San Lucas, Baja California, and in the Gulf of California. The larval specimens described herein are from the northern extent of the range of *H. guttulata* but early records (Jordan and Gilbert 1880) show that it has long been a resident of San Francisco Bay. Compared to the *Pleuronichthys* turbot, little is known of the life history of the diamond turbot, especially its reproductive habits.

Limbaugh (1955) stated that the pelagic eggs are released during summer and fall. Eggs from running ripe diamond turbot were taken by Limbaugh during the summer and similar eggs were taken repeatedly in plankton collections made off the Scripps Institution of Oceanography pier during the summer of 1952 (Orton and Limbaugh 1953).

The purpose of this paper is to describe the early life history stages of *H. guttulata* and to give characters that will readily separate it from the larvae of the two *Pleuronichthys* species whose adults occur in San Francisco Bay. The description is handicapped by the lack of a complete developmental series. There were no specimens obtained between 5.8 mm

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and 11.4 mm (0.23 and 0.45 inch). Therefore, the study concentrates on the younger larvae. Juvenile and adult specimens used in this study were obtained from field collections in San Francisco Bay and from the collection of the California Academy of Sciences.

#### METHODS

The larval specimens used for this description were collected in Richardson Bay, California, which is an approximate 11.0 km<sup>2</sup> (4.25 mile<sup>2</sup>) shallow embayment located immediately to the north of the entrance to and within San Francisco Bay. Two methods were used to catch the diamond turbot. A standard 0.5 meter plankton net was towed at randomly selected stations throughout Richardson Bay, and two stationary channel nets, modified from a design of Lewis, et al (1970), were fished simultaneously. One channel net was positioned midway up the Bay and the other near the entrance to the Bay. All nets had a mesh aperture size of 333 micra.

A total of 135 specimens were examined in this study, 95 of which were larvae. The larvae were preserved in 5% buffered formalin, while the juvenile and adult fish were preserved in 40% isopropyl alcohol. Morphometric measurements followed those described by Ahlstrom and Ball (1954) and were made with an ocular micrometer. I selected the illustrated specimens to represent stages of development. The illustrations are literal, drawn by means of a camera lucida.

The meristic data were taken from either specimens stained with alizarin or from x-ray photographs.

The following description is organized by character according to the approach used by Ahlstrom and Ball (1954). Each character is followed through its development. Pigmentation is presented first followed by morphology and meristics.

#### PIGMENTATION

The discussion on pigmentation is limited to those melanophores visible in the preserved specimens. It is possible other body pigments are present in diamond turbot larvae but are lost in formalin preservation. The pigmentation varied within any given size class as might be expected for a species with heavy pigmentation. Throughout the entire series the larvae exhibited generally heavy body pigmentation on the anterior  $\frac{3}{4}$ 's of the body of yolk-sac larvae and extending  $\frac{4}{5}$ 's of the body length in 5 mm larvae. The most notable variation in pigment was the range of development of patches of scattered fine melanophores located along the dorsal and ventral midlines posterior to the anus. In younger forms, these patches ranged from barely detectable spots on the bases of the finfolds to occasionally a definite triangular patch in one or both finfolds. The older larvae did not exhibit any patches extending onto the finfold, but dark strips of fine spots were clearly visible.

Newly hatched larvae (Figure 1a) completely lacked eye pigment. The head and body were pigmented. The head melanophores were discrete stellate units while the body exhibited fine stippling at 50 x magnification. The yolk-sac was devoid of pigment except for approximately 10-15 stellate melanophores on the surface of the large oil globule.

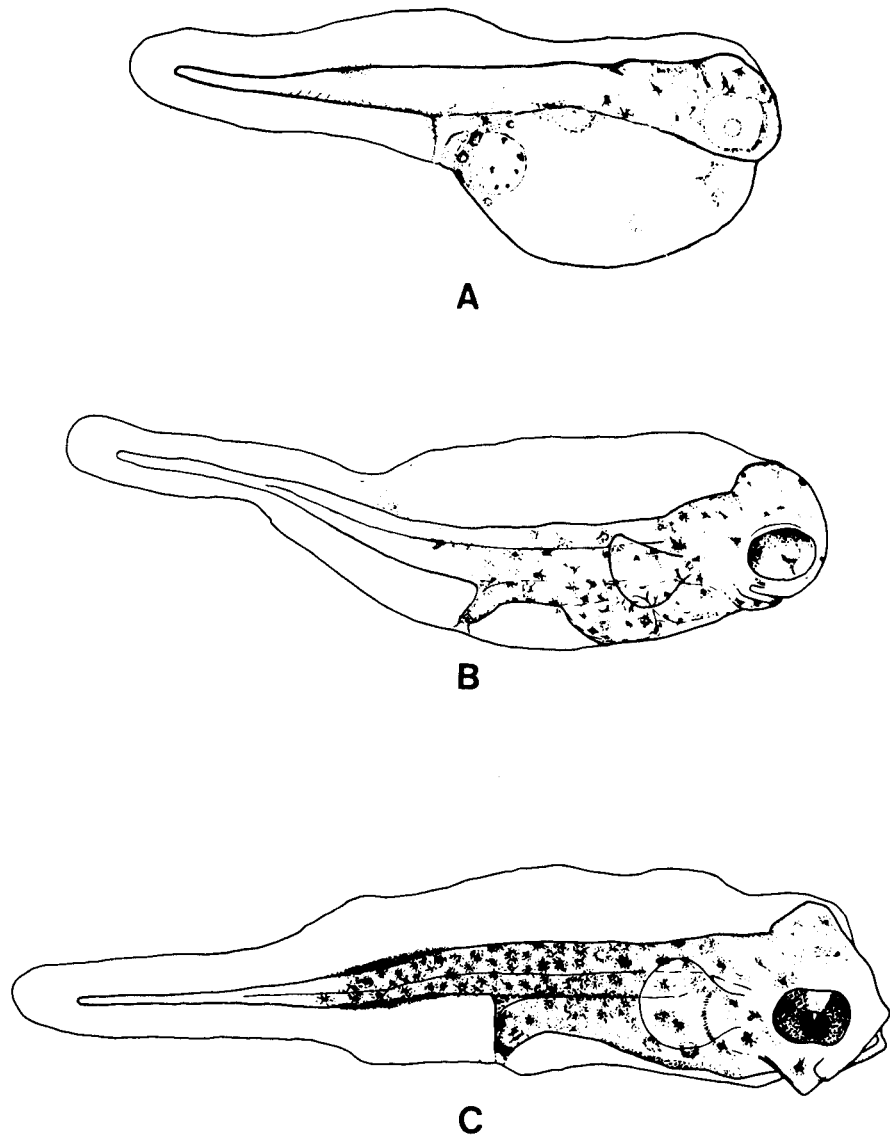


FIGURE 1. Diamond turbot. A, 1.7 mm; B, 212 mm; C, 216 mm.

As the yolk was absorbed and the gut became functional, the pigment spread ventrally over the yolk-sac. The hindgut enlarged and pigment was seen over its ventral flexion to the anus. Melanophores persisted on the oil globule. An interconnecting network of stellate melanophores was present over most of the anterior half of the body. The postanal patches on the dorsal and ventral midlines were now visible. In most specimens these were seen only as intensification of the fine pigment spots near the base of the finfold.

Eye pigmentation developed along the dorsal rim of the eye (Figure 1b). There was still some yolk visible at this stage and the mouth was well developed with up to 10 stellate melanophores along the margin of

the dentary. The past-anal patches lessened in size in larger specimens and were routinely seen as concentrations of midline pigment (Figure 1c). The body became covered with discrete large stellate melanophores. Several spots were also visible in the isthmus. This general pattern continued into larger specimens (Figure 2a).

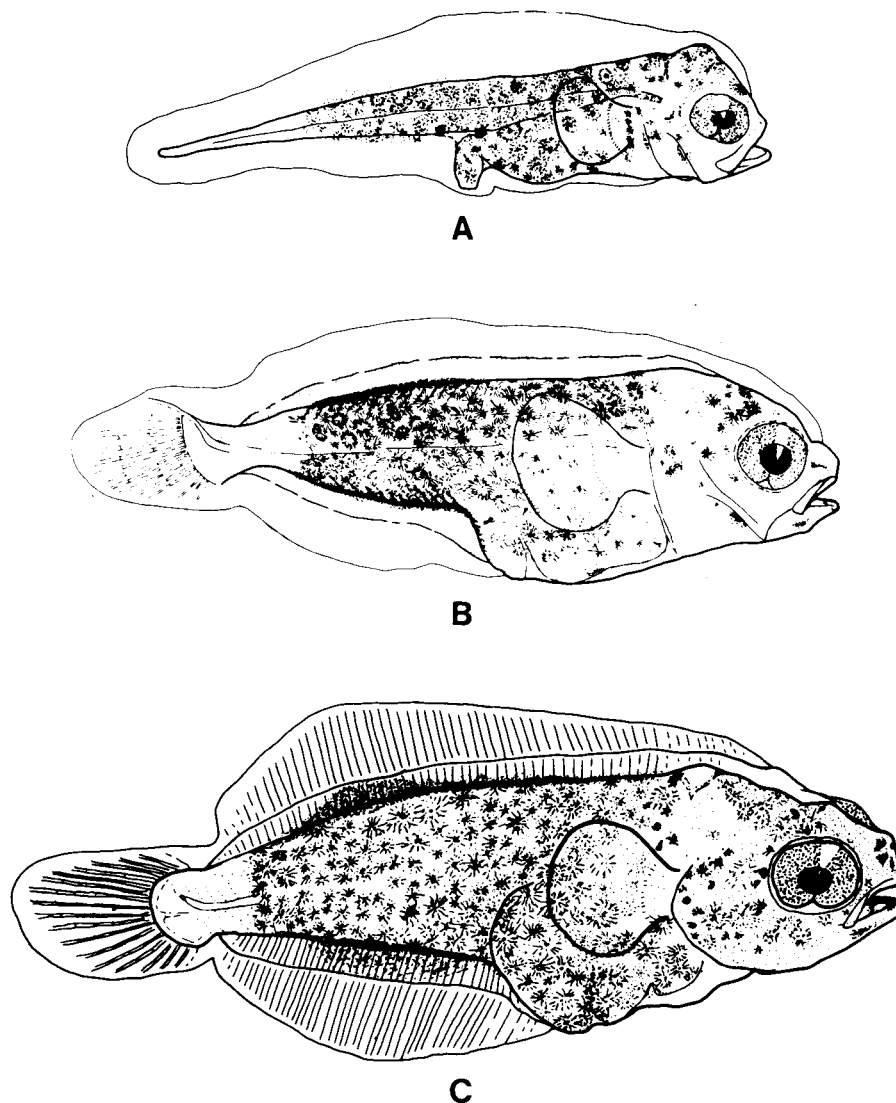


FIGURE 2. Diamond turbot larvae. A, 3.8 mm; B, 4.9 mm; C, 5.8 mm.

The more developed larvae around 4.0 to 4.9 mm were distinguished by the elongate patches which now were densely pigmented but still confined to the base of the developing vertical fin anlage. The head had less surface pigment spots but imbedded melanophores were visible, especially at the nape.

The metamorphosing larvae (Figure 2c) continued these pigment patterns. The median patches were more extensive, spreading onto the pterygiophore bases of the dorsal and anal fins. The specimens at this stage of development presented different appearances depending on the extent of expansion or contraction of the melanophores. Almost the entire body exclusive of the outer fin margins and the posterior portion of the body was covered with stellate melanophores.

Meristic characters easily distinguish metamorphosed juveniles. These characters are presented in Table 1. All juvenile specimens had a total of 35 vertebrae; 12 abdominal and 23 caudal. The dorsal fin averaged 71 rays and the anal fin 50 rays. The caudal fin averaged 19 rays. The eyed side was densely pigmented over the entire body. Dark spots were scattered on both sides and ended prior to the caudal peduncle. Pigment extended onto the vertical fins.

#### MORPHOMETRY AND MERISTICS

The newly hatched larvae averaged 1.6 mm (0.063 inch) standard length (s.L.) and appeared deep bodied because of the large yolk-sac. The oval shaped yolk-sac contained unsegmented yolk with numerous oil globules, the largest positioned to the rear of the yolk-sac. The single large oil globules averaged 0.14 mm (0.005 inch) in diameter. As the yolk was absorbed, the yolk-sac appeared more ovate and the head and hindgut more outlined. By approximately 2.2 mm (0.087 inch) s.L., the yolk was more than  $\frac{1}{2}$  absorbed. The oil globule now averaged around 0.06 mm (0.002 inch). Larvae ranging 2.3 to 2.4 mm (0.090 to 0.094 inch) had consumed nearly all their yolk.

As the yolk was consumed, the gut and mouth became more developed. Newly hatched larvae had no functional mouth and the hindgut leading to the anus appeared as a thin transparent tube extending ventrally through the finfold. Gut development was most evident in the bulging or enlargement proceeding ventrally to the anus, accompanied by heavy gut pigmentation. By 2.3–2.4 mm (0.090 to 0.094 inch) s.L., the gut was functional and food was seen in the intestine. In general, the gut length shortened relative to body length in the larvae; at metamorphosis the snout to anus length was approximately 35% s.L. (Figure 3).

Body shape became more fusiform as yolk absorption progressed. Some specimens slightly hunched over the yolk-sac, but this disappeared with yolk absorption. With the thickening of the gut, the development of the mouth and enlargement of the head, the body deepened in relation to its length (Figure 3). The specimens around 3.8 mm to 4.9 mm began to exhibit the compressed flatfish form. The illustrated larvae display the gradual rotation of the gut anteroventrally with a characteristic sag to the stomach. The metamorphic specimens had a rounded appearance to the gut. Their bodies were more compressed. Throughout the developmental series the myomeres were difficult to see mostly because of the intense pigmentation.

The head of the hatchling showed a midbrain bulge separated from forebrain and medulla which is typical of many pleuronectid larvae. By 2.4 mm, it appeared as a large dome which continued throughout the series. The fore and hindbrain sections could be seen also at these sizes. The head increased in overall relative size throughout development finally reaching approximately  $\frac{1}{3}$  of the body length, then it

TABLE 1.—Average Morphometrics and Meristics of Larval and Juvenile Diamond Turbot, *Hypopsetta guttulata*

Standard length	Average Morphometrics (mm)						Average Meristics			
	Number examined	Standard length	Head length	Eye diam.	Depth at base of pectoral	Snout to anus	Vertebrae	Dorsal	Anal	
1.0-1.4	3	1.4	.30	.17	ys*	.8				
1.5-1.9	36	1.7	.36	.19	.42	1.0				
2.0-2.4	44	2.2	.46	.20	.44	1.1				
2.5-2.9	1	2.5	.53	.22	.45	1.3				
3.0-3.4	2	3.2	.67	.30	.65	1.7				
3.5-3.9	3	3.6	.94	.35	.97	2.0				
4.0-4.4										
4.5-4.9	4	4.7	1.31	.46	1.33	2.5				
5.0-5.9	2	5.8	1.80	.56	1.80	2.7				
11.0-11.9	1	11.5	4.5	2.4	6.6	4.6	35	75	48	
12.0-12.9	1	12.8	4.4	1.4	6.9	4.5	35	66	50	
13.0-13.9	2	13.4	4.6	1.9	7.6	4.8	35	72	52	
14.0-14.9	3	14.5	5.2	1.5	8.0	5.4	35	71	49	
15.0-15.9	5	15.5	5.4	1.7	8.7	5.8	35	70	51	
16.0-19.9	13	17.6	5.7	2.0	9.4	6.1	35	71	52	
20.0-49.9	12	31.3	9.9	2.9	17.4	11.7	35	67	50	
50.0	3	73.3	20.3	5.3	35.7	23.0	35	72	51	

\* Yolk-sac present

decreased slightly as the body deepened (Figure 2). The mouth was inferior in position until 3.5–3.9 mm when it became terminal. The larvae around 5.8 mm exhibited asymmetric growth, with the left eye

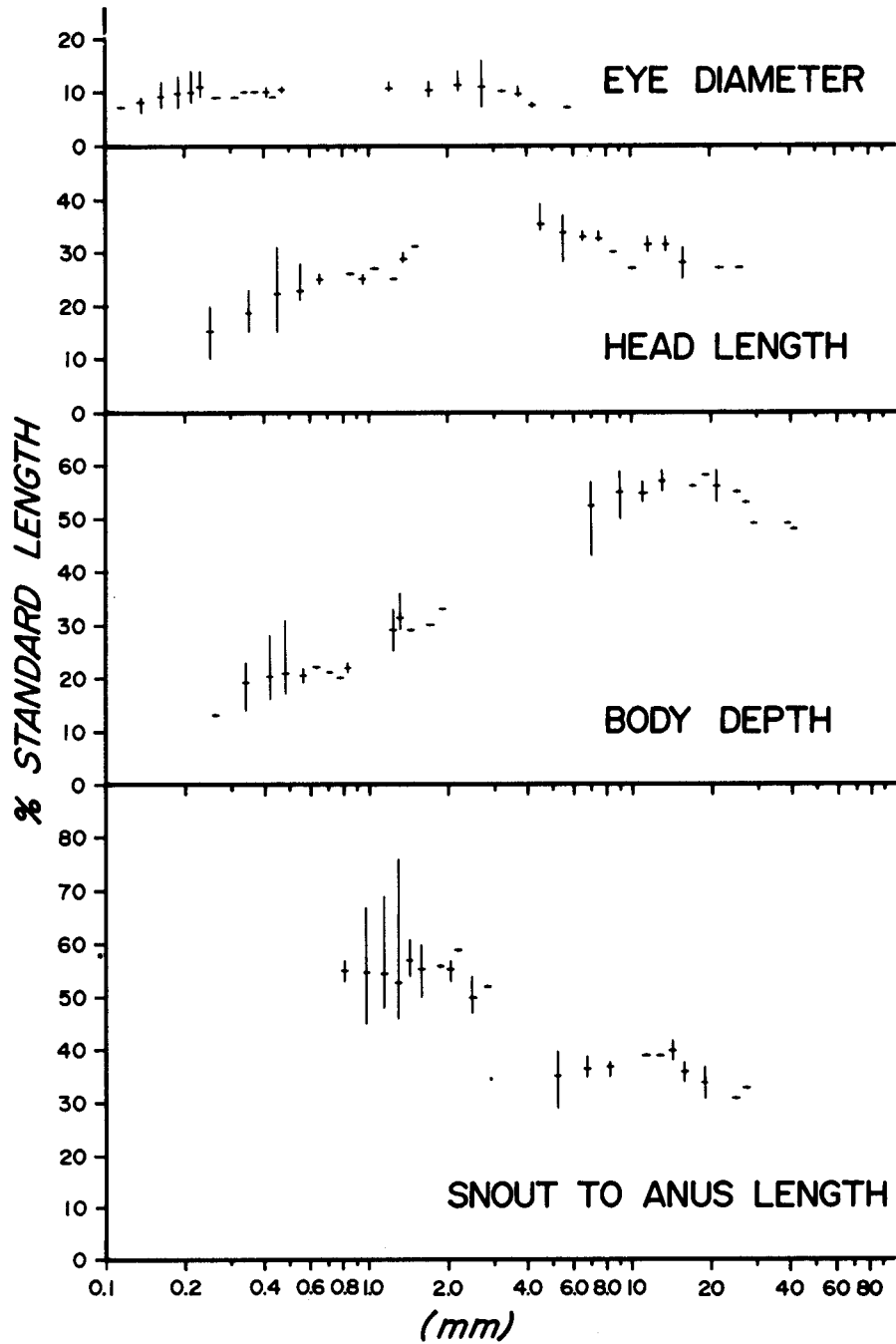


FIGURE 3. Morphometric proportions (in logarithmic scale) of the diamond turbot, plotted as percentages of standard length.

in the midst of migration to the right side. Eye diameters remained much the same in relation to body length throughout development (Figure 3).

The finfold began at the forehead and extended posteriorly around the tail and forward to the yolk-sac or gut. It remained complete and translucent throughout development until around 3.8 mm when the anlagen of the dorsal and anal fins and the caudal fin were seen forming. At hatching the pectoral fin bud was visible on the dorsal aspects of the yolk-sac. By approximately 2.4 mm, the pectoral fins appeared as small lateral projections.

The 4.9 mm larvae possessed nearly developed dorsal and anal fins but the fin ray counts were not complete. Likewise, the metamorphosing larvae did not have complete dorsal and anal fin development, but the rays were more discernible. The caudal fin developed simultaneously with the dorsal and anal fins. The upward flexion of the caudal notochord occurs at about 4.0 mm S.L. The hypural cartilages and the full complement of caudal rays were visible in the metamorphic specimens (Figure 2c). In these advanced larvae, the pterygiophore primordia appeared as longitudinal ridges along the bases of these fins. The smallest juvenile specimen (11.5 mm) did show complete vertical fin ray development.

#### DISCUSSION

From occurrences of the larvae, *Hypsopsetta guttulata* appeared to have an extended spawning period. Larvae, and what I believe to be the pelagic eggs of the diamond turbot, were collected from early June through mid-October.

These eggs averaged 0.80 mm in diameter with usually one large oil globule (average 0.14 mm diameter) and numerous other globules scattered throughout the yolk. They can easily be distinguished from *Pleuronichthys* eggs by the absence of the hexagonal pattern on the chorion and the presence of oil globules.

It is very easy to confuse *H. guttulata* larvae with *Pleuronichthys* larvae, especially with the similarity in pigmentation and morphology. There are no other known larvae in this geographical area which have such heavy pigmentation and which might be confused with turbot larvae. So differentiation needs to be made between the larvae of the different turbot species which might occur in the San Francisco Bay area.

In general, the *Pleuronichthys* larvae are larger than *Hypsopsetta* larvae in the early stages of development. *P. verticalis* is the smallest at hatching being 3.16 mm (0.12 inch) long (Budd 1940). Even allowing for shrinkage during preservation, *Hypsopsetta* larvae would not exceed about 2.00 mm (0.08) at hatching. Yolk-sac larvae of *P. verticalis* have a notable crest not as pronounced in the diamond turbot. Another distinguishing characteristic for the young is the presence of oil globules in the yolk. The finfold pigment patches found in both *P. verticalis* and *P. decurrens* are not as developed or as consistently present in the diamond turbot. Only the very small *Hypsopsetta* larvae (2.4 mm) had finfold patches. The mottled turbot, *P. coenosus*, is separated most easily because it is very large at hatching (5.54 mm) and has heavy pigmentation throughout its finfold.

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It can be seen that various turbot larvae are best separated by pigmentation (especially in the finfold), and relative size at which structures develop in post yolk-sac larvae.

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