EARLY DEVELOPMENT OF SEVEN FLATFISHES OF THE EASTERN NORTH PACIFIC WITH HEAVILY PIGMENTED LARVAE (PISCES, PLEURONECTIFORMES)

B. Y. SUMIDA, E. H. AHLSTROM, AND H. G. MOSER[1]

ABSTRACT

Eggs and larval series are described for six species of flatfishes occurring off California with heavily pigmented larvae. These are the pleuronectids *Pleuronichthys coenosus, P. decurrens, P. ritteri, P. verticalis,* and *Hypsopsetta guttulata* and the bothid, *Hippoglossina stomata*. A brief description of postflexion larvae of the Gulf of California species, *P. ocellatus*, is also presented.

Eggs of *Pleuronichthys* are unusual among flatfishes in possessing a sculptured chorion composed of a network of polygonal walls, whereas the chorions of *Hypsopsetta guttulata* and *Hippoglossina stomata* eggs are smooth and unornamented. Eggs of *Hypsopsetta guttulata* and *P. ritteri* are unusual among those of pleuronectid flatfishes in possessing an oil globule.

A combination of pigmentation, morphology, and meristics can distinguish the seven species of flatfishes with heavily pigmented larvae. Larvae of two species, *H. guttulata* and *P. decurrens*, have a distinctive pterotic spine on either side of the head. Sizes at hatching, at fin formation, and at transformation are important considerations to distinguish these species. Meristic counts, particularly of precaudal and caudal groups of vertebrae, are important to relate a larval series to its juvenile and adult stages and thus substantiate identification of the series.

This report deals primarily with the eggs, larvae, and early juveniles of flatfishes of the genus *Pleuronichthys*. Descriptions are included for complete series of larvae of four species, *P. decurrens* (curlfin turbot),[2] *P. coenosus* (C-O turbot), *P. verticalis* (hornyhead turbot), and *P. ritteri* (spotted turbot). A brief account of postflexion larvae of the Gulf of California species, *P. ocellatus* (Gulf turbot), is also given. Larvae of *Pleuronichthys* are heavily pigmented, even at hatching, as are those of the pleuronectid, *Hypsopsetta guttulata* (diamond turbot), and the bothid, *Hippoglossina stomata* (bigmouth sole). To identify heavily pigmented flatfish larvae obtained in plankton collections from the eastern North Pacific, it is necessary to know the larval developmental series of all of the above species. These species comprise minor incidental catches within California commercial and sport fisheries and are reported as a general grouping of "turbots." Species most commonly caught in the fisheries are *P. decurrens, P. coenosus, P. verticalis*, and *Hypsopsetta guttulata* (Frey 1971; Bell 1971; Oliphant 1973; Pinkas 1974; McAllister 1975). No specific catch data are available for *Hippoglossina stomata*, but the species is probably caught incidentally and included in the "miscellaneous sole" category of catch data.

In a review of the genus *Pleuronichthys*, Fitch (1963) recognized six species including the five listed above and *P. cornutus* from off Japan and China. In an earlier review of the genus, Starks and Thompson (1910) recognized these six species and *P. nephelus* Starks and Thompson. Norman (1934) concurred with Starks and Thompson in recognizing seven species. Fitch (1963), however, agreed with Hubbs (1928) in finding no grounds for the separation of *P. nephelus* from *P. coenosus* after his examination of the type material of *P. nephelus*. Fitch's review is thorough; he examined more than 5,700 individuals of the genus. We follow his classification.

The first descriptions of the eggs and early-stage larvae of *Pleuronichthys* were given by Budd (1940) who dealt with *P. coenosus, P. decurrens,* and *P. verticalis*. Orton and Limbaugh (1953) described the eggs of *Hypsopsetta guttulata* and *P.*

[1]Southwest Fisheries Center La Jolla Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038.

[2]The common name turbot is used for all species of *Pleuronichthys*, a usage consistent with Fitch (1963), Miller and Lea (1972), and Gates and Frey (1974:79). The American Fisheries Society's list of common names (Bailey et al. 1970) designates *P. coenosus* and *P. decurrens* as soles, but we disagree with giving species within a genus different common general names.

Manuscript accepted September 1978.
FISHERY BULLETIN: VOL. 77, NO. 1, 1979.

ritteri. Larvae of *P. verticalis* were illustrated in Ahlstrom and Moser (1975), and Eldridge (1975) described and illustrated larvae of *H. guttulata*.

MATERIALS AND METHODS

Eggs, larvae, and some juveniles were primarily obtained from California Cooperative Oceanic Fisheries Investigations (CalCOFI) collections. These samples were preserved in a consistent manner as described in Kramer et al. (1972). Additional material was obtained from bay, estuarine, and coastal collections of Occidental College; Southwest Fisheries Center Tiburon Laboratory, National Marine Fisheries Service; California State University at Fullerton; Scripps Institution of Oceanography; Oregon State University; and Humboldt State University. Specimens of *P. ritteri, P. verticalis,* and *H. guttulata* reared at the Southwest Fisheries Center La Jolla Laboratory, National Marine Fisheries Service, were also utilized.

Egg and oil globule diameters were measured using an ocular micrometer in a stereomicroscope. For eggs that were not perfectly round, the greatest diameter was recorded. Scanning electronmicrographs were made for four kinds of *Pleuronichthys* eggs and for eggs of *Synodus lucioceps* (Synodontidae). The greatest diameter of 10 randomly selected polygonal facets of the chorion of *Pleuronichthys* and *Synodus* eggs were measured using an ocular micrometer in a compound microscope. To do this the chorion was cut into pieces that were laid flat on a glass slide with a cover slip over them.

The number of specimens examined varied by species, depending on their availability and abundance, ranging from several hundred larvae of *P. verticalis*, the most abundant species, to two larvae of *P. ocellatus*. For most species, the minimum number of specimens studied is indicated in the morphometric tables with usually twice as much material looked at for pigmentation development. A developmental series of larvae through juveniles was assembled for each species. Measurements of selected body parts were taken to provide descriptive and comparative morphometric data. Measurements were made on the right side of each pleuronectid specimen, and on the left side of the bothid, *Hippoglossina stomata*, using an ocular micrometer in a stereomicroscope. Terminology used in the morphometric tables is as follows:

Body length = In preflexion and flexion stages, horizontal distance from tip of snout to tip of notochord, referred to as notochord length (NL); in postflexion stages, from tip of snout to posterior margin of hypural elements, i.e., standard length (SL).

Snout to anus = Horizontal distance from tip of snout through midline of body to vertical through anus.

Head length = Horizontal distance from tip of snout through midline of head to margin of cleithrum preceding the pectoral fin base.

Snout length = Horizontal distance from tip of snout to anterior margin of pigmented region of eye.

Eye width = Horizontal distance through midline of pigmented eye.

Eye height = Vertical distance through center of pigmented eye.

Body depth at pectoral base = Vertical distance across body at pectoral fin base prior to formation of dorsal fin pterygiophores. An asterisk follows this measurement in the morphometric tables when it includes the depth of dorsal fin pterygiophores.

Body depth at anus = Vertical distance across body at anus prior to formation of dorsal fin pterygiophores. An asterisk follows this measurement when it includes the depth of the dorsal fin pterygiophores.

Caudal peduncle depth = Vertical distance across tail immediately posterior to terminal dorsal and anal fin rays.

Caudal peduncle length = Medial horizontal distance from vertical through terminal dorsal and anal fin rays to posterior margin of hypural elements.

Snout to pelvic fin origin = Horizontal distance from tip of snout to vertical through origin of right pelvic fin (left in *H. stomata*).

Larval specimens for each species were not available in sufficient numbers to clear and stain for complete data on meristics and sequence of ossification of bony elements. However, fin ray counts were made and tabulated on unstained specimens. A partial larval series of *P. verticalis*, our most abundant species, was cleared with KOH and stained with Alizarin Red-S by Hollister's method (1934) to determine the process of axial skeletal development and fin formation. In addition, several larvae of *P. coenosus* and *P. decurrens* were cleared and stained for precaudal and total vertebral counts which verified identifications and proved that Budd (1940) confused identifications of larvae of these two species. Radiographs of transforming larvae, juveniles, and adults of each species provided additional meristic data.

We divide the larval period into three stages, preflexion, flexion, and postflexion, based on the flexion of the notochord which occurs during caudal fin formation (Moser and Ahlstrom 1970; Ahlstrom et al. 1976; Moser et al. 1977). In *Pleuronichthys* and some other flatfishes the initiation of caudal fin formation begins while the notochord is still straight, in the late preflexion stage; we designate this phase as "early caudal formation." We found it convenient to divide the flexion stage into three substages, early flexion, midflexion, and late flexion, dependent upon the state of flexion of the notochord. In the early flexion stage, the notochord is very slightly flexed upward; in midflexion, it is flexed midway (nearly a 45° angle); and in late flexion, the notochord is approaching a terminal position, except that the caudal rays remain in a slightly oblique position. Transformation from the larval to juvenile stage was marked by eye migration, development of ossified pectoral fin rays, scales, and the lateral line.

MERISTIC COUNTS OF LARVAE

Meristic counts overlap among species considered here, and for discrimination of species it is necessary to use a combination of counts (Table 1). Precaudal and caudal vertebral counts, used in conjunction with dorsal and anal fin counts, are of most use in relating larvae to juveniles or adults. Pelvic fin ray counts are six per side in all seven species and branchiostegal ray counts are seven per side. Pectoral fin counts cannot be made on larvae since ossified pectoral rays form at metamorphosis. Gill rakers are not fully formed during the larval period in the species described.

DESCRIPTION OF EGGS

Pleuronichthys spp.

Eggs of three *Pleuronichthys* species were first described by Budd (1940) who collected them in plankton hauls from Monterey Bay, Calif. Budd noted the hexagonal patterns on the chorions of *Pleuronichthys* eggs. This type of ornamentation of the egg shell is confined to *Pleuronichthys* among flatfishes, but similar polygonal sculpturing is found on eggs of the families Synodontidae (Sanzo 1915; Mito 1961) and Callionymidae (Holt 1893; Ehrenbaum 1905; Mito 1962) and in a more exaggerated form on eggs of the sternoptychid, *Maurolicus muelleri* (Sanzo 1931; Mito 1961), and the macrourid, *Coelorhynchus coelorhynchus* (Sanzo 1933). Eggs of the three species of *Pleuronichthys* described by Budd were strikingly different in size; his largest, *P. coenosus*, averaged 1.88 mm in diameter, his intermediate-sized egg, *P. decurrens*, 1.44 mm, and his smallest, *P. verticalis*, 1.07 mm. All had homogeneous yolk, and lacked an oil globule. Our work shows that Budd misidentified the two larger eggs and corresponding larvae; the one he called *P. coenosus* is *P. decurrens* and vice versa. Orton and Limbaugh (1953) described an egg with an hexagonal pattern on its chorion that possessed a single oil globule; they tentatively, but correctly, assigned it to *P. ritteri*. White (1977) illustrated a developing egg of *P. ritteri* from Newport Bay, Calif.

Information concerning egg diameters, presence or absence of an oil globule, and character of the chorion are given in Table 2 for six of the seven species treated in this paper. Egg diameters do not change noticeably with the duration of preservation, although some shrinkage is known at the initial time of preservation. There is no overlap in egg size for the three species of *Pleuronichthys* that lack an oil globule. Eggs of *P. decurrens* range from 1.84 to 2.08 mm; those of *P. coenosus*, from

TABLE 1.—Meristics of the seven species of flatfishes in the eastern North Pacific that have heavily pigmented larvae.[1]

Species	Dorsal rays	Anal rays	Pectoral rays (eyed side)	Vertebrae			Total gill rakers	Caudal rays	
				Precaudal	Caudal	Total		Total	Branched
Pleuronichthys decurrens	67-81	46-55	10-14	*14*-15	24-26	38-41	9-12	*19*-21	12-15(*13*)
P. coenosus	66-78	44-56	9-12	12-*13*	24-26	37-39	11-15	18-20(*19*)	12-15(*13*)
P. verticalis	66-79	44-51	10-12	13	23-25	36-38	9-11	*19*-20	12-14(*13*)
P. ocellatus	62-74	44-53	10-12	*12*-13	22-24	34-36	10-14	19	12-15(*13*)
P. ritteri	62-72	43-52	9-11	*12*-13	22-24	34-36	12-17	18-*19*	*13*-14
Hypsopsetta guttulata	65-75	47-55	11-13	11-*12*	22-24	34-36	?+[2](5-6)	*19*-20	13
Hippoglossina stomata	63-70	47-55	11-12	*11*	26-28	37-39	15-21	17½-*18½*	11-*13*

[1]Meristics compiled in Table 1 are derived in part from literature, particularly Fitch (1963), Norman (1934), Townsend (1936), Clothier (1950), and Ginsburg (1952), and in part from our original counts. Where a range is given and one count is predominant, that count is italicized.

[2]Lower limb count only.

TABLE 2.—Measurements of eggs of *Pleuronichthys* species, *Hypsopsetta guttulata*, and *Hippoglossina stomata*, including *Synodus lucioceps* for comparative data.

Species	Character of chorion	No. of eggs measured	No. of samples	Egg diameters (mm)			Oil globule diameters (mm)		
				Range	Mean	SD	Range	Mean	SD
Pleuronichthys decurrens	Sculptured	41	28	1.84-2.08	1.97	0.058	—	—	—
P. coenosus (CalCOFI)	Sculptured	20	15	1.28-1.56	1.47	0.066	—	—	—
P. coenosus (King Harbor)	Sculptured	287	2	1.20-1.42	1.29	0.047	—	—	—
P. verticalis	Sculptured	188	19	1.00-1.16	1.09	0.040	—	—	—
P. ritteri	Sculptured	82	13	0.94-1.08	1.01	0.029	0.08-0.14	0.10	0.009
Hypsopsetta guttulata	Smooth	35	4	0.78-0.89	0.84	0.027	0.12-0.14	0.13	0.010
Hippoglossina stomata	Smooth	26	9	1.22-1.38	1.29	0.045	0.20-0.26	0.23	0.018
Synodus lucioceps	Sculptured	168	8	1.20-1.48	1.32	0.049	—	—	—

1.20 to 1.56 mm; and those of *P. verticalis*, from 1.00 to 1.16 mm. Although eggs of *P. ritteri*, ranging in diameter from 0.94 to 1.08 mm, fall within the size range of *P. verticalis*, they can be readily distinguished by the presence of a small oil globule, 0.08-0.14 mm in diameter. Eggs of *P. ocellatus* were unavailable.

Differences in mean diameter of *P. coenosus* eggs were noted by locality, with eggs taken in open waters off the coast having a larger mean diameter and standard deviation (Table 2, CalCOFI collections) than eggs sampled from the inlet of a small, shallow, manmade harbor near a power plant discharge (Table 2, King Harbor samples). Except that they are often slightly larger in size, early- and middle-stage eggs of *P. coenosus* are difficult to differentiate from *Synodus lucioceps* eggs. They can be separated, however, by careful examination of the size and arrangement of polygons on the chorion. The mean of the greatest distance across polygons (sample size = 200 polygons) on *P. coenosus* eggs is 0.035 mm in contrast to 0.047 mm for *S. lucioceps* eggs (Table 3). Furthermore, the polygons on *P. coenosus* eggs are more regular in arrangement than on *S. lucioceps* eggs (Figure 1). This more uniform compacting of smaller polygons on *P. coenosus* eggs versus a more random patterning of larger polygons on *S. lucioceps* eggs is visible under a light microscope, and will separate these eggs. Late-stage eggs are easily distinguished by the heavy pigmentation on the embryo of *P. coenosus* compared with the sparse pigment on advanced *S. lucioceps* embryos, which also have a longer gut.

TABLE 3.—Comparison of polygon size on chorion of eggs of *Pleuronichthys* and *Synodus lucioceps*.

Species	No. of eggs measured	No. of polygons measured	Range of diameters (mm)	Mean (mm)	SD (mm)
Synodus lucioceps	20	200	0.038-0.053	0.047	0.0033
Pleuronichthys coenosus	20	200	0.029-0.043	0.035	0.0029
P. decurrens	2	20	0.038-0.046	0.042	0.0021
P. verticalis	2	20	0.037-0.051	0.042	0.0046
P. ritteri	2	20	0.028-0.032	0.030	0.0011

The arrangement of polygons on the chorion of eggs of the other three species of *Pleuronichthys* from the eastern Pacific is similarly uniform (Figure 2). The polygons are somewhat larger on the chorion of eggs of *P. decurrens* and *P. verticalis* than *P. coenosus*, averaging ca. 0.042 mm in both species (Table 3). Interestingly, Budd (1940) gave the identical value, 0.042 mm, for this measurement on eggs of these two species. The polygons are smaller on eggs of *P. ritteri*, averaging 0.030 mm.

The eggs of *P. cornutus* were described by Mito (1963) and Takita and Fujita (1964). Mito gave the egg diameters as 1.16-1.26 mm, the oil globule as 0.016-0.020 mm. Takita and Fujita gave similar measurements for the hexagonal meshes of 0.018 mm, but gave a smaller egg diameter of 1.03-1.11 mm.

Hypsopsetta guttulata

Orton and Limbaugh (1953) obtained running ripe eggs of *H. guttulata* by stripping ripe adults and obtained similar eggs from plankton collections. The eggs were notable in that they contained a conspicuous, moderately large oil globule. This was the first record of an oil globule in eggs of flatfishes of the family Pleuronectidae, subfamily Pleuronectinae. The egg capsule was simple, without polygonal sculpturing or other apparent texture; the yolk was homogenous. Orton (1953) gave a fairly detailed description of pigment development on embryos of *H. guttulata*. Neither of the above papers contained information on egg size. Eldridge (1975) reported a mean egg diameter of 0.80 mm with usually one oil globule of 0.14 mm in mean diameter and numerous other small oil globules in the yolk. Eggs in our samples had a mean diameter of 0.84 mm (range 0.78-0.89 mm) with a single oil globule averaging 0.13 mm in

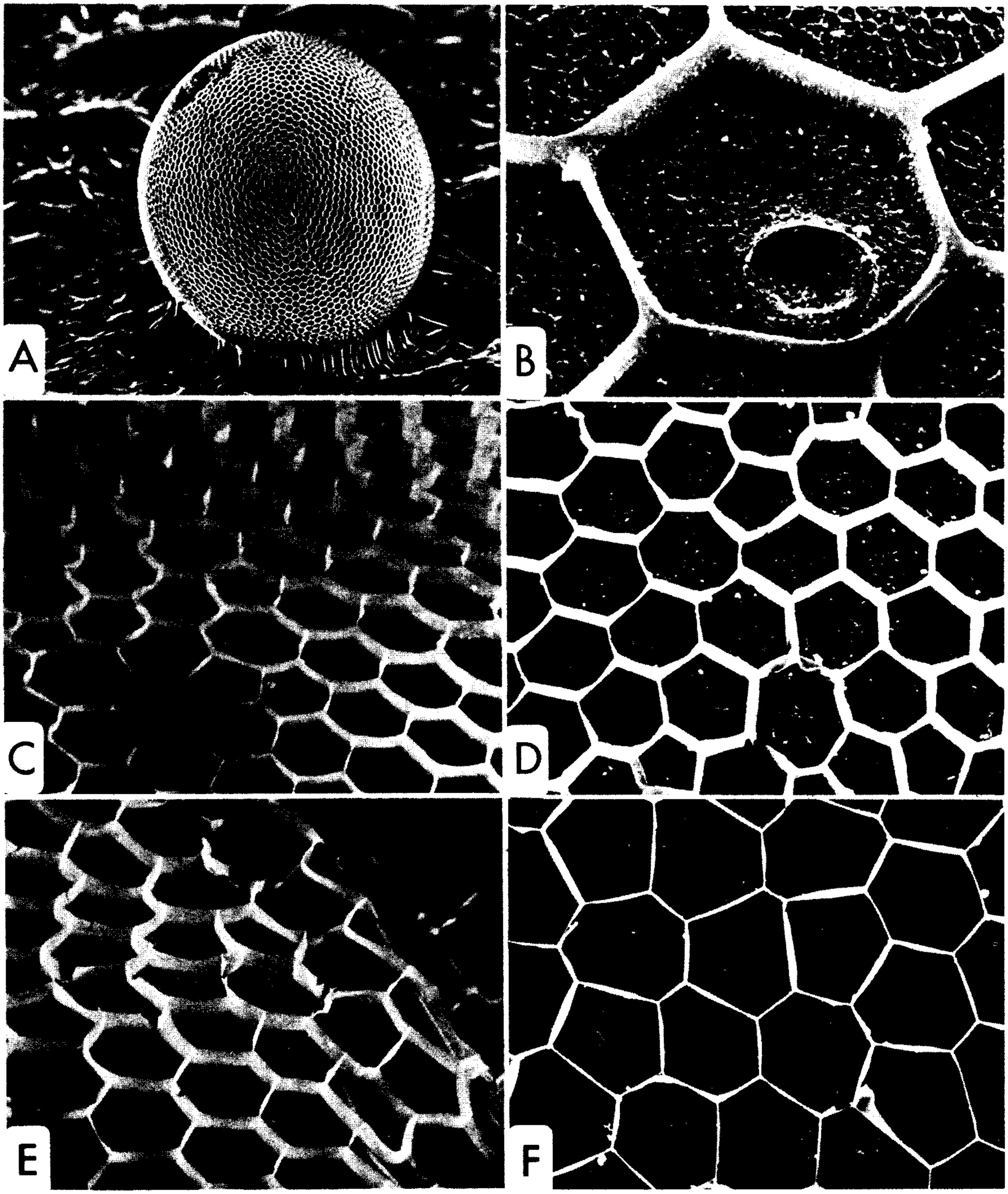


FIGURE 1.—Scanning electronmicrographs of *Pleuronichthys* and *Synodus lucioceps* eggs. A. Entire egg of *P. coenosus*, 40×; B. Single polygon from same egg showing micropyle and texture of chorion surface, 1,880×; C. Side view of same egg showing polygons in perspective and micropyle at lower left, 420×; D. Face view of same egg, 480×; E. Side view of *S. lucioceps* egg showing polygons in perspective, 455×; note delicate nature of polygons; F. Face view of same egg showing irregular nature of polygons and smooth surface of chorion, 490×.

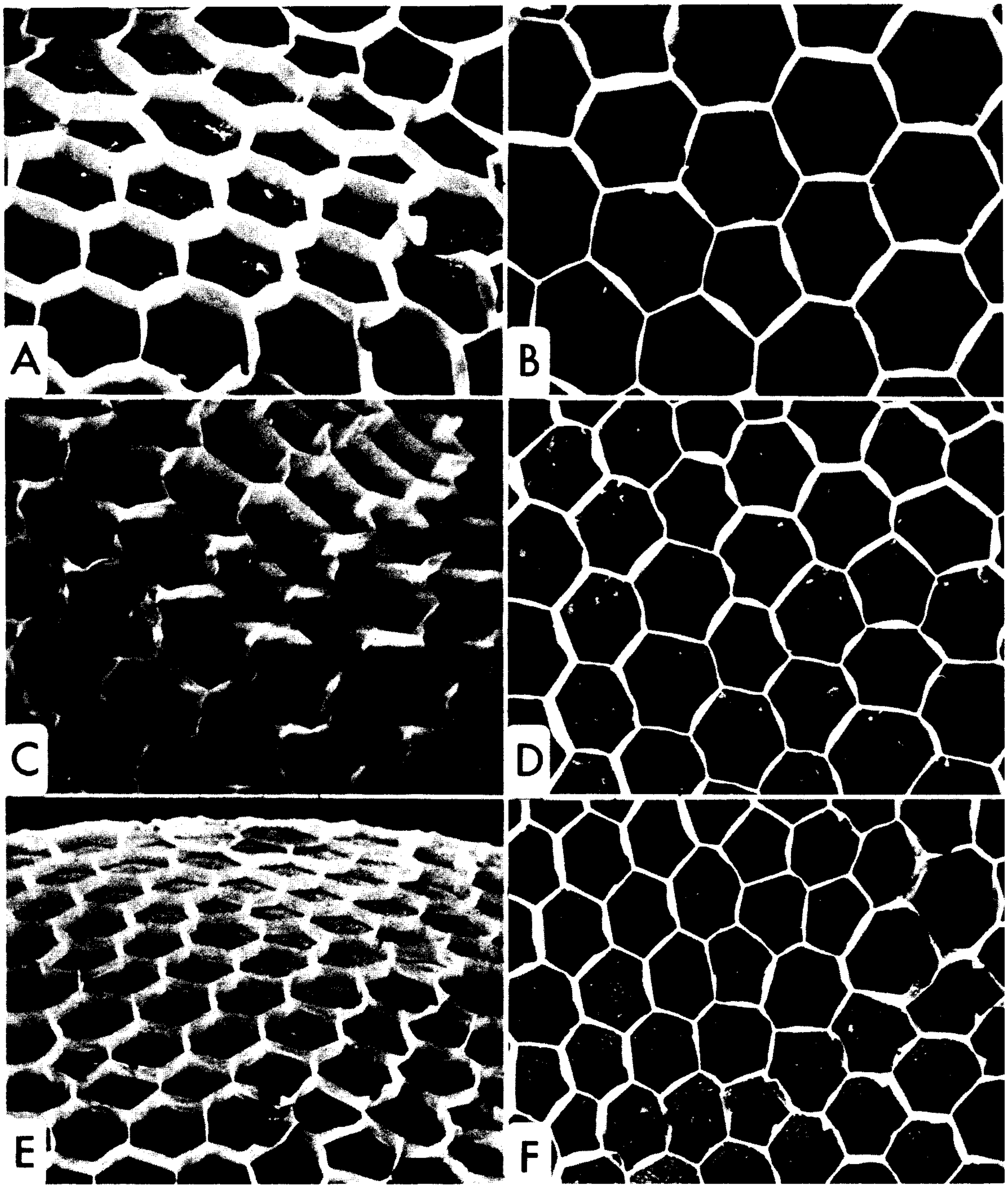


FIGURE 2.—Scanning electromicrographs of *Pleuronichthys* eggs. A. Side view of *P. decurrens* egg, 475×; B. Face view of same egg, 475×; C. Side view of *P. verticalis* egg, 410×; D. Face view of same egg, 450×; E. Side view of *P. ritteri* egg, 460×; F. Face view of same egg, 475×.

diameter (Table 2). There was no evidence of other small oil globules in the yolk, although a few eggs had a damaged oil globule which had separated in two. However, the original oil globule could easily be determined because of surrounding pigment. The oil globule is positioned near the center of the developing embryo in middle-stage eggs. The body of the late-stage embryo is heavily pigmented, similar to the newly hatched larvae.

Hippoglossina stomata

Eggs of *H. stomata* have not been previously described. Eggs are round with a slightly pinkish, unornamented shell and a single oil globule. The egg has a mean diameter of 1.29 mm (range 1.22-1.38 mm) and the oil globule a mean diameter of 0.23 mm (range 0.20-0.26 mm) (Table 2). The oil globule lacks pigment and lies near the tip of the tail of developing embryos in middle-stage eggs. In late-stage eggs the oil globule is in the posterior part of the yolk sac; the embryo is heavily pigmented over the body except for the posteriormost portion of the tail; pigment patches occur on the finfolds in the same places as in early preflexion stage larvae; pigment is widespread over the yolk surface.

DESCRIPTION OF DEVELOPMENTAL STAGES—LARVAL, TRANSFORMING, AND EARLY JUVENILE

Pleuronichthys decurrens Jordan and Gilbert (curlfin turbot) Figures 3, 4

Literature.—A series of egg stages and two preflexion larvae of *P. decurrens* were described and illustrated by Budd (1940) but incorrectly identified as *P. coenosus*. His larval illustrations were based on a recently hatched specimen, 5.54 mm, and an emaciated specimen, 8 days old, of somewhat smaller size.

Distinguishing characters.—Larvae of this species are unique in the genus *Pleuronichthys* in developing a pterotic spine on each side of the head, in having a higher precaudal vertebral number of 14 or 15, and in having the largest larvae during all stages of development. Larval pigmentation is heaviest in this species with the body and finfold entirely pigmented except for the posteriormost region. Because of their relatively large size and dense pigment, *P. decurrens* larvae cannot be confused with *Hippoglossina stomata* or *Hypsopsetta guttulata*.

Pigmentation.—Newly hatched, preflexion, and early flexion larvae (4.9-9.8 mm NL) are heavily pigmented over the head, trunk, tail, and finfolds with only the pectoral fin and posteriormost tip of the notochord and finfold unpigmented (Figure 3A, B, C). As the first few caudal rays become evident (ca. 9.7 mm NL), several small, discrete melanophores appear on the pectoral fin base (Figure 3C). In late flexion and early postflexion stages during dorsal and anal fin development, the continuous heavy pigment on the finfolds changes to form three to four dorsal and three ventral bands of pigment which extend out from the body margin to part of the rayed fin membrane (Figure 3D). Larvae at this stage have a soft, saccular body with semitransparent and sparsely pigmented areas in the pterygiophore region between the body proper and developing dorsal and anal fins. Larvae >11.2 mm SL have dorsal and anal pterygiophores fully developed; the pterygiophore region is no longer transparent and the specimens become robust (Figure 4).

Morphology.—Larvae of *P. decurrens* are the largest members of the genus at hatching and attain the largest size before transformation. Our smallest specimen is 4.9 mm NL and has yolk remnants (Table 4). The left eye begins to migrate at 10.5 mm SL and has not completed migration in a larva 21.0 mm SL. The smallest available juvenile is 29.4 mm SL.

The gut begins as a tube which diminishes in diameter posteriorly and ends with a free terminal section that diverges from the body in a slight posteriad direction. In 5- to 7-mm NL larvae, the gut increases markedly in diameter and the free terminal section becomes vertical to the body axis. At about 8.0 mm NL, the gut begins to coil and its terminal section begins to slant anteriad. Coiling and the anterior displacement of the anus become more marked as development proceeds. This is reflected in the decreasing relative snout-anus length in postflexion larvae and especially in juveniles (Table 5).

Relative head length increases during larval development whereas relative snout length decreases (Table 5). Relative eye width decreases slightly during the three phases of the larval

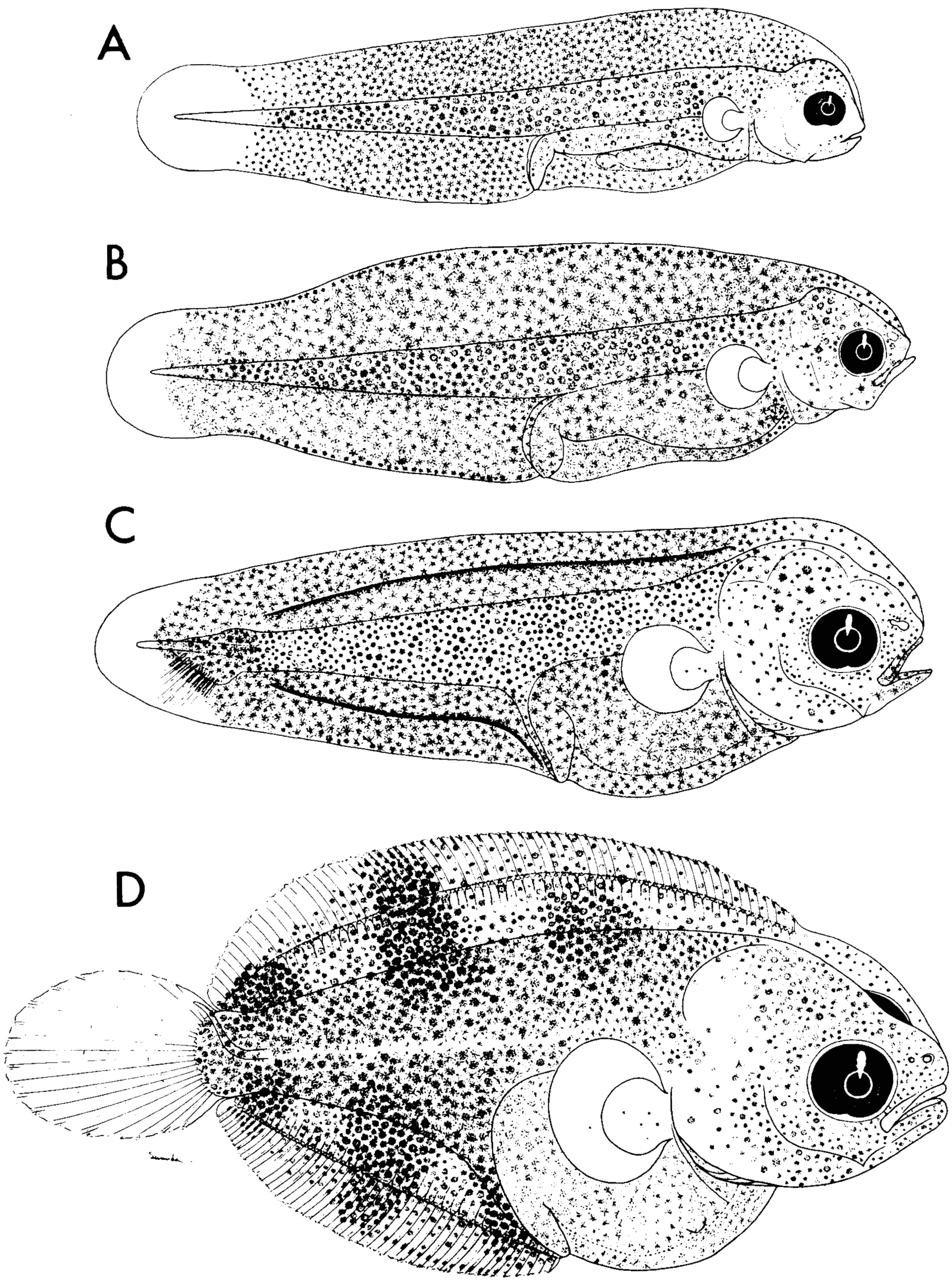

A
B
C
D

FIGURE 3.—Larval stages of *Pleuronichthys decurrens*: A. 5.9 mm; B. 6.5 mm; C. 9.7 mm; D. 10.0 mm.

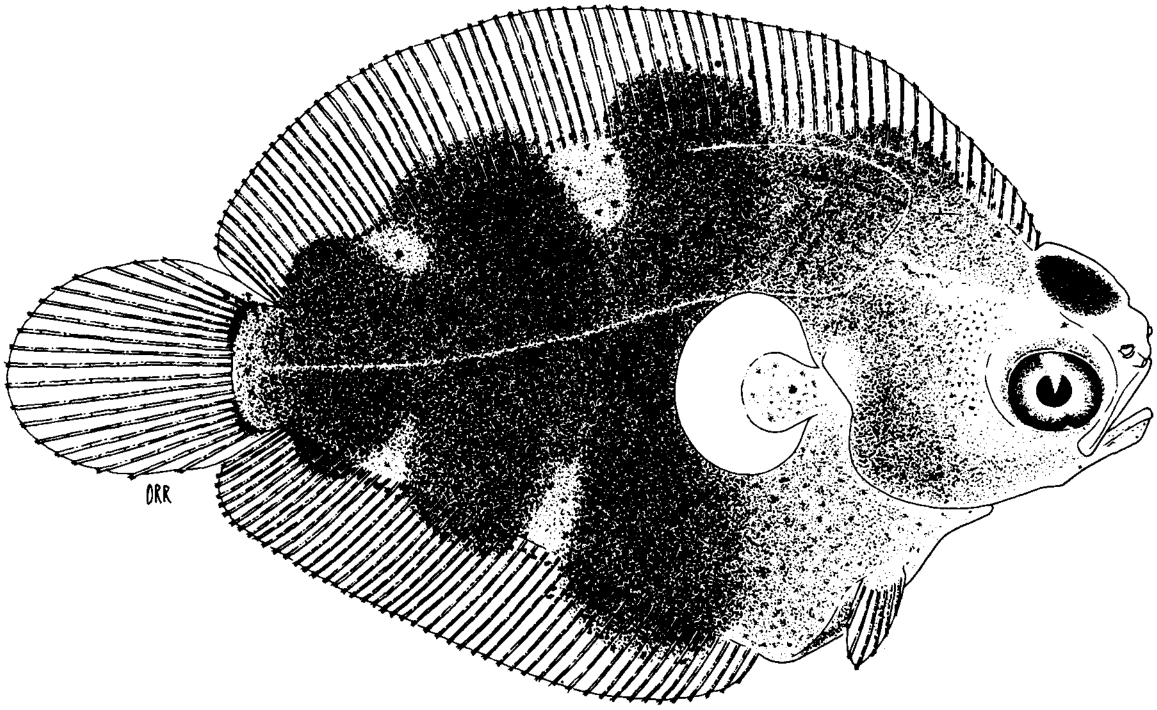


FIGURE 4.—Transforming specimen of *Pleuronichthys decurrens*, 14.4 mm.

TABLE 4.—Morphometrics, in millimeters, of larvae and a juvenile of *Pleuronichthys decurrens*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Body length	Left eye[1]	Notochord[2]	Snout to anus	Head length	Snout length	Eye width	Eye height	Body depth at P base[3]	Body depth at anus[3]	Caudal peduncle depth	Caudal peduncle length	Snout to origin pelvic fin
5401-90.60	4.9 NL	Sym.	Str.	2.4	0.80	0.14	0.30	0.24	0.54	0.64	—	—	—
5704-87.50	5.6	Sym.	Str.	3.0	1.1	0.20	0.40	0.32	0.90	0.96	—	—	—
6501-63.52	6.0	Sym.	Str.	3.0	1.1	0.20	0.40	0.36	0.90	0.74	—	—	—
5206-70.65	6.5	Sym.	Str.	3.2	1.2	0.22	0.42	0.40	0.94	1.1	—	—	—
6501-60.70	7.9	Sym.	Str.	3.9	1.6	0.30	0.50	0.48	1.3	1.3	—	—	—
5003-87.35	8.5	Sym.	Str.	4.1	1.8	0.32	0.60	0.56	1.7	1.8*	—	—	—
6606-60.65	9.3	Sym.	Str.	4.3	2.0	0.32	0.66	0.62	1.6	1.8*	—	—	—
6605-80.80	9.8	Sym.	Str.	4.3	2.2	0.36	0.68	0.64	2.0	2.2*	—	—	—
5706-93.65	7.8	Sym.	E fl.	3.9	1.9	0.30	0.64	0.64	2.3*	2.3*	—	—	—
5711-87.55	9.1	Sym.	E fl.	4.7	2.1	0.40	0.70	0.66	2.4*	2.5*	—	—	—
5401-85.60	10.0	Sym.	Midfl.	4.4	2.6	0.44	0.80	0.72	2.8*	3.0*	—	—	2.7
6507-87.55	11.0	Sym.	L fl.	5.8	3.2	0.48	0.98	1.0	4.0*	4.6*	—	—	3.3
5009-47.60	10.2 SL	Sym.	Flexed	5.3	3.4	0.60	0.96	0.94	4.5*	4.6*	1.0	0.60	3.4
5407-60.70	10.5	Migr.	Flexed	5.5	3.6	0.64	1.1	1.1	4.9*	5.4*	1.0	0.64	3.4
5805-70.80	11.2	Migr.	Flexed	5.7	3.9	0.64	1.3	1.2	5.2*	5.9*	1.3	0.68	3.6
7505-90.70	14.5	Migr.	Flexed	6.2	5.2	0.66	1.6	0.96	8.1*	8.6*	2.1	0.83	4.6
4903-82.57	15.4	Migr.	Flexed	7.0	5.7	0.67	1.8	1.7	9.0*	9.7*	2.1	1.1	4.7
6609-80.60	17.0	Migr.	Flexed	8.7	6.4	0.67	1.9	1.5	9.2*	11.4*	2.9	1.2	6.0
5308-73.60	19.2	Migr.	Flexed	7.7	6.5	0.91	1.7	1.5	10.0*	11.4*	2.8	1.2	6.4
5004-97.32	21.0	Migr.	Flexed	8.4	6.7	0.66	1.7	1.7	11.7*	12.4*	3.2	1.4	6.2
Off Santa Cruz Island, Calif.	29.4	Over	Juv.	9.7	9.0	0.66	3.3	2.5	13.9*	14.5*	3.6	2.2	6.8

[1]Sym. - symmetrical; Migr. - migrating.
[2]Str. - straight; E fl. - early flexion; Midfl. - midflexion; L fl. - late flexion; Juv. - juvenile.
[3]Asterisk indicates inclusion of dorsal fin pterygiophores in body depth measurement.

TABLE 5.—Body proportions of larvae and early juveniles of seven flatfishes with heavily pigmented larvae. (Values given for each body proportion expressed as percentage of body length or head length: mean, standard deviation, and range. Numbers derived from data in morphometric tables for each species.)

Body proportion	*Pleuronichthys decurrens*	*P. coenosus*	*P. verticalis*	*P. ocellatus*	*P. ritteri*	*Hypsopsetta guttulata*	*Hippoglossina stomata*
Snout to anus/body length:							
Preflexion	48.6±2.9(44-54)	46.2±3.4(39-50)	50.9±1.2(50-53)	—	49.2±3.8(44-57)	50.0±1.2(48-52)	40.1±3.9(36-45)
Flexion	49.8±4.0(44-53)	44.5±3.3(42-51)	50.0±4.7(44-56)	—	49.0±1.4(48-51)	48.5±1.7(46-50)	39.4±1.4(37-41)
Postflexion	46.9±5.3(40-52)	42.4±4.6(37-49)	42.7±4.3(36-45)	47.5±0.7(47-48)	40.7±7.9(31-51)	44.6±5.2(37-52)	40.5±2.6(36-44)
Juvenile	33	31	32.4±0.9(31-33)	32.2±2.2(30-36)	31.2±1.3(30-33)	36.0±1.1(35-38)	33.5±2.1(32-35)
Head length/body length:							
Preflexion	19.6±2.1(16-22)	20.0±2.7(15-23)	22.1±1.7(20-25)	—	24.4±2.3(20-28)	21.6±2.8(17-25)	21.5±3.3(17-26)
Flexion	25.5±2.6(23-29)	24.8±3.3(22-31)	27.3±1.9(25-30)	—	27.2±3.9(22-31)	25.8±1.3(24-27)	25.6±1.9(22-28)
Postflexion	34.9±2.0(32-38)	31.1±1.8(28-33)	33.2±2.6(31-37)	30.0	32.8±1.5(31-35)	33.0±1.9(30-36)	31.4±1.7(29-34)
Juvenile	31	28	27.4±1.5(26-30)	27.8±1.2(27-30)	29.0±1.2(28-30)	33.0±0.6(32-34)	34.5±0.7(34-35)
Snout length/head length:							
Preflexion	17.6±1.1(16-19)	20.5±3.5(16-27)	22.4±2.8(18-26)	—	18.8±1.8(17-22)	21.9±2.8(18-26)	18.1±4.0(10-24)
Flexion	16.8±1.7(15-19)	18.1±2.4(14-21)	19.7±3.1(15-23)	—	22.0±4.7(17-28)	18.8±1.5(17-20)	20.9±2.2(18-24)
Postflexion	13.9±3.2(10-18)	16.7±2.1(13-19)	14.7±2.9(11-18)	17.0±2.8(15-19)	16.3±1.4(15-18)	17.9±1.6(16-20)	23.1±2.8(19-27)
Juvenile	7	12	6.2±3.0(2-10)	14.2±1.5(12-16)	10.8±1.0(10-12)	14.7±1.8(12-17)	19.5±0.7(19-20)
Eye width/head length:							
Preflexion	34.1±2.5(31-38)	36.6±4.1(31-43)	36.4±4.1(31-44)	—	37.2±6.0(31-48)	40.6±3.1(37-45)	35.1±4.9(28-44)
Flexion	32.0±1.5(31-34)	32.0±2.6(28-35)	32.5±1.0(31-34)	—	33.5±6.4(29-43)	31.8±1.0(31-33)	31.9±1.5(30-34)
Postflexion	29.5±2.9(25-33)	29.6±1.7(26-31)	32.5±4.5(29-41)	28.5±2.1(27-30)	30.8±1.2(30-32)	31.5±2.7(28-36)	30.5±2.2(27-34)
Juvenile	37	30	38.4±3.0(34-42)	33.3±2.2(31-37)	36.2±2.9(32-38)	30.7±3.7(28-38)	33.0±2.8(31-35)
Eye height/head length:							
Preflexion	30.8±1.6(29-33)	32.1±2.0(29-35)	32.6±4.2(26-39)	—	32.8±3.9(29-40)	33.6±2.6(32-37)	28.6±3.4(26-33)
Flexion	31.0±2.4(28-34)	29.0±3.3(24-34)	30.8±1.7(28-33)	—	32.2±4.6(27-40)	28.8±1.5(27-30)	30.8±3.8(26-37)
Postflexion	26.1±4.7(18-31)	26.7±1.4(25-28)	27.0±2.8(23-30)	27.5±0.7(27-28)	27.2±2.3(25-31)	25.5±1.8(22-28)	29.4±3.7(24-36)
Juvenile	28	—	29.6±4.1(23-33)	33.3±2.2(31-37)	28.3±2.1(26-30)	24.2±3.4(21-30)	—
Body depth at P base before development of D base/body length:							
Preflexion	16.1±3.0(11-20)	17.4±4.5(8-22)	16.7±3.7(9-20)	—	20.9±6.4(10-28)	18.6±7.3(8-25)	17.6±4.5(12-23)
Flexion	—	23	—	—	—	23.2±1.0(22-24)	—
Body depth at P base after development of D base/body length:							
Preflexion	—	—	—	—	35	—	28.1±6.1(22-34)
Flexion	30.0±4.3(26-36)	27.4±4.0(22-33)	29.8±3.1(25-33)	—	33.8±2.6(31-36)	—	30.6±2.1(28-33)
Postflexion	51.6±5.3(44-58)	39.9±5.9(31-45)	39.7±5.0(31-46)	33.0	40.7±1.5(39-42)	39.2±6.2(33-47)	38.1±2.0(36-41)
Juvenile	47	46	40.4±0.9(39-41)	42.0±1.6(39-43)	39.5±2.1(37-42)	52.8±1.5(51-54)	37.0
Body depth at anus before development of D&A bases/body length:							
Preflexion	15.0±2.4(12-17)	15.7±2.9(12-19)	14.3±0.8(13-15)	—	18.0±2.4(14-20)	18.4±3.4(13-22)	14.6±3.9(9-21)
Flexion	—	—	—	—	—	22.2±0.5(22-23)	—
Body depth at anus after development of D&A bases/body length:							
Preflexion	20.7±1.5(19-22)	—	—	—	27.7±5.5(22-33)	—	26
Flexion	32.5±6.4(28-42)	28.3±4.2(24-35)	27.7±4.1(21-32)	—	33.2±4.4(27-36)	—	26.6±2.6(24-31)
Postflexion	57.0±7.0(45-67)	44.1±7.1(32-50)	41.7±5.8(31-46)	33.0	42.2±1.6(40-45)	41.2±6.1(35-48)	38.0±4.4(33-45)
Juvenile	49	49	42.2±0.8(41-43)	44.8±1.7(42-47)	40.8±1.9(38-42)	54.7±1.2(54-57)	36.0
Caudal peduncle depth/body length:							
Postflexion	13.4±2.5(10-17)	12.4±2.4(9-16)	11.8±1.9(8-13)	7.5±0.7(7-8)	12.0±1.8(9-14)	9.1±1.4(8-11)	8.9±0.8(8-10)
Juvenile	12	14	13.2±0.8(12-14)	12.5±0.6(12-13)	11.5±0.6(11-12)	11.5±0.6(11-12)	9.5±0.7(9-10)
Caudal peduncle length/body length:							
Postflexion	6.4±0.5(6-7)	5.1±0.4(5-6)	6.5±1.2(5-8)	6.5±0.7(6-7)	5.8±0.8(5-7)	8.5±0.5(8-9)	8.5±0.5(8-9)
Juvenile	7	6	6.6±0.6(6-7)	6.3±0.5(6-7)	6.2±1.0(5-7)	8.0±1.1(6-9)	8.5±0.7(8-9)
Snout to pelvic base/body length:							
Preflexion	—	—	—	—	26	—	—
Flexion	28.5±2.1(27-30)	22.8±2.4(20-27)	26.2±1.8(25-29)	—	27.5±1.9(25-29)	—	24.4±1.8(22-27)
Postflexion	32.1±1.6(30-35)	28.6±0.8(28-30)	28.6±3.1(24-32)	29.5±0.7(29-30)	29.3±3.9(26-36)	29.8±1.9(26-32)	28.0±2.6(24-30)
Juvenile	23	22	24.4±1.1(23-26)	23.8±1.3(22-26)	25.0±2.2(22-27)	27.8±0.8(27-29)	29.5±0.7(29-30)

period and then increases sharply in juveniles (Table 5). Relative eye height is consistently less than eye width; this is the usual pattern among all species being dealt with in this report.

The spine on each pterotic bone first appears on larvae about 6.0 mm NL and achieves maximum development in flexion larvae. It begins to regress near the end of the larval period and is a rugose bump in newly transformed juveniles. No other species of *Pleuronichthys* develops pterotic spines during the larval period, although they are present on larvae of *H. guttulata*.

Another distinctive feature of *P. decurrens* larvae is body depth. As in other species of *Pleuronichthys*, early larvae are slender. Relative body depth increases markedly during the postflexion stage with the result that larvae of this species become strikingly deeper bodied than those of the other six flatfishes with heavily pigmented larvae (Table 5).

Fin and axial skeleton formation.—Because this species is larger at corresponding stages of development than the other six flatfishes considered, fin formation occurs at comparatively larger larval sizes. Caudal fin development occurs between 7.9 and 11.0 mm NL; the smallest postflexion specimen, 10.2 mm SL, has the full count of 19 caudal rays (Table 6). The dorsal and anal fins begin forming simultaneously with the caudal, but obtain their full complement of rays later, by 14.5 mm SL. Pelvic buds are evident on most specimens undergoing flexion, but the full count of fin rays was first obtained on a 15.4-mm SL specimen. The axial skelton is ossified on specimens as small as 11.2 mm SL, as determined by radiographs. Counts of 14 precaudal and 24-27 caudal vertebrae were recorded on five postflexion specimens.

Transformation.—Flatfish larvae are normally symmetrical larvae with eyes opposite each other on either side of the head during their preflexion to flexion stages and into the postflexion stage. Some flatfish larvae remain symmetrical with regard to eye placement until attaining quite large sizes, i.e., 50-120 mm (Hubbs and Chu 1934; Bruun 1937; Nielsen 1963; Amaoka 1970, 1971, 1972, 1973). However, in the flatfishes being studied the migration of one eye (left in dextral flounders, right in sinistral flounders) begins early in the postflexion stage. It can require some time to move completely over. Thus, the left eye was migrating on a 10.5-mm larva of *P. decurrens*, but was not completely over on a 21.0-mm specimen. Ossified rays are not formed in the pectoral fin until after eye migration is completed. On first formation the rays are spaced some distance apart in the blade of the pectoral fin. The pectoral fin rapidly changes form with the structure of the larval pectoral (base and blade) disappearing, to be replaced by a group of ossified, closely spaced rays. Metamorphosis is

TABLE 6.—Meristics of larvae and a juvenile of *Pleuronichthys decurrens*. (Specimens between dashed lines are undergoing notochord flexion.)

			Fin rays					Vertebrae			
Station	Size (mm)	Stage[1]	Dorsal	Anal	Caudal	Pelvic	Pectoral right/left	Precaudal	Caudal	Total	Source of count
5401-90.60	4.9 NL	Prefl.	0	0	0	0	LP[2]				
5704-87.50	5.6	Prefl.	0	0	0	0	LP[2]				
6501-63.52	6.0	Prefl.	0	0	0	0	LP[2]				
5206-70.65	6.5	Prefl.	0	0	0	0	LP[2]				
6501-60.70	7.9	Prefl.	0	0	0	0	LP[2]				
5003-87.35	8.5	Prefl.	Forming	Forming	Forming	0	LP[2]				
6606-60.65	9.3	Prefl.	Forming	Forming	4	0	LP[2]				
6605-80.80	9.8	Prefl.	Forming	Forming	ca. 8	0	LP[2]				
5706-93.65	7.8	E fl.	Forming	Forming	ca. 8	Bud	LP[2]				
5711-87.55	9.1	E fl.	Forming	Forming	ca. 12	0	LP[2]				
5401-85.60	10.0	Midfl.	Forming	Forming	ca. 12	Bud	LP[2]				
6507-87.55	11.0	L fl.	ca. 50	ca. 42	17	Bud	LP[2]				
5009-47.60	10.2 SL	Postfl.	>50	46	19	Bud	LP[2]				
5407-60.70	10.5	Postfl.	ca. 64	45	19	5/5	LP[2]				
5805-70.80	11.2	Postfl.	71	46	19	5/5	LP[2]	14	25	39	X-ray
7505-90.70	14.5	Postfl.	74	52	19	5/5	LP[2]				
4903-82.57	15.4	Postfl.	72	48	19	6/6	LP[2]	14	25	39	X-ray
6609-80.60	17.0	Postfl.	77	48	19	6/6	LP[2]	14	24	38	X-ray
5308-73.60	19.2	Postfl.	75	52	19	6/6	LP[2]	14	27	41	X-ray
5004-97.32	21.0	Postfl.	74	48	19	6/6	LP[2]	14	25	39	X-ray
Off Santa Cruz Island, Calif.	29.4	Juv.	78	52	19	6/6	11/11	14	26	40	X-ray

[1]Prefl. - preflexion; E fl. - early flexion; Midfl. - midflexion; L fl. - late flexion; Postfl. - postflexion; Juv. - juvenile.
[2]LP refers to functional larval pectoral fins which have no ossified rays.

considered complete when the lateral line can be discerned and scale formation has begun.

Distribution.—Fitch (1963) reported that the range for this species was from Alaska to San Quintin, Baja California. Miller and Lea (1976) gave an extended southern range limit to 25 mi north-northeast of Cedros Island (lat. 28°47.5′N, long. 114°57.0′W). Egg and larval material in our collections was taken off the entire coast of California over a broad band of stations, from nearshore to 150 or more miles offshore (Figure 5). Lack of egg and larval material off Baja California, despite the intensive coverage of these waters by CalCOFI surveys, indicates a more northerly distribution for young stages than for adults.

Pleuronichthys coenosus Girard (C-O turbot) Figures 6, 7

Literature.—Budd (1940) described and illustrated a series of eggs and four reared larvae of *P. coenosus* which he mistakenly identified as *P. decurrens*. The larvae illustrated were newly hatched to 9 days old, ranging in size from 3.88 to 4.72 mm.

Distinguishing characters.—This species is distinguished by having 13 (rarely 12) precaudal vertebrae and a total of 37-39 vertebrae. The larvae are larger than comparable stages of *H. guttulata* and other species of *Pleuronichthys* except *P. decurrens*. Pigmentation patterns discussed below will also separate *P. coenosus* from other species treated in this work.

Pigmentation.—Preflexion larvae are characterized by having opposing, similar appearing, pigment clusters on the dorsal and ventral finfolds posterior to the anus, and by small melanophores dotting the margin of the otherwise unpigmented posterior tip of the tail (Figure 6A, B). The rest of the body is heavily pigmented, with the exclusion of the undifferentiated pectoral fin and the ventral half of the head.

Flexion (6.2-7.8 mm NL) and postflexion larvae (7.1-11.4 mm SL) show an increase anteriorly of the finfold pigment and an increase in pigmentation on the lower region of the head (Figure 6C, D, E). A distinctively narrow, unpigmented zone along the hypurals persists through late flexion specimens, but is subsequently pigmented in

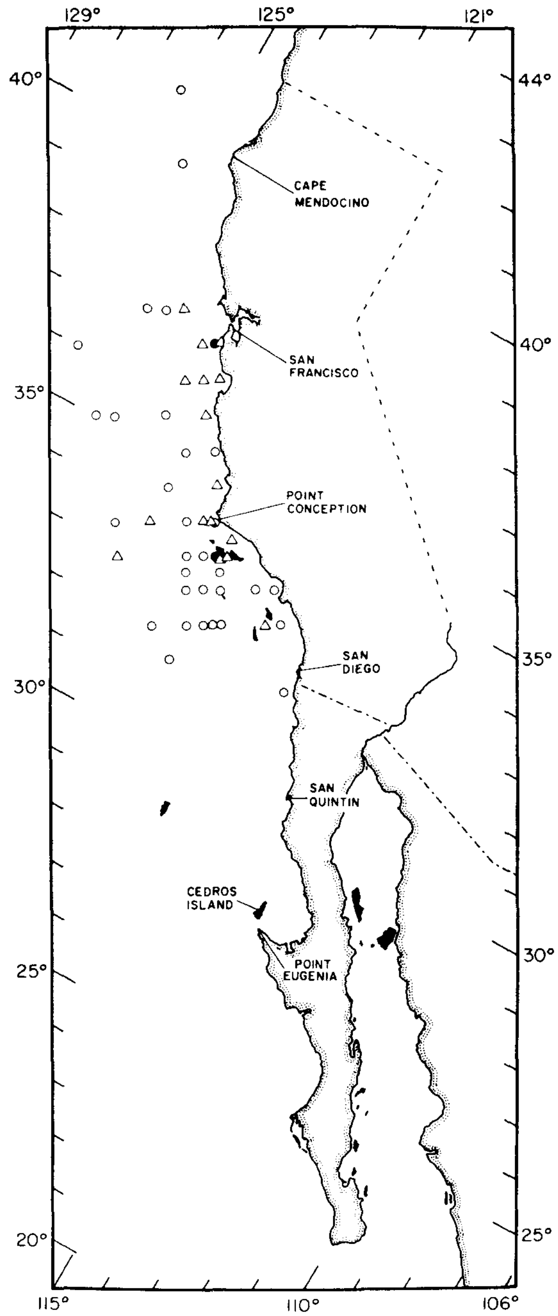
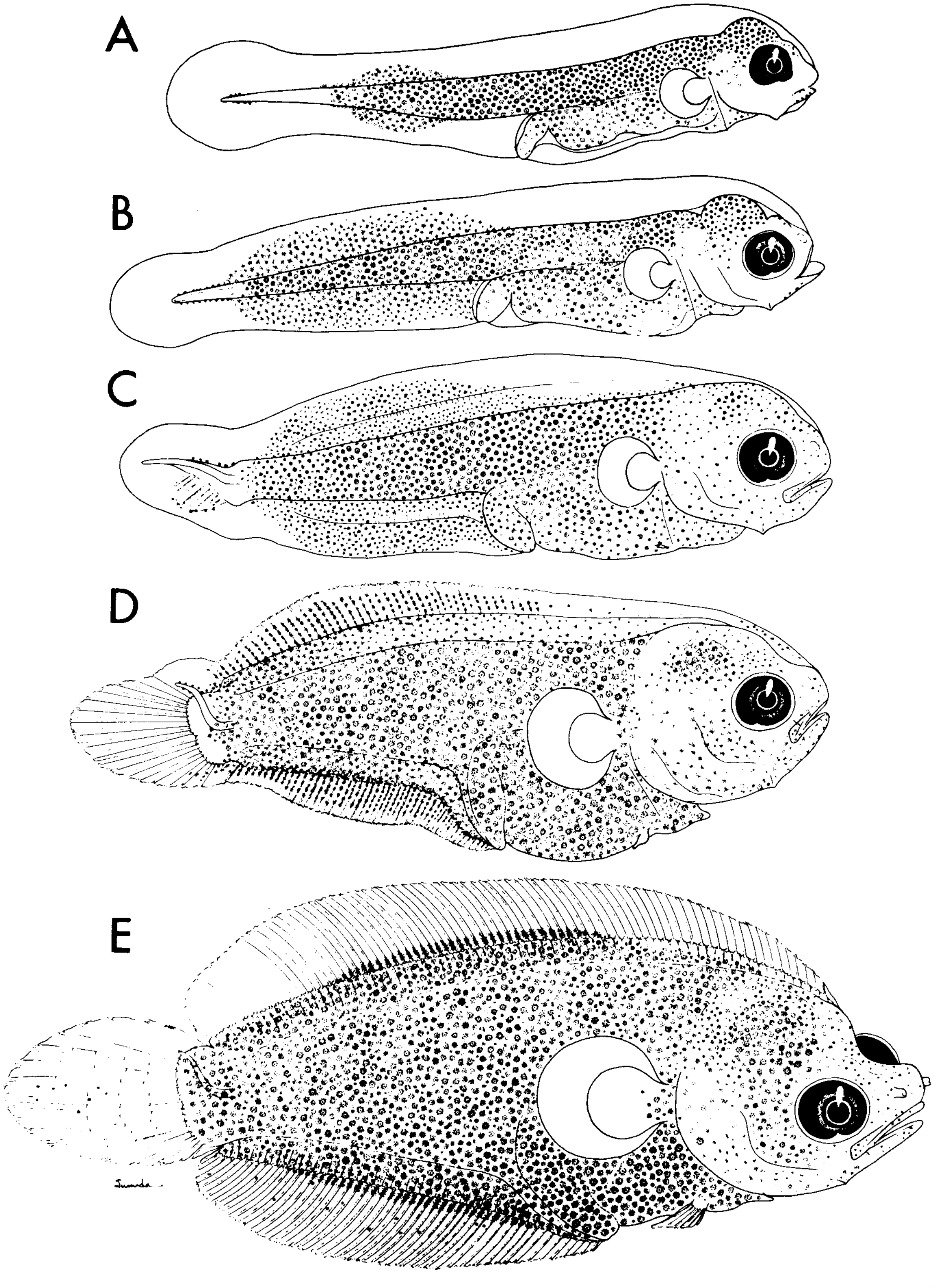


FIGURE 5.—Distribution of eggs and larvae of *Pleuronichthys decurrens* examined in this study. (Triangles represent eggs, open circles larvae, and closed circles eggs and larvae.)

FIGURE 6.—Larval stages of *Pleuronichthys coenosus*: A. 3.7 mm; B. 5.9 mm; C. 6.1 mm; D. 7.8 mm; E. 8.9 mm.


A
B
C
D
E
Sumida

postflexion specimens (Figure 6E). A few pigment spots dot the anterior margin of the pectoral fin base in postflexion specimens, and extend farther onto the fin base in larger specimens. At dorsal and anal fin formation, pigment clustered in the finfold aligns along the dorsal and anal fin rays, and later in postflexion specimens becomes compacted into a narrow band adjacent to the fin bases. Pigment over the pterygiophores, however, is as dense as on the body (Figure 7).

Morphology.—Larvae of *P. coenosus* are larger at hatching and at transformation than all other species of *Pleuronichthys* except *P. decurrens*. A 3.9-mm NL specimen has much of its yolk sac remaining (Table 7). The smallest specimen in which the left eye begins to migrate is 8.2 mm SL; eye migration is almost complete in our largest transforming specimen, 11.4 mm SL.

The gut begins to coil and the free section becomes vertical to the body axis in larvae between 5.5 and 6.0 mm NL. Snout-anus distance has a moderate decrease relative to body length in all larval phases and decreases markedly after transformation (Table 5).

As in the other species, relative head length increases during larval development through the postflexion stage, but decreases moderately in juveniles. Both relative snout length and eye size decrease during the three larval phases (Table 5).

As in other species of *Pleuronichthys*, body depth increases during each larval stage (Table 5). Relative body depths for larvae of *P. coenosus* are in the intermediate range compared with other species in the genus. Body depth in juveniles is comparable with that in the relatively deep-bodied *P. decurrens*.

Fin and axial skeleton formation.—Fin formation in *P. coenosus* takes place at smaller sizes than in *P. decurrens* but at larger sizes than in other species of *Pleuronichthys*. Larvae undergoing caudal fin formation range from 6.2 to 8.5 mm NL. The smallest fully flexed larva is 7.1 mm SL. The full count of caudal rays is developed on a postflexion specimen 8.2 mm SL (Table 8). Dorsal and anal fin formation takes place at the same size as caudal fin formation; rays are mostly formed on late flexion specimens and fully formed on the 8.2-mm SL postflexion larva. Pelvic buds are present on all specimens undergoing notochord flexion except the smallest (6.2 mm NL), and the full count of six rays per fin is developed on the 9.6-mm SL postflexion specimen. Vertebral counts from two cleared and stained larvae, 8.6 and 10.0 mm SL, are 13+24.

Distribution.—Fitch (1963) denoted the distribution of *P. coenosus* as Alaska to Cape Colnett, Baja California. Collections of our egg and larval mate-

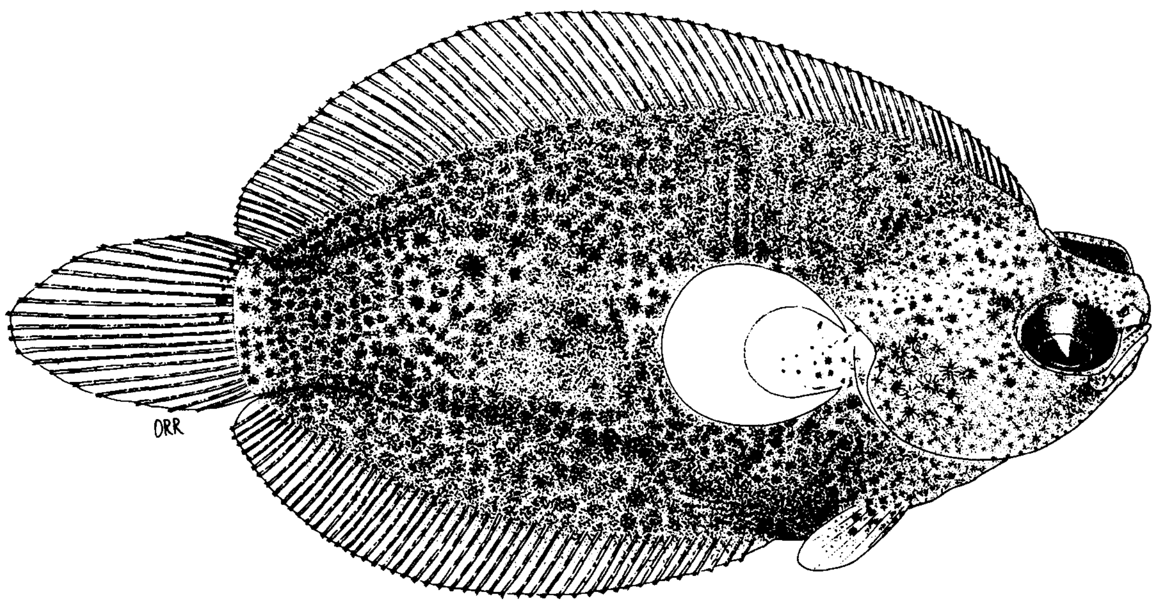


FIGURE 7.—Transforming specimen of *Pleuronichthys coenosus*, 10.0 mm.

TABLE 7.—Morphometrics, in millimeters, of larvae and a juvenile of *Pleuronichthys coenosus*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Body length	Left eye[1]	Noto-chord[2]	Snout to anus	Head length	Snout length	Eye width	Eye height	Body depth at P base[3]	Body depth at anus[3]	Caudal peduncle depth	Caudal peduncle length	Snout to origin pelvic fin
5902-83.43	3.9 NL	Sym.	Str.	1.8	0.60	0.16	0.26	0.20	0.30	0.46	—	—	—
5007-127.50	3.7	Sym.	Str.	1.8	0.68	0.14	0.26	0.22	0.60	0.52	—	—	—
5005-120.45	4.2	Sym.	Str.	2.1	0.80	0.16	0.32	0.24	0.70	0.56	—	—	—
Off La Jolla, Calif.	5.1	Sym.	Str.	2.5	1.1	0.20	0.40	0.38	1.1	0.90	—	—	—
5704-82.47	5.6	Sym.	Str.	2.6	1.1	0.26	0.40	0.36	0.90	0.84	—	—	—
6304-93.40	6.9	Sym.	Str.	3.1	1.6	0.30	0.50	0.46	1.3	1.3	—	—	—
6304-120.70	6.5	Sym.	Str.	3.0	1.5	0.28	0.46	0.46	1.4	1.6*	—	—	—
5206-90.41	8.5	Sym.	Str.	3.3	1.7	0.28	0.64	0.60	1.6	1.6	—	—	—
5110-97.30	6.2	Sym.	E fl.	2.7	1.4	0.30	0.48	0.42	1.4	1.5*	—	—	—
7207-93.45	7.2	Sym.	E fl.	3.1	1.6	0.30	0.56	0.54	1.6	1.8*	—	—	1.6
5705-93.27	7.4	Sym.	Midfl.	3.3	1.8	0.26	0.60	0.54	2.0*	1.9*	—	—	1.6
5304-85.50	8.3	Sym.	Midfl.	3.5	1.9	0.36	0.60	0.54	2.2*	2.4*	—	—	1.7
1941-25.45	7.2	Sym.	L fl.	3.1	1.9	0.36	0.58	0.54	2.1*	2.2*	—	—	1.6
4908-72.56	7.8	Sym.	L fl.	4.0	2.4	0.40	0.68	0.58	2.6*	2.7*	—	—	2.1
5007-90.53	7.1 SL	Sym.	Flexed	3.3	2.0	0.38	0.62	0.56	2.2*	2.3*	0.62	0.36	2.0
5004-100.60	8.2	Migr.	Flexed	3.4	2.5	0.40	0.74	0.70	3.1*	3.4*	0.98	0.50	2.3
6606-70.70	8.8	Migr.	Flexed	4.0	2.7	0.48	0.80	0.74	2.9*	3.3*	0.84	0.42	2.6
5304-85.50	9.6	Migr.	Flexed	4.7	3.0	0.60	0.92	0.80	4.2*	4.8*	1.2	0.52	2.8
5206-90.41	9.9	A. over	Flexed	3.9	3.2	0.56	0.84	0.80	4.4*	4.9*	1.4	0.48	2.8
5407-83.51	10.2	A. over	Flexed	3.8	3.4	0.52	1.0	0.84	4.6*	5.1*	1.6	0.52	3.0
5304-100.29	11.4	Over	Flexed	4.3	3.4	0.60	1.0	0.88	5.0*	5.4*	1.6	0.60	3.2
Off Coronados Islands, B.C.	17.0	Over	Juv.	5.2	4.7	0.58	1.4	—	7.9*	8.3*	2.4	1.0	3.8

[1]Sym. - symmetrical; Migr. - migrating; A. over - About over.
[2]Str. - straight; E fl. - early flexion; Midfl. - midflexion; L fl. - late flexion; Juv. - juvenile.
[3]Asterisk indicates inclusion of dorsal fin pterygiophores in body depth measurement.

TABLE 8.—Meristics of larvae and a juvenile of *Pleuronichthys coenosus*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Size (mm)	Stage[1]	Fin rays: Dorsal	Anal	Caudal	Pelvic	Pectoral right/left	Vertebrae: Precaudal	Caudal	Total	Source of count
5902-83.43	3.9 NL	Yolk-sac	0	0	0	0	LP[2]				
5007-127.50	3.7	Prefl.	0	0	0	0	LP[2]				
5005-120.45	4.2	Prefl.	0	0	0	0	LP[2]				
Off La Jolla, Calif.	5.1	Prefl.	0	0	0	0	LP[2]				
5704-82.47	5.6	Prefl.	0	0	0	0	LP[2]				
6304-93.40	6.9	Prefl.	0	0	0	0	LP[2]				
6304-120.70	6.5	Prefl.	Forming	Forming	4	0	LP[2]				
5206-90.41	8.5	Prefl.	Forming	Forming	ca. 8	0	LP[2]				
5110-97.30	6.2	E fl.	Forming	Forming	ca. 8	0	LP[2]				
7207-93.45	7.2	E fl.	Forming	Forming	12	Bud	LP[2]				
5705-93.27	7.4	Midfl.	Forming	Forming	12	Bud	LP[2]				
5304-85.50	8.3	Midfl.	Forming	30	12	Bud	LP[2]				
1941-25.45	7.2	L fl.	ca. 55	ca. 44	ca. 14	Bud	LP[2]				
4908-72.56	7.8	L fl.	ca. 60	ca. 45	16	Bud	LP[2]				
5007-90.53	7.1 SL	Postfl.	ca. 70	ca. 50	16	Bud	LP[2]				
5004-100.60	8.2	Postfl.	74	55	19	ca. 4/4	LP[2]				
6606-77.55	8.6	Postfl.	72	54	19	ca. 5/5	LP[2]	13	24	37	C&S[3]
6606-70.70	8.8	Postfl.	76	50	19	ca. 4/4	LP[2]				
5304-85.50	9.6	Postfl.	73	ca. 52	19	6/6	LP[2]				
5206-90.41	9.9	Postfl.	69	50	19	6/6	LP[2]				
5206-87.45	10.0	Postfl.	71	53	19	—	LP[2]	13	24	37	C&S[3]
5407-83.51	10.2	Postfl.	69	49	19	6/6	LP[2]				
5304-100.29	11.4	Postfl.	72	50	19	6/6	LP[2]				
Off Coronados Islands, B.C.	17.0	Juv.	75	53	19	6/6	9/9	13	25	38	X-ray

[1]Prefl. - preflexion; E fl. - early flexion; Midfl. - midflexion; L fl. - late flexion; Post fl. - postflexion; Juv. - juvenile.
[2]LP refers to functional larval pectoral fins which have no ossified rays.
[3]Cleared and stained.

rial range from northern California south to Point Abreojos, Baja California (Figure 8). Our records extend the range considerably southward for the species. Larval specimens range widely from nearshore to about 200 mi offshore, but most occurrences are between 50 and 200 mi offshore.

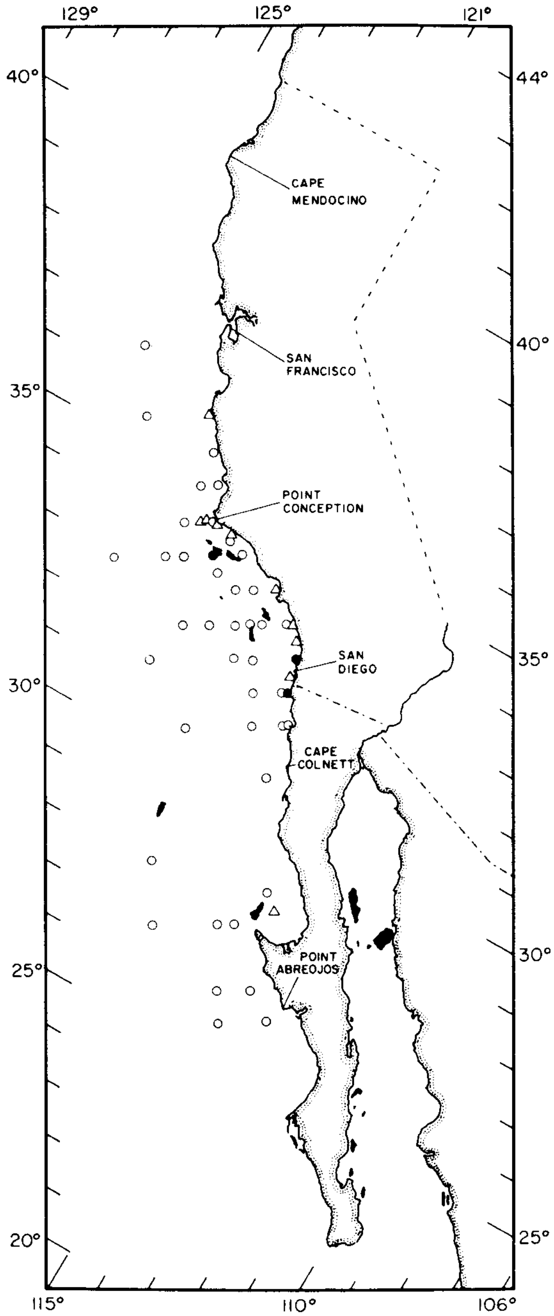


FIGURE 8.—Distribution of eggs and larvae of *Pleuronichthys coenosus* examined in this study. (Triangles represent eggs, open circles larvae, and closed circles eggs and larvae.)

Pleuronichthys verticalis Jordan and Gilbert (hornyhead turbot) Figures 9, 10

Literature.—The eggs and two early larvae (3.16 and 3.35 mm) were described and illustrated by Budd (1940). Four illustrations of larvae, between 4.4 and 8.7 mm SL, are contained in CalCOFI Atlas No. 23 (Ahlstrom and Moser 1975).

Distinguishing characters.—Preflexion and early flexion larvae of this species are recognizable by the triangular patches of pigment, one each on the dorsal and ventral finfold posterior to the anus; these form late in the yolk-sac stage and persist through the notochord flexion stage. No other species of *Pleuronichthys* develops this distinctive pigmentation character.

Late flexion and postflexion larvae are distinguished by size (i.e., larger than *H. guttulata, P. ritteri,* and *P. ocellatus*, but smaller than *P. coenosus* and *P. decurrens*), and by sparse pigment on the head and on the dorsal and anal fin pterygiophores. This is in sharp contrast to the heavy pigment in these areas for the other species discussed.

Newly transformed specimens are difficult to distinguish from comparable stages of *P. ritteri*. However, pigment on the body tends to be mottled on *P. verticalis* rather than evenly distributed as on *P. ritteri* at this stage. Small juveniles are easily separable from *P. ritteri* because *P. verticalis* lacks the anterior prolongation of the supratemporal branch of the lateral line found on *P. ritteri* juveniles.

Pigmentation.—Pigment on yolk-sac and older preflexion larvae of *P. verticalis* is heavy on the head, trunk, and tail and ends anterior to the last three to five myomeres (Figure 9A, B). As the last remnant of yolk is absorbed, scattered finfold pigment differentiates into triangular-shaped clusters posterior to the anus, the dorsal patch being situated slightly anterior of the ventral patch. The head region below and on each side of the eye is only sparsely pigmented which is typical of most early preflexion larvae of several species of *Pleuronichthys*. The top of the head to the shoulder region is unpigmented, a character shared with preflexion larvae of *P. ritteri*. Small pigment spots dot the margin of the tip of the tail, but do not persist beyond the flexion stage (Figure 9C, D).

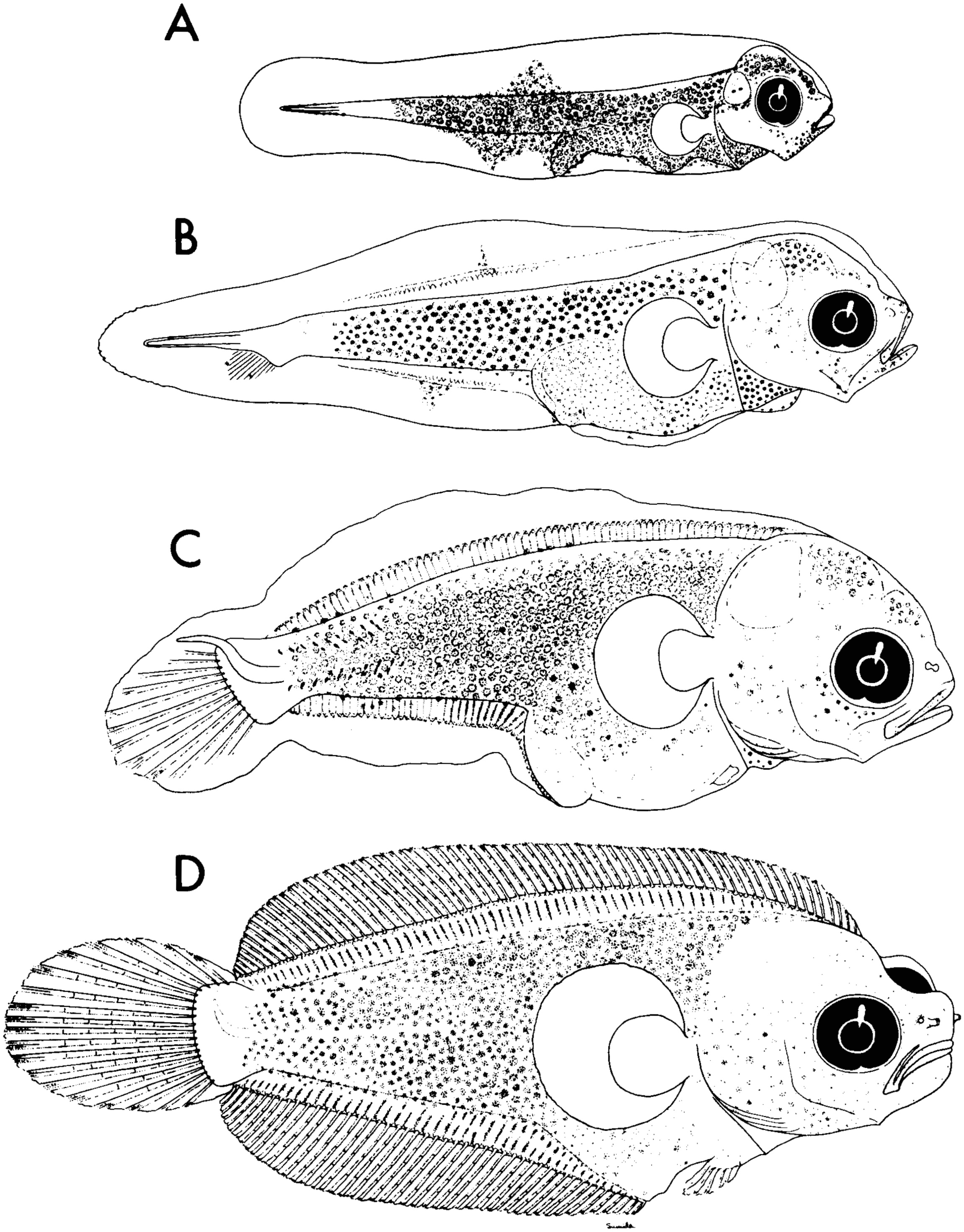


FIGURE 9.—Larval stages of *Pleuronichthys verticalis*: A. 4.4 mm; B. 6.5 mm; C. 7.1 mm; D. 8.7 mm.

Flexion larvae undergo little change in pigment pattern from earlier stages. The triangular patches of finfold pigment are diminished in size and pigment intensity, but are visible by careful examination in specimens through notochord flexion.

Following the completion of notochord flexion, pigment on the tail spreads posteriad leaving only the caudal peduncle unpigmented (Figure 9D). The outlying regions of the head and body, particularly the pterygiophore region, are sparsely pigmented compared with late larvae of other *Pleuronichthys* species and *H. guttulata*.

Transformed specimens develop heavy pigment over the body giving them a mottled appearance. Dark blotches appear along bases of the dorsal and anal fins (Figure 10).

Morphology.—Larvae of *P. verticalis* attain a size intermediate between the large species, *P. decurrens* and *P. coenosus*, and the smaller *P. ritteri*. A specimen with most of its yolk sac remaining is 2.4 mm NL (Table 9). The left eye is beginning to migrate in a specimen as small as 7.3 mm SL and transformation is almost complete at 9.2 mm SL. The smallest available juvenile is 12.2 mm SL, reared from eggs collected off San Diego, Calif.

Gut development follows the course of other *Pleuronichthys*. Snout-anus length is about 50% of body length in preflexion and flexion stages and then is reduced in postflexion and early juvenile stages. The gut begins to coil at about 4.0 mm NL but the free terminal section does not become vertical until at least 5.0 mm NL.

As in the other species, relative head length increases throughout the larval period and then decreases at transformation. Snout length and eye size undergo a gradual relative diminution during the larval stages; however, relative eye width increases sharply at transformation (Table 5).

Larvae of *P. verticalis* are intermediate in body depth when compared with other species of *Pleuronichthys* (Table 5).

Fin and structural development.—*P. verticalis* is the only species for which we could clear and stain a series of larvae (Tables 10, 11). The sequence of fin formation was followed more precisely in this species as was the sequence of ossification of other structures including the vertebral column, supporting bones of the caudal fin, branchiostegal rays, gill rakers, and teeth.

The caudal fin begins to form on the under side of the body a short distance anterior to the tip of the notochord on specimens of about 5.0 mm NL. Some caudal rays form before flexion begins (Figure 11A). Rays initially form at midcaudal and those that will be associated with superior hypural bones differentiate posteriorward, while those that will be associated with inferior hypural bones

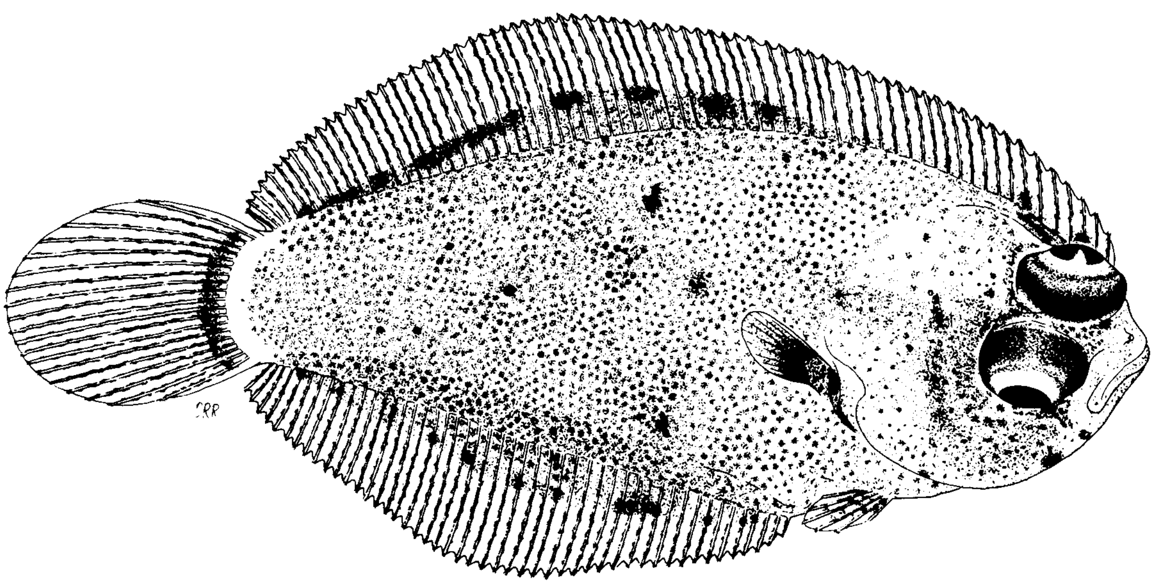


FIGURE 10.—Reared transforming specimen of *Pleuronichthys verticalis*, 11.0 mm.

TABLE 9.—Morphometrics, in millimeters, of larvae and juveniles of *Pleuronichthys verticalis*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Body length	Left eye[1]	Notochord[2]	Snout to anus	Head length	Snout length	Eye width	Eye height	Body depth at P base[3]	Body depth at anus[3]	Caudal peduncle depth	Caudal peduncle length	Snout to origin pelvic fin
7501-120.26	2.4 NL	Sym.	Str.	1.2	0.56	0.10	0.22	0.20	0.22	0.34	—	—	—
Off La Jolla, Calif.	2.7	Sym.	Str.	1.4	0.54	0.12	0.24	0.22	0.38	0.40	—	—	—
SCBS-2-203	3.0	Sym.	Str.	1.5	0.64	0.16	0.22	0.20	0.48	0.40	—	—	—
7203-103.30	3.8	Sym.	Str.	2.0	0.86	0.20	0.30	0.26	0.70	0.54	—	—	—
7203-103.30	4.3	Sym.	Str.	2.2	0.94	0.24	0.34	0.32	0.84	0.62	—	—	—
7203-103.30	4.8	Sym.	Str.	2.4	1.0	0.20	0.36	0.32	0.90	0.70	—	—	—
7501-120.26	5.2	Sym.	Str.	2.6	1.3	0.30	0.40	0.34	1.0	0.80	—	—	—
5708-110.33	5.0	Sym.	E fl.	2.8	1.5	0.34	0.50	0.42	1.6*	1.4*	—	—	—
7203-103.30	5.6	Sym.	E fl.	2.7	1.4	0.30	0.48	0.46	1.4*	1.2*	—	—	1.5
7503-90.27.6	5.6	Sym.	Midfl.	2.9	1.5	0.30	0.48	0.46	1.8*	1.8*	—	—	1.4
5510-117.26	5.9	Sym.	Midfl.	2.7	1.6	0.24	0.50	0.52	1.7*	1.6*	—	—	1.5
7503-120.26	7.2	Sym.	Midfl.	3.2	1.9	0.32	0.60	0.56	2.1*	2.0*	—	—	1.8
5708-110.33	6.3	Sym.	L fl.	3.2	1.9	0.32	0.60	0.56	2.1*	2.0*	—	—	1.8
7505-120.30	6.5 SL	Sym.	Flexed	3.2	2.0	0.36	0.64	0.60	2.0*	2.0*	0.54	0.50	?
SCBS-4-303	7.3	Migr.	Flexed	3.3	2.6	0.40	0.76	0.68	3.1*	3.3*	0.96	0.40	2.2
5506-120.45	7.9	Migr.	Flexed	3.3	2.9	0.40	0.84	0.68	3.6*	3.6*	1.0	0.44	2.4
6606-103.29	8.3	Migr.	Flexed	3.5	2.7	0.48	0.84	0.68	3.2*	3.5*	1.0	0.44	2.7
6504-137.30	9.2	Migr.	Flexed	3.9	2.9	0.36	0.96	0.84	3.8*	4.2*	1.1	0.60	2.5
Reared	11.0	Over	Flexed	4.0	3.4	0.36	1.4	1.0	4.3*	4.4*	1.4	0.76	2.7
Reared	12.2	Over	Juv.	4.0	3.6	0.36	1.4	1.2	5.0*	5.1*	1.6	0.80	3.2
Reared	15.9	Over	Juv.	5.2	4.3	0.32	1.8	1.4	6.5*	6.6*	2.2	1.0	3.6
Reared	16.9	Over	Juv.	5.3	4.5	0.32	1.8	1.3	6.6*	6.9*	2.3	1.0	4.2
Santo Tomas	19.5	Over	Juv.	6.4	5.3	0.08	1.8	1.2	7.8*	8.4*	2.5	1.3	4.7
Bay, B.C.	26.5	Over	Juv.	8.4	7.0	0.33	2.6	2.1	10.9*	11.4*	3.3	1.9	6.5

[1]Sym. - symmetrical, Migr. - migrating.
[2]Str. - straight; E fl. - early flexion; Midfl. - midflexion; L fl. - late flexion; Juv. - juvenile.
[3]Asterisk indicates inclusion of dorsal fin pterygiophores in body depth measurement.

TABLE 10.—Meristics of larvae and juveniles of *Pleuronichthys verticalis*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Size (mm)	Stage[1]	Fin ray: Dorsal	Fin ray: Anal	Fin ray: Caudal	Fin ray: Pelvic	Fin ray: Pectoral right/left	Gill rakers	Teeth: Upper jaw R	Teeth: Upper jaw L	Teeth: Lower jaw R	Teeth: Lower jaw L
6609-97.29	5.3 NL	Prefl.	Forming	Forming	4	0	LP[2]	—				
7503-90.27.6	5.6	Prefl.	Forming	Forming	4	0	LP[2]	—				
—	5.5	Prefl.	Forming	Forming	6	0	LP[2]	—				
6507-107.30	5.8	Prefl.	Forming	Forming	6	0	LP[2]	—				
5708-117.26	5.7	Prefl.	Forming	Forming	6	0	LP[2]	—				
5708-117.26	5.8	Prefl.	Forming	Forming	6	0	LP[2]	—				
5708-117.26	6.1	E fl.	Forming	Forming	8	Bud	LP[2]	—				
—	7.0	L fl.	43	37	16	Bud	LP[2]	0+2	1	2	3	3
6606-97.29	6.9	L fl.	63	43	18	4/4	LP[2]	0+3	1	2	0	3
—	7.0	Postfl.	67	47	19	5/5	LP[2]	0+6	1	3	3	5
6407-83.43	7.1	Postfl.	64	44	19	3/3	LP[2]	Not taken	1	4	3	5
5110-100.40	7.3	Postfl.	67	47	19	5/5	LP[2]	0+5	?	6	5	6
6606-97.29	8.3	Postfl.	65	46	19	6/6	LP[2]	0+5	0	5	5	7
6504-137.30	9.2	Postfl.	65	44	19	6/6	LP[2]	Not taken	Not taken			
Reared	11.0	Postfl.	72	49	19	6/6	11/?	2+9	Not taken			
Reared	12.2	Juv.	72	47	19	6/6	11/11	3+7	Not taken			
Reared	15.9	Juv.	74	49	20	6/6	12/12	3+8	Not taken			
Reared	16.9	Juv.	72	48	19	6/6	10/11	3+7	Not taken			
Santo Tomas	19.5	Juv.	67	47	19	6/6	10/10	2+7	Not taken			
Bay, B.C.	26.5	Juv.	70	49	19	6/6	11/11	3+7	Not taken			

[1]Prefl. - preflexion; E fl. - early flexion; L fl. - late flexion; Postfl. - postflexion; Juv. - juvenile.
[2]LP refers to functional larval pectoral fins which have no ossified rays.

differentiate progressively anteriorward. A number of specimens, 5.3-5.8 mm NL with the notochord still straight, possess 2+2 or 3+3 caudal rays. The complete complement of 10+9 caudal rays is present on specimens 7.0 mm NL and larger. Flexion occurs in larvae between 6.1 and 7.0 mm NL (Figure 11B). By the time the caudal ray complement is fully formed, the rays are aligned in a terminal position (Figure 11C). The hypurals are observed as cartilaginous plates before they ossify. There are two superior and two inferior hypurals[3] in pleuronectid flatfishes. The

[3]We include the "parhypural" as a hypural bone. In flatfishes it is a splinter bone without remnant of a haemal arch.

TABLE 11.—Development of vertebral column, caudal fin rays, and caudal fin supporting bones in larvae of *Pleuronichthys verticalis*.

			Precaudal vertebrae[2]		Caudal vertebrae[2]						Ural bones[2]				
											Sup. hyp.		Inf. hyp.		
Station	Body length	Stage[1]	n.pr.	centra	n.pr.	h.pr.	centra	Ural centrum	Total vert.[3]	C fin rays	Upper	Mid	Mid	Lower	Epural
6609-97.29	5.3 NL	Prefl.	0	0	0	0	0	0	0	2+2	0	0	0	0	0
7503-90.27.6	5.6	Prefl.	0	0	0	7	0	0	7*	2+2	0	0	0	0	0
—	5.5	Prefl.	4+2	0	14	14	0	0	20*	3+3	0	0	0	0	0
6507-107.30	5.8	Prefl.	6+3	0	15	15	0	0	24*	3+3	0	0	0	0	0
5708-117.26	5.7	Prefl.	7+5	0	16	16	0	0	28*	3+3	0	0	0	0	0
6507-107.30	5.8	Prefl.	7+4	0	17	17	0	0	28*	3+3	0	0	0	0	0
5708-117.26	6.1	E fl.	13	0	19	20	0	0	33*	4+4	0	0	0	0	0
—	7.0	L fl.	13	0	22	22	0	0	35*	8+8	0	0	0	0	0
6606-97.29	6.9	L fl.	13	13	22	22	20	1	36	9+9	0	X	X	X	0
—	7.0 SL	Postfl.	13	13	23	23	23	1	37	10+9	0	X	X	X	X
6407-83.43	7.1	Postfl.	13	13	22	22	22	1	36	10+9	0	X	X	X	X
5110-100.40	7.3	Postfl.	13	13	22	22	22	1	36	10+9	X	X	X	X	X
6606-97.29	8.3	Postfl.	13	13	22	22	22	1	36	10+9	X	X	X	X	X
Reared	11.0	Postfl.	13	13	24	23	23	1	37	10+9	X	X	X	X	X
Reared	12.2	Juv.	13	13	22	22	22	1	36	10+9	X	X	X	X	X
Reared	15.9	Juv.	13	13	22	22	22	1	36	10+10	X	X	X	X	X
Reared	16.9	Juv.	13	13	22	22	22	1	36	10+9	X	X	X	X	X
Santo Tomas	19.5	Juv.	13	13	23	23	23	1	37	10+9	X	X	X	X	X
Bay, B.C.	26.5	Juv.	13	13	23	23	23	1	37	10+9	X	X	X	X	X

[1]Prefl. - preflexion; E fl. - early flexion; L fl. - late flexion; Postfl. - postflexion; Juv. - juvenile.
[2]Abbreviations in heading: n.pr. - neural process; h.pr. - haemal process; vert. - vertebrae; Sup. hyp. - Superior hypurals; Inf. hyp. - Inferior hypurals.
[3]Asterisk indicates incomplete count.

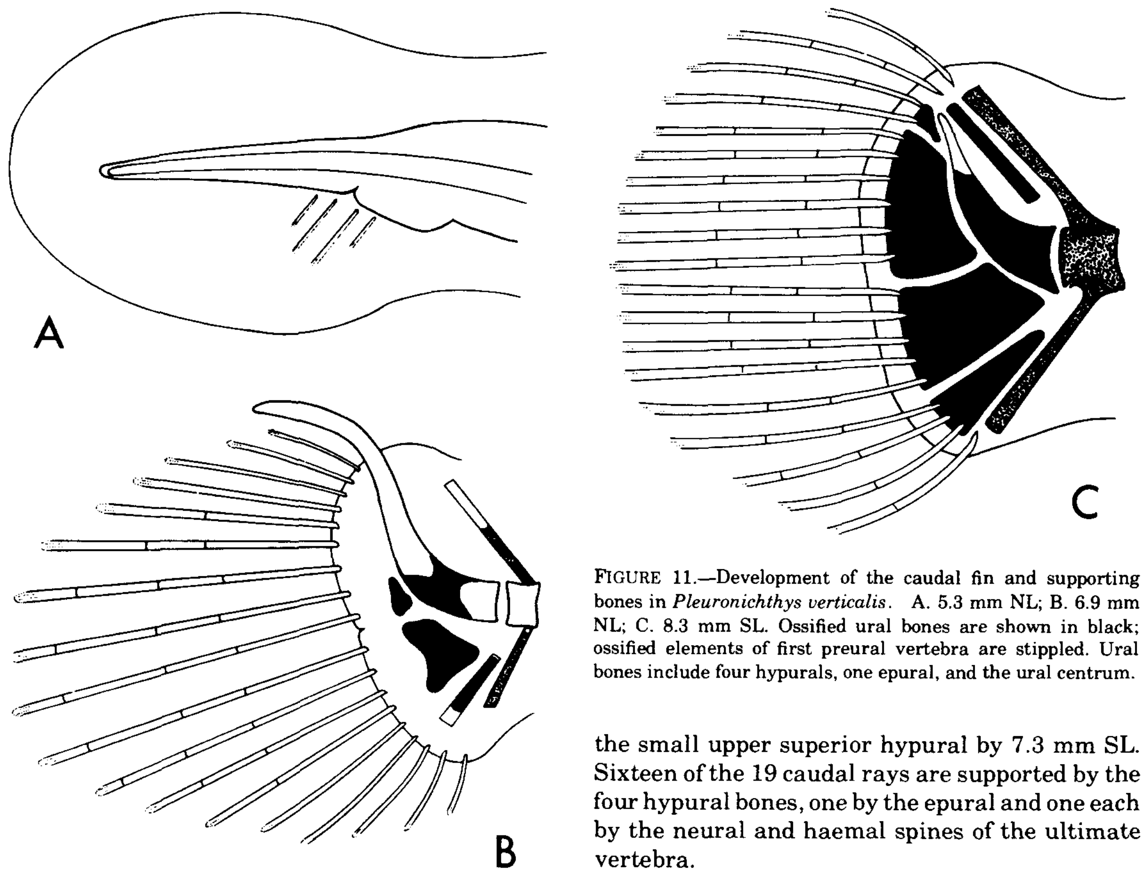


FIGURE 11.—Development of the caudal fin and supporting bones in *Pleuronichthys verticalis*. A. 5.3 mm NL; B. 6.9 mm NL; C. 8.3 mm SL. Ossified ural bones are shown in black; ossified elements of first preural vertebra are stippled. Ural bones include four hypurals, one epural, and the ural centrum.

main superior hypural and the two inferior hypurals are ossifying in specimens 6.9 mm NL and larger, the single epural by 7.0 mm SL, and the small upper superior hypural by 7.3 mm SL. Sixteen of the 19 caudal rays are supported by the four hypural bones, one by the epural and one each by the neural and haemal spines of the ultimate vertebra.

The vertebral column begins to ossify at about the same time rays begin forming in the caudal fin (Table 11). A 5.6-mm NL specimen which has 2+2 caudal rays has the first seven haemal processes of the caudal group of vertebrae forming. A slightly more advanced 5.5-mm NL specimen has 14 opposing neural and haemal processes of caudal vertebrae formed as well as the four anteriormost and last two precaudal neural processes. A neural or haemal process consists of two portions—a divided basal portion that forms the neural or haemal arch ending in the second portion as a terminal spine. On the 5.5-mm NL specimen, only the tips of the neural spines of the caudal group are ossified. Of the precaudal group, ossification first occurs in the arched portion of the anterior four neural processes and on the tips only of the last two precaudal neural spines. On a 5.8-mm NL specimen with the first 7 and last 4 precaudal neural processes and 17 pairs of neural and haemal processes in the caudal group ossifying, all of the neural processes except those of the 7 anterior precaudal vertebrae were ossifying initially from both ends, i.e., from the distal tips of the neural spines and from the basal portion of the neural arches, with ossification from both ends proceeding medially (Figure 12A). In a 6.1-mm NL specimen all 13 precaudal neural processes and 19 neural and haemal processes in the caudal group are ossified (Figure 12B). A 7.0-mm NL late flexion specimen has all neural and haemal processes ossified except those on the terminal preural vertebra, but no centra are ossified. A 6.9-mm NL specimen, with all neural and haemal processes ossifying, has various stages of vertebral centra ossification with initial ossification of centra occurring below the bases of the neural and haemal arches and then filling in medially; only the two vertebral centra adjacent to the urostyle lack any ossification; the six vertebrae immediately forward of these have the best ossified centra. A 7.0-mm SL specimen has all centra ossified.

The bases of the dorsal and anal fins are present on larvae as small as 5.3 mm NL and rays begin to form by late flexion. Full complements of dorsal and anal fin rays are present on most postflexion specimens. Buds of the pelvic fins were first seen on a 6.1-mm NL specimen, and the complete count of six rays per fin is developed by 8.3 mm SL. Pectoral rays form only toward the end of the transformation stage after the left eye has nearly completed its migration to the right side.

Branchiostegal rays form progressively anteriorward during the period of caudal fin forma-

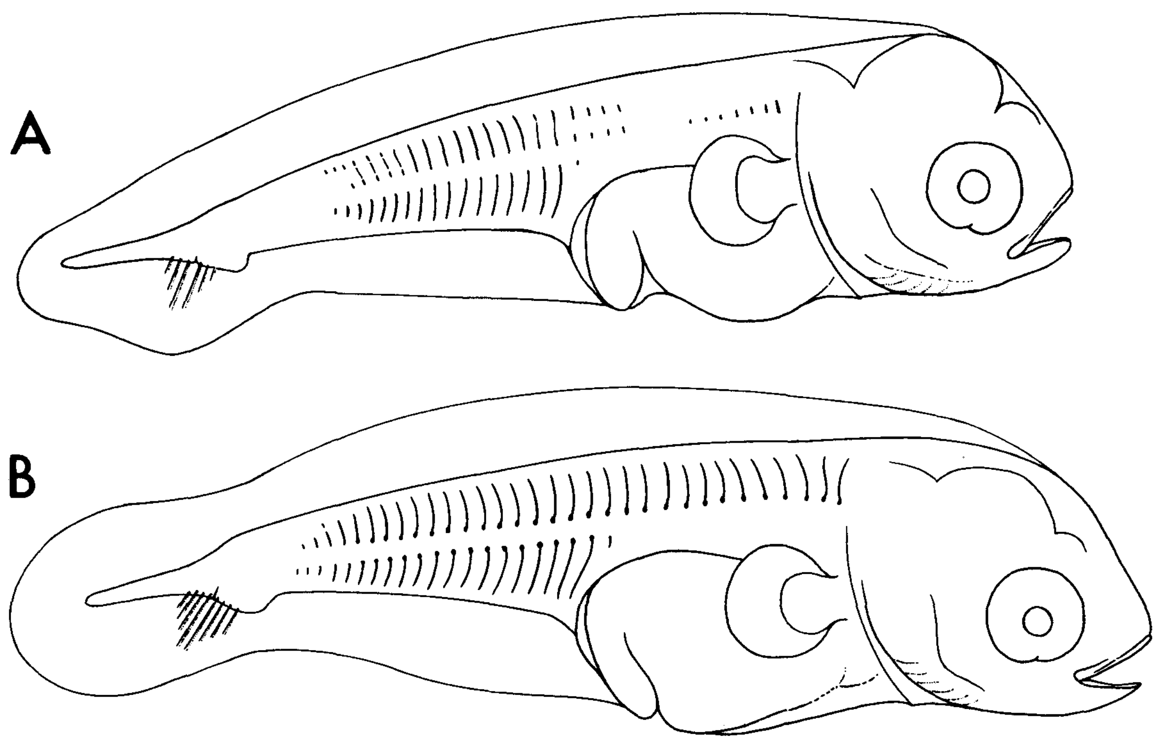


FIGURE 12.—Ossification pattern of the axial skeleton of *Pleuronichthys verticalis*: A. 5.8 mm; B. 6.1 mm.

tion between 5.6 and 6.9 mm NL, and the full count of seven rays per side is present on late flexion specimens. Gill rakers begin to develop by late flexion, but the full count is not obtained until the early juvenile stage. Few teeth form during the larval period. Only a single tooth is developed on the right side of the upper jaw in postflexion larvae, compared with 3-6 on the left side of this jaw. The disproportion is less marked in the lower jaw, with 3-5 teeth on the right side compared with 5-7 on the left side.

Distribution.—This species ranges from Point Reyes, Calif., south to Magdalena Bay, Baja California, with an isolated population at the northern end of the Gulf of California (Norman 1934; Fitch 1963). Eggs and larvae are common in our collections, particularly at inshore stations located over the continental shelf, with only an occasional specimen being taken more than 60 mi from the coast (Figure 13).

Pleuronichthys ocellatus Starks and Thompson (Gulf turbot) Figure 14

Literature.—Neither eggs nor larvae have been described previously.

Distinguishing characters.—This species may only be confused with *P. verticalis* or *H. guttulata* which cooccur with it in the upper Gulf of California. Larvae may be distinguished from *P. verticalis* by the lower total vertebral number of 34 or 35 and pigmentation differences. The larger size of larvae, lack of pterotic spines, and different pigment pattern separate it from *H. guttulata*. Meristics of the larvae and juveniles, given in Table 12, are distinctive for the species.

Pigmentation.—Only two postflexion larvae (6.6 mm SL and 7.0 mm SL) were available. Both specimens are heavily pigmented and somewhat resemble similar stages of *P. verticalis* larvae (Figure 14 vs. Figure 9D). However, smaller sized larvae of *P. ocellatus* are heavier in pigment than *P. verticalis* in regions of the head and dorsal and anal fin pterygiophores. Only the margin of the opercle, otic region, pectoral fin, and caudal peduncle remain unpigmented.

Morphology.—Larvae of *P. ocellatus* are intermediate in size between comparable stages of *P. ritteri* and *P. verticalis* (Table 13). It is the most slender-bodied species having the smallest body depth ratios in the postflexion larval stage within its genus (Table 5).

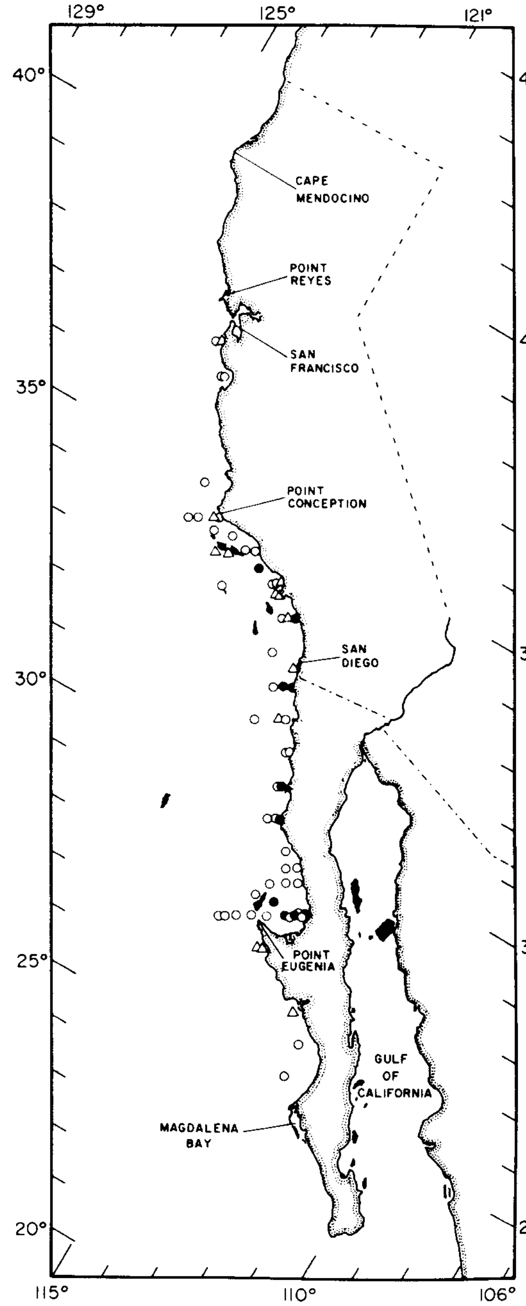


FIGURE 13.—Distribution of eggs and larvae of *Pleuronichthys verticalis* examined in this study. (Triangles represent eggs, open circles larvae, and closed circles eggs and larvae.)

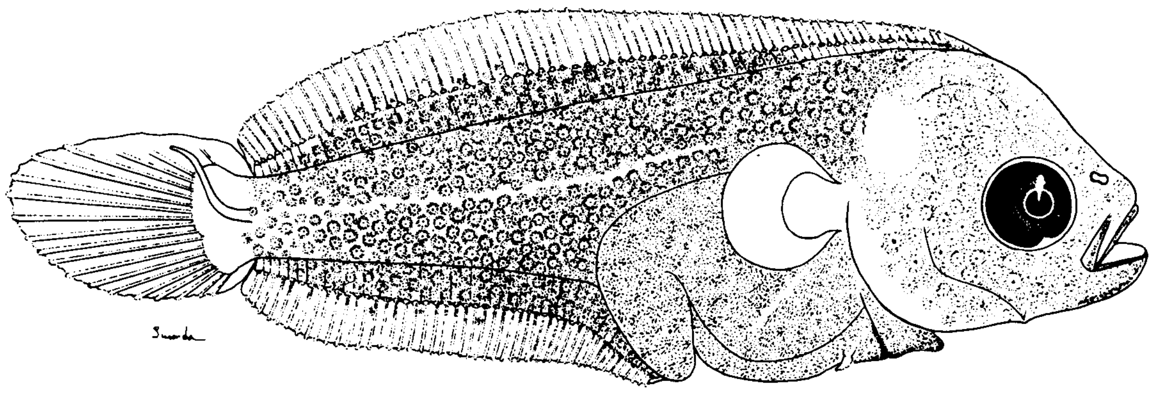


FIGURE 14.—*Pleuronichthys ocellatus* larva, 7.0 mm.

TABLE 12.—Meristics of larvae and juveniles of *Pleuronichthys ocellatus*.

			Fin rays					Vertebrae			
Station	Size (mm)	Stage[1]	Dorsal	Anal	Caudal	Pelvic	Pectoral right/left	Precaudal	Caudal	Total	Source of count
5604-111.G.14	6.6 SL	Postfl.	65	49	19	ca. 4/4	LP[2]				
5604-109.G.25	7.0	Postfl.	73	50	19	ca. 3/3	LP[2]				
Upper Gulf of	19.2	Juv.	64	46	19	6/6	10/11	12	22	34	X-ray
California	22.0	Juv.	73	49	19	6/6	10/10	12	24	36	X-ray
	24.0	Juv.	67	48	19	6/6	—/11	12	22	34	X-ray
	24.5	Juv.	71	51	19	6/6	11/10	12	23	35	X-ray
	25.0	Juv.	70	50	19	6/6	11/10	12	22	34	X-ray
	25.5	Juv.	68	46	19	6/6	10/10	12	23	35	X-ray

[1]Postfl. - postflexion; Juv. - juvenile.
[2]LP refers to functional larval pectoral fins which have no ossified rays.

TABLE 13.—Morphometrics, in millimeters, of larvae and juveniles of *Pleuronichthys ocellatus*.

Station	Body length	Left eye[1]	Noto-chord[2]	Snout to anus	Head length	Snout length	Eye width	Eye height	Body depth at P base	Body depth at anus	Caudal peduncle depth	Caudal peduncle length	Snout to origin pelvic fin
5604-111.G.14	6.6 SL	Sym.	Flexed	3.2	2.0	0.30	0.54	0.56	2.2	2.2	0.50	0.40	1.9
5604-109.G.25	7.0	Sym.	Flexed	3.3	2.1	0.40	0.62	0.56	2.3	2.3	0.52	0.50	2.1
Upper Gulf of	19.2	Over	Juv.	7.0	5.7	0.83	1.8	—	8.2	9.0	2.4	1.2	5.0
California	22.0	Over	Juv.	7.0	6.2	0.91	1.9	—	9.4	9.8	2.8	1.4	5.2
	24.0	Over	Juv.	7.7	6.5	0.91	2.1	—	9.4	10.2	2.8	1.4	5.7
	24.5	Over	Juv.	7.4	6.8	1.1	2.3	—	10.5	11.0	3.2	1.5	5.5
	25.0	Over	Juv.	7.5	6.7	0.83	2.5	—	10.4	11.2	3.2	1.7	5.7
	25.5	Over	Juv.	8.5	6.8	0.91	2.3	—	10.7	11.7	3.1	1.8	6.0

[1]Sym. - symmetrical.
[2]Juv. - juvenile.

Distribution.—This species is restricted to the northern half of the Gulf of California (Norman 1934; Fitch 1963). Larvae were collected at two stations in the upper Gulf.

Pleuronichthys ritteri Starks and Morris (spotted turbot) Figures 15-17

Literature.—The egg of *P. ritteri* was described by Orton and Limbaugh (1953) and illustrated by White (1977). Larvae of this species have not been described previously.

Distinguishing characters.—Larval stages of this species may be confused with *P. verticalis* and *H. guttulata*. Characters of preflexion and flexion larvae which separate it from *P. verticalis* include the lack of triangular clusters of pigment on the finfold, less pigment on the tail with 8 or 9 unpigmented myomeres compared with 3-5 in *P. verticalis*, and a more robust body. Postflexion larvae are more heavily pigmented, particularly on the dorsal and anal fin pterygiophores, and are smaller than comparable stages of *P. verticalis*. Distinguishing characters for newly transformed and early juvenile stages have been discussed earlier under *P. verticalis*.

Characters for distinguishing yolk-sac larvae of *P. ritteri* from *H. guttulata* include the presence of pigment on the finfolds of *P. ritteri*, a smaller oil globule (average 0.10 vs. 0.14 mm), lack of pigment on the oil globule, and presence of pigment ventrally near the tip of the notochord. Distinctive characters of preflexion and flexion larvae of *P. ritteri* include the lack of pterotic spines on the head which is more rounded than on preflexion *H. guttulata*, the lack of pigment from the top of the head posteriorly to the nape, a more robust head and trunk (compare Figure 15D with Figure 19D), and the presence of small pigment spots on the pectoral fin blade along its margin or base. Postflexion and early transforming specimens can be distinguished by a deeper and shorter caudal peduncle, a more robust body, and the origin of the dorsal fin on the future blind side of the head instead of on the medial line of the head as found in *H. guttulata*.

Pigmentation.—Yolk-sac larvae are heavily pigmented with the exception of the last 8 or 9 myomeres. Pigment is also scattered on the remnant of the yolk sac, on the dorsal and ventral finfolds, and ventrally on the tail near the tip of the notochord (Figure 15A). Except for the appearance of pigment along the margins of the pectoral fin blade, no significant changes in pigmentation occur in early preflexion larvae of ca. 3.0 mm NL (Figure 15B).

By 4.0 mm NL, pigment found earlier along the top of the head posterior to the nape is lost, leaving an unpigmented streak which persists until flexion of the notochord is complete at 5.5 mm NL (Figures 15C, D; 16A, B). Ventral pigment is similarly lost on the abdominal region, resulting in an unpigmented lower abdomen in late preflexion and flexion specimens. Marginal pectoral fin pigment present on larvae to about 3.3 mm NL, changes to small, discrete spots on the fin membrane along its base. These melanophores persist through postflexion larvae until the pectoral fin differentiates into a small, rayed fin by ca. 10.0 mm SL (Figures 16C, 17).

Pigment on the tail extends posteriad the same distance in flexion larvae as in preflexion larvae, but in postflexion larvae the tail pigment fills in posteriorly to the terminal dorsal and anal fin rays. In later postflexion and transformation stages, the head, trunk, and tail, except the caudal peduncle, are completely covered with pigment which extends over the dorsal and anal fin pterygiophores (Figures 16C, 17).

At 10.0 mm SL, a dark circular blotch of pigment develops on the middle section of the body, with a heavy band of pigment at the posterior extreme of body pigment. Several triangular patches are clustered on the dorsal and anal fin rays above the pterygiophores. The caudal peduncle area remains unpigmented (Figure 17).

Morphology.—Larvae of *P. ritteri* are the smallest among species of *Pleuronichthys* in comparable stages of development. Our smallest specimen has a large yolk sac and is 2.1 mm NL (Figure 15A). The oil globule is positioned posteriorly in the yolk mass and measures 0.11 mm in diameter. The left eye begins to migrate at about 6.0 mm SL and migration of the eye is completed before 10.0 mm SL (Table 14). The smallest available juvenile was 12.7 mm SL.

The gut develops as in other *Pleuronichthys* but coiling begins earlier, at about 3.0 mm NL, and the terminal section of the gut is in a vertical position in most specimens >4.0 mm NL.

The head is relatively larger in preflexion larvae of *P. ritteri* than in the other species (Table 5). Relative head length increases throughout the larval period, then is moderately reduced at transformation. Mean relative snout length increases in *P. ritteri* larvae undergoing notochord flexion and decreases during subsequent stages, but in other species of *Pleuronichthys* it decreases during all major phases of larval development. Relative eye size is largest in preflexion larvae, becomes reduced in later larval stages, and increases at transformation.

The early larvae of *P. ritteri* are the deepest bodied species of *Pleuronichthys*. Mean relative body depth measured at the base of the pectoral fin is greater during preflexion and flexion stages of the notochord than in any other species. In postflexion larvae, however, mean relative body depth is markedly less than in *P. decurrens* and about equal to that in *P. coenosus* and *P. verticalis* (Table 5).

Fin and axial skeleton formation.—Early caudal formation involving thickening in the hypural area of the developing caudal fin occurs on larvae 4.3-5.1 mm NL (Table 15). Caudal rays are forming on larvae as small as 4.5 mm NL, with a simultaneous initiation of flexion of the notochord. Specimens between 4.5 and 5.6 mm NL undergo notochord flexion. Our smallest specimen with a fully flexed notochord is 5.3 mm SL. The full

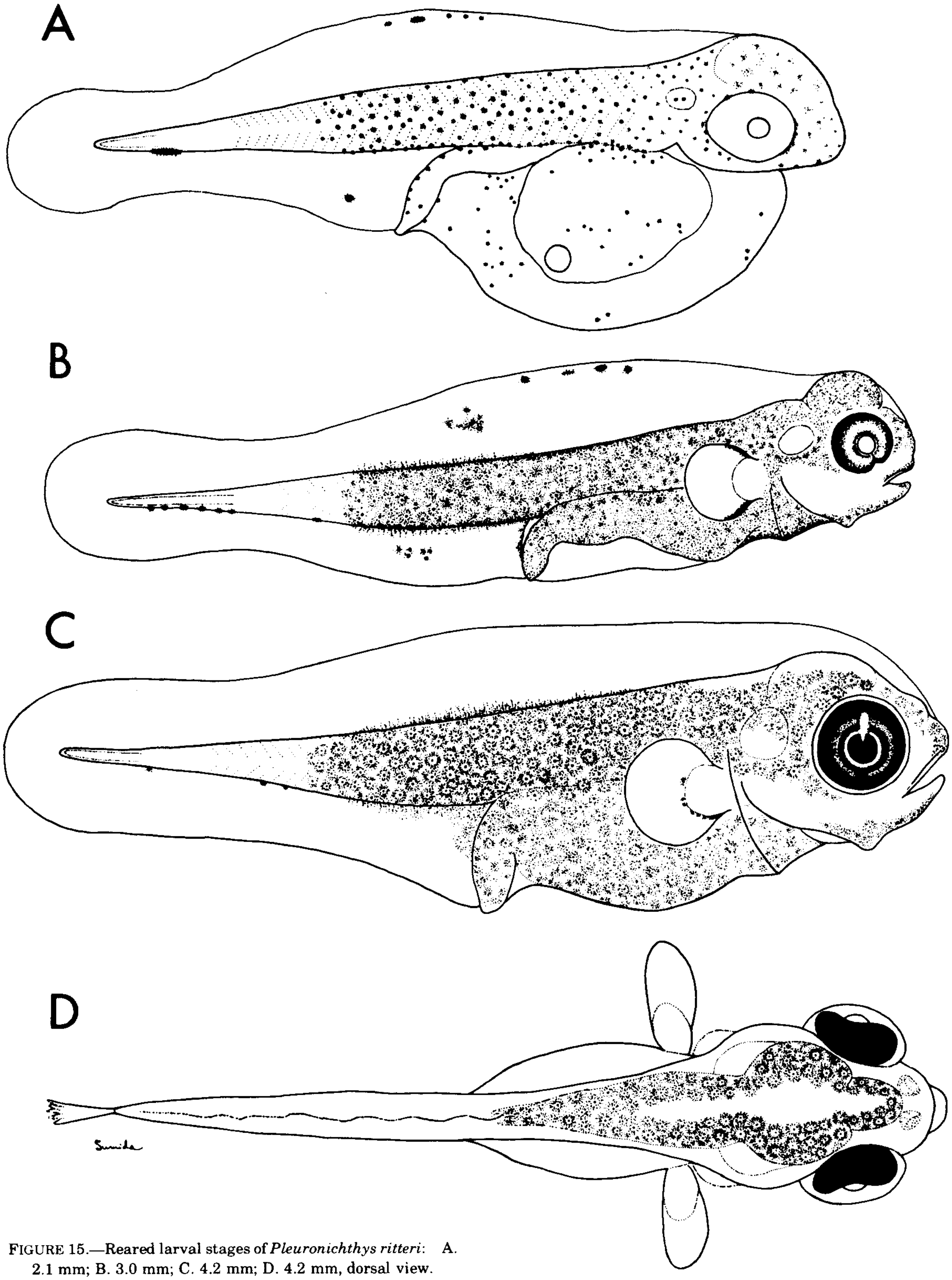


FIGURE 15.—Reared larval stages of *Pleuronichthys ritteri*: A. 2.1 mm; B. 3.0 mm; C. 4.2 mm; D. 4.2 mm, dorsal view.

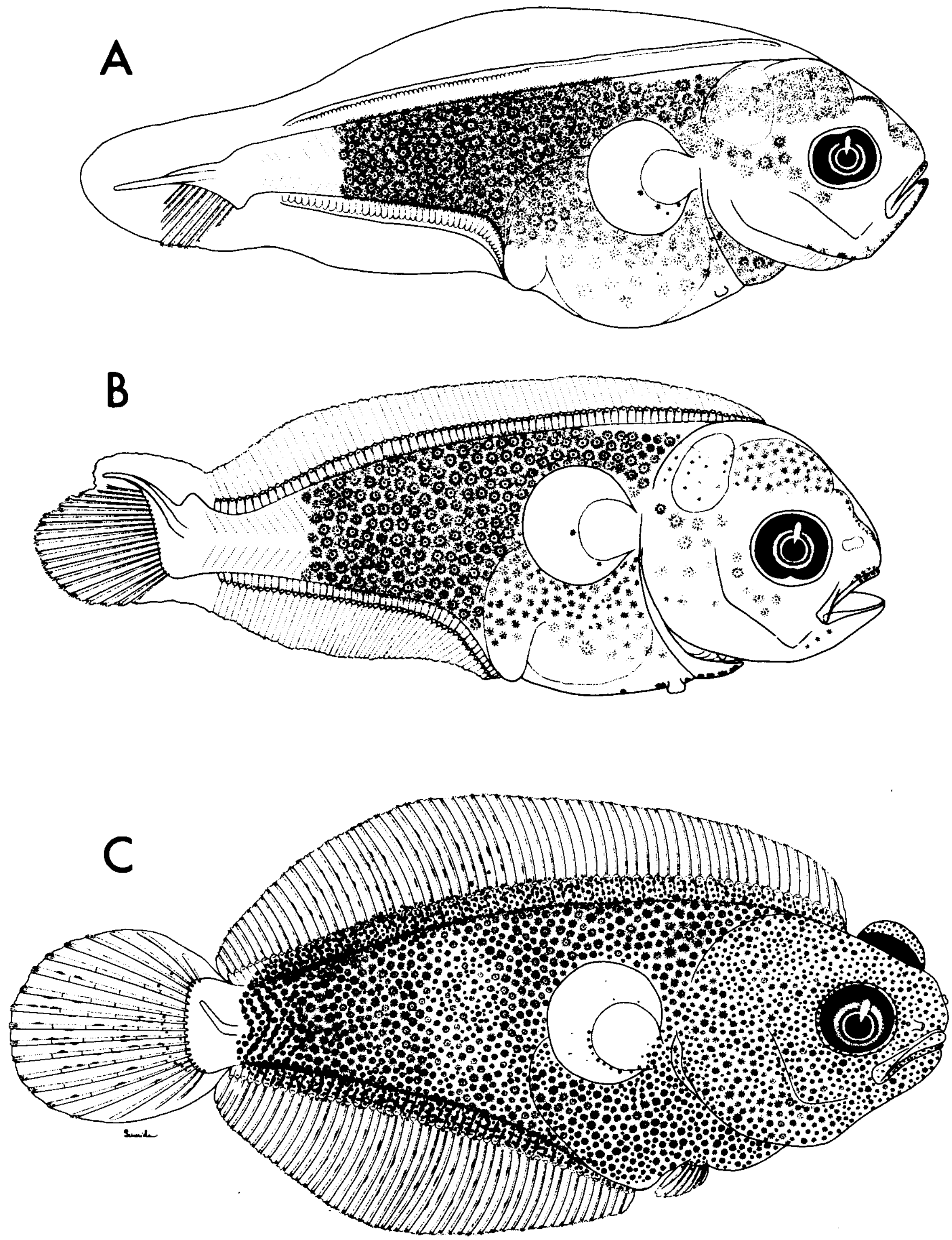


FIGURE 16.—Larval stages of *Pleuronichthys ritteri*: A. 5.6 mm; B. 5.5 mm; C. 6.4 mm.

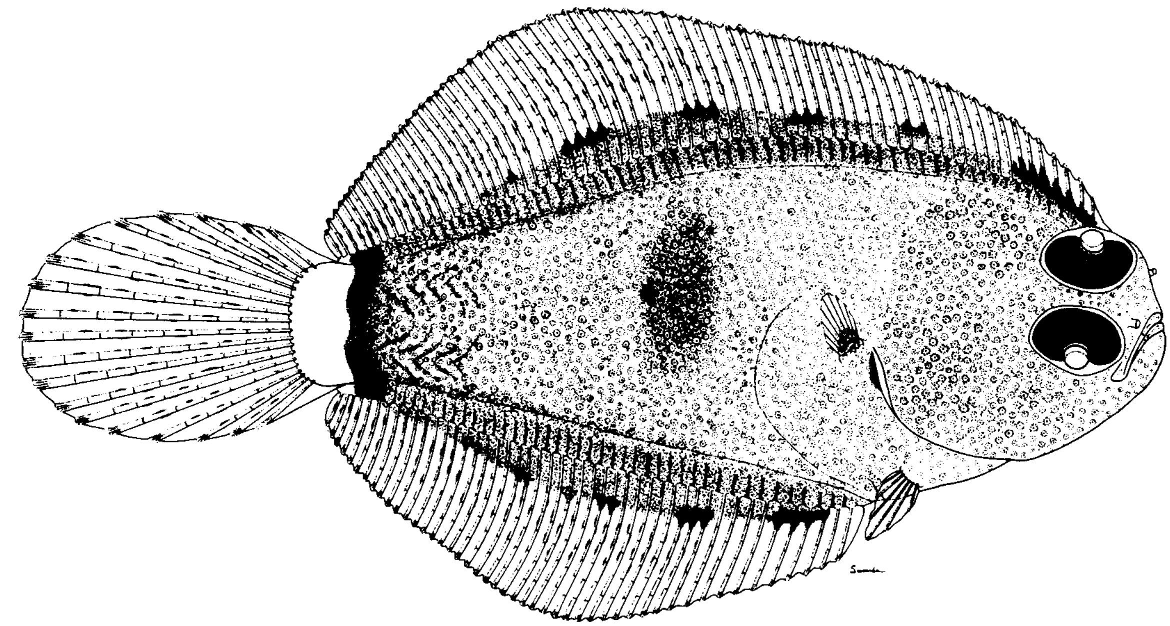


FIGURE 17.—Transforming specimen of *Pleuronichthys ritteri*, 10.0 mm.

TABLE 14.—Morphometrics, in millimeters, of larvae and juveniles of *Pleuronichthys ritteri*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Body length	Left eye[1]	Noto-chord[2]	Snout to anus	Head length	Snout length	Eye width	Eye height	Body depth at P base[3]	Body depth at anus[3]	Caudal peduncle depth	Caudal peduncle to length	Snout to origin pelvic fin
Off La Jolla, Calif.	2.1 NL	Sym.	Str.	1.2	0.50	0.10	0.24	0.20	0.20	0.38	—	—	—
	3.0	Sym.	Str.	1.4	0.60	0.12	0.26	0.22	0.42	0.42	—	—	—
7412-123.36	3.3	Sym.	Str.	1.6	0.80	0.14	0.28	0.24	0.78	0.58	—	—	—
Off La Jolla	4.2	Sym.	Str.	2.2	1.0	0.18	0.40	0.32	0.96	0.86	—	—	—
5709-117.26	4.3	Sym.	Str.	2.1	1.1	0.20	0.40	0.36	1.2	1.2*	—	—	—
7207-123.36	4.4	Sym.	Str.	2.1	1.1	0.24	0.34	0.32	1.0	0.9	—	—	—
6204-120.25	5.0	Sym.	Str.	2.2	1.2	0.20	0.38	0.38	1.2	1.1*	—	—	—
5708-120.25	5.1	Sym.	Str.	2.5	1.4	0.24	0.46	0.40	1.8*	1.7*	—	—	1.3
6507-120.35	4.5	Sym.	E fl.	2.3	1.4	0.32	0.44	0.42	1.6*	1.6*	—	—	1.2
5506-120.40	4.8	Sym.	E fl.	2.3	1.4	0.28	0.40	0.38	1.5*	1.7*	—	—	1.4
5510-117.26	5.5	Sym.	Midfl.	2.7	1.2	0.34	0.52	0.48	2.0*	1.9*	—	—	1.6
7501-120.25	5.6	Sym.	Midfl.	2.7	1.5	0.26	0.46	0.40	1.8*	1.5*	—	—	1.4
5112-120.35	5.3 SL	Sym.	Flexed	2.7	1.7	0.30	0.52	0.52	2.2*	2.2*	0.50	0.36	1.4
5802-137.23	6.0	Migr.	Flexed	2.9	2.0	0.32	0.60	0.54	2.4*	2.7*	0.66	0.30	1.8
Off La Jolla	6.4	Migr.	Flexed	2.6	2.2	0.40	0.64	0.60	2.5*	2.7*	0.76	0.38	2.0
Sebastian Viscaino Bay, B.C.	7.5	A. over	Flexed	3.0	2.6	0.40	0.80	0.64	2.9*	3.0*	1.0	0.48	2.7
7501-120.22.4	8.5	A. over	Flexed	2.8	2.7	0.40	0.86	?	3.6*	3.6*	1.1	0.44	2.3
Off La Jolla	10.0	Over	Flexed	3.1	3.1	0.48	1.0	0.80	4.2*	4.2*	1.4	0.60	2.6
Reared	12.7	Over	Juv.	4.2	3.8	0.36	1.4	1.0	5.1*	5.4*	1.4	0.76	3.4
Reared	15.0	Over	Juv.	4.5	4.2	0.48	1.6	1.2	5.9*	6.1*	1.8	1.0	3.9
Reared	16.7	Over	Juv.	5.2	4.7	0.48	1.8	1.4	6.2*	6.4*	2.0	1.1	4.2
Off San Juanico, B.C.	23.0	Over	Juv.	7.2	6.8	0.83	2.2	?	9.7*	9.7*	2.6	1.2	5.8

[1]Sym. - symmetrical; Migr. - migrating; A. over - About over.
[2]Str. - straight; E fl. - early flexion; Midfl. - midflexion; Juv. - juvenile.
[3]Asterisk indicates inclusion of dorsal fin pterygiophores in body depth measurement.

caudal count of 19 rays was observed on a 6.0-mm SL postflexion specimen.

Dorsal and anal fin bases are forming in the finfold on larvae 4.3 mm NL, and the full complement of rays develops by 6.0 mm SL. Pelvic fin buds are evident during early caudal formation but rays are first observed on a 6.0-mm specimen. Pectoral rays were fully formed on a 10.0-mm

TABLE 15.—Meristics of larvae and juveniles of *Pleuronichthys ritteri*. (Specimens between dashed lines are undergoing notochord flexion.)

			Fin rays					Vertebrae			
Station	Size (mm)	Stage[1]	Dorsal	Anal	Caudal	Pelvic	Pectoral right/left	Precaudal	Caudal	Total	Source of count
Off La Jolla, Calif.	2.1 NL	Yolk-sac	0	0	0	0	LP[2]				
	3.0	Prefl.	0	0	0	0	LP[2]				
7412-123.36	3.3	Prefl.	0	0	0	0	LP[2]				
Off La Jolla	4.2	Prefl.	0	0	0	0	LP[2]				
5709-117.26	4.3	Prefl.	Forming	Forming	Forming	0	LP[2]				
7207-23.36	4.4	Prefl.	Forming	Forming	Forming	0	LP[2]				
6204-120.25	5.0	Prefl.	Forming	Forming	Forming	0	LP[2]				
5708-120.25	5.1	Prefl.	Forming	Forming	Forming	Bud	LP[2]				
6507-120.35	4.5	E fl.	Forming	Forming	ca. 6	Bud	LP[2]				
5506-120.40	4.8	E fl.	Forming	Forming	ca. 4	Bud	LP[2]				
5510-117.26	5.5	Midfl.	Forming	Forming	ca. 8	Bud	LP[2]				
7501-120.25	5.6	Midfl.	Forming	Forming	ca. 8	Bud	LP[2]				
5112-120.35	5.3 SL	Postfl.	ca. 60	ca. 45	16	Bud	LP[2]				
5802-137.23	6.0	Postfl.	72	49	19	6/6	LP[2]				
Off La Jolla	6.4	Postfl.	65	45	19	6/6	LP[2]				
Sebastian Viscaino Bay, B.C.	7.5	Postfl.	70	48	19	6/6	LP[2]				
7501-120.22.4	8.5	Postfl.	69	51	19	6/6	LP[2]				
Off La Jolla	10.0	Postfl.	68	47	19	6/6	9/9	12	23	35	X-ray
Reared	12.7	Juv.	69	47	19	6/6	10/11	12	23	35	X-ray
Reared	15.0	Juv.	64	44	19	6/6	10/11	12	23	35	X-ray
Reared	16.7	Juv.	65	44	19	6/6	11/11	12	22	34	X-ray
Off San Juanico, B.C.	23.0	Juv.	68	49	Damaged	6/6	9/9	12	23	35	X-ray

[1]Prefl. - preflexion; E fl. - early flexion; Midfl. - midflexion; Postfl. - postflexion; Juv. - juvenile.
[2]LP refers to functional larval pectoral fins which have no ossified rays.

larva. A radiograph of this specimen showed 12 precaudal and 23 caudal vertebrae, the typical count for this species.

Distribution.—This species ranges from Morro Bay, Calif., to Magdalena Bay, Baja California (Fitch 1963; Miller and Lea 1972; Fierstine et al. 1973). Our egg and larval material, which was collected between southern California and Magdalena Bay, Baja California, shows a markedly coastal, inshore distribution for *P. ritteri*, with a majority of collections made over or near the continental shelf (Figure 18).

Hypsopsetta guttulata Girard (diamond turbot) Figures 19-22

Literature.—Orton and Limbaugh (1953) and Orton (1953) briefly described the eggs of *H. guttulata*. Eldridge (1975) described and illustrated larvae of this species, and noted the average size of its egg and oil globule. Although the larval series is quite well described in Eldridge (1975) (except for the omission of the pterotic spine on the head), we are including information about distinguishing characters, pigmentation, etc. to facilitate identification.

Distinguishing characters.—Larvae of *H. guttulata* are distinguishable from species of *Pleuronichthys*, except for *P. ritteri*, by their lower total vertebral number, by attaining comparable stages of development at smaller sizes, and by the presence of a pterotic spine on each side of the head in yolk-sac larvae to midflexion larvae. In the genus *Pleuronichthys*, only *P. decurrens* develops pterotic spines. (See Distinguishing characters for *P. decurrens*.)

The only species with which larval *H. guttulata* may be confused is *P. ritteri* because of its relatively small size and somewhat similar pigment pattern. (See Distinguishing characters for separating larvae of the two species discussed under *P. ritteri*.)

Pigmentation.—Yolk-sac larvae are heavily pigmented on the head, trunk, and for a short distance on the tail, with the posteriormost 9 or 10 myomeres remaining unpigmented (Figure 19A). Pigment spots are scattered over the ventral and posterior surfaces of the yolk sac and oil globule, and over the terminus of the gut.

Preflexion larvae show little change in pigment pattern. One or two melanophores develop on the pectoral fin base. The isthmus has a line of pigment spots, and the entire abdominal area is covered with pigment (Figure 19B).

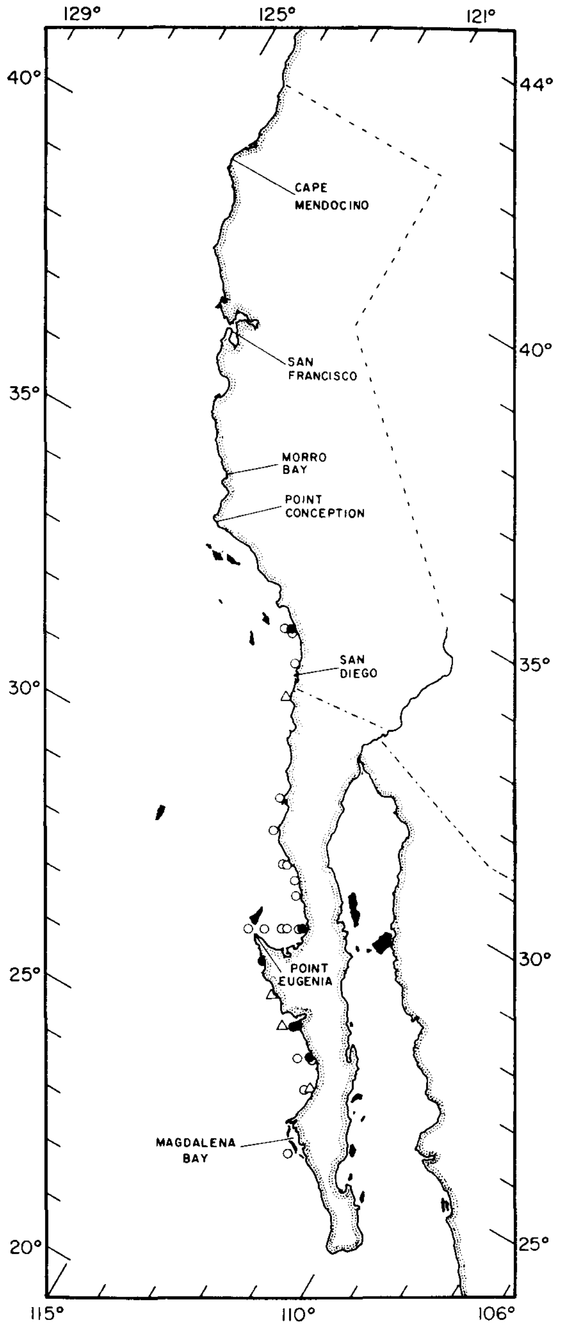


FIGURE 18.—Distribution of eggs and larvae of *Pleuronichthys ritteri* examined in this study. (Triangles represent eggs, open circles larvae, and closed circles eggs and larvae.)

At the initiation of dorsal and anal fin formation, the tail pigment spreads out dorsally and ventrally onto the finfold, resulting in conspicuous dark mounds of pigment opposing each other in the area between the body and the dorsal and anal fin bases (Figure 19C). The tops of the head, nape, and shoulder area are pigmented in contrast to *P. ritteri*, which has an unpigmented streak dorsally (Figure 19D). Flexion, postflexion, and early transforming specimens maintain the earlier pigment pattern and the only obvious change is a slight posteriad extension of trunk pigment, leaving 5 or 6 unpigmented myomeres posteriorly compared with 9 or 10 in earlier stages (Figure 20). The base of the pectoral fin acquires more pigment spots in postflexion larvae, and pigment on the head similarly increases in density (Figure 20B).

Preserved small juveniles are brownish-black with numerous small, dark spots scattered over the body and pterygiophores, giving them a mottled appearance (Figure 21).

Morphology.—Our smallest yolk-sac larva is 2.2 mm NL and has a posteriorly positioned oil globule 0.14 mm in diameter (Figure 19A). The left eye is beginning to migrate in a specimen 4.4 mm SL and is complete in a 7.3-mm SL larva (Table 16). The smallest available juvenile was 11.2 mm SL.

A major distinguishing feature of *Hypsopsetta* larvae is the presence of a pterotic spine on each side of the head. The spines are present on the smallest yolk-sac larva and are prominent in most preflexion larvae. The spines begin to regress on late preflexion larvae, and are totally regressed in late flexion specimens. In *P. decurrens* the spines are well developed throughout the larval period and begin to regress late in the postflexion stage.

Although mean relative body depth of *H. guttulata* larvae increases with development, it is slightly less in postflexion specimens than in any species of *Pleuronichthys*, except *P. ocellatus* (Table 5). In newly transformed juveniles, however, relative body depth is greater than in any species of *Pleuronichthys*. As a juvenile, *H. guttulata* assumes a diamond-shaped body form.

Relative body width is useful to separate *Hypsopsetta* larvae from those of *P. ritteri*. As shown in Figures 15D and 19D, larvae of *Hypsopsetta* have narrower bodies.

Fin formation.—The caudal fin forms on larvae between 4.0 and 5.2 mm NL and is complete on some specimens as small as 4.4 mm (Table 17). The dorsal and anal fins form simultaneously with the

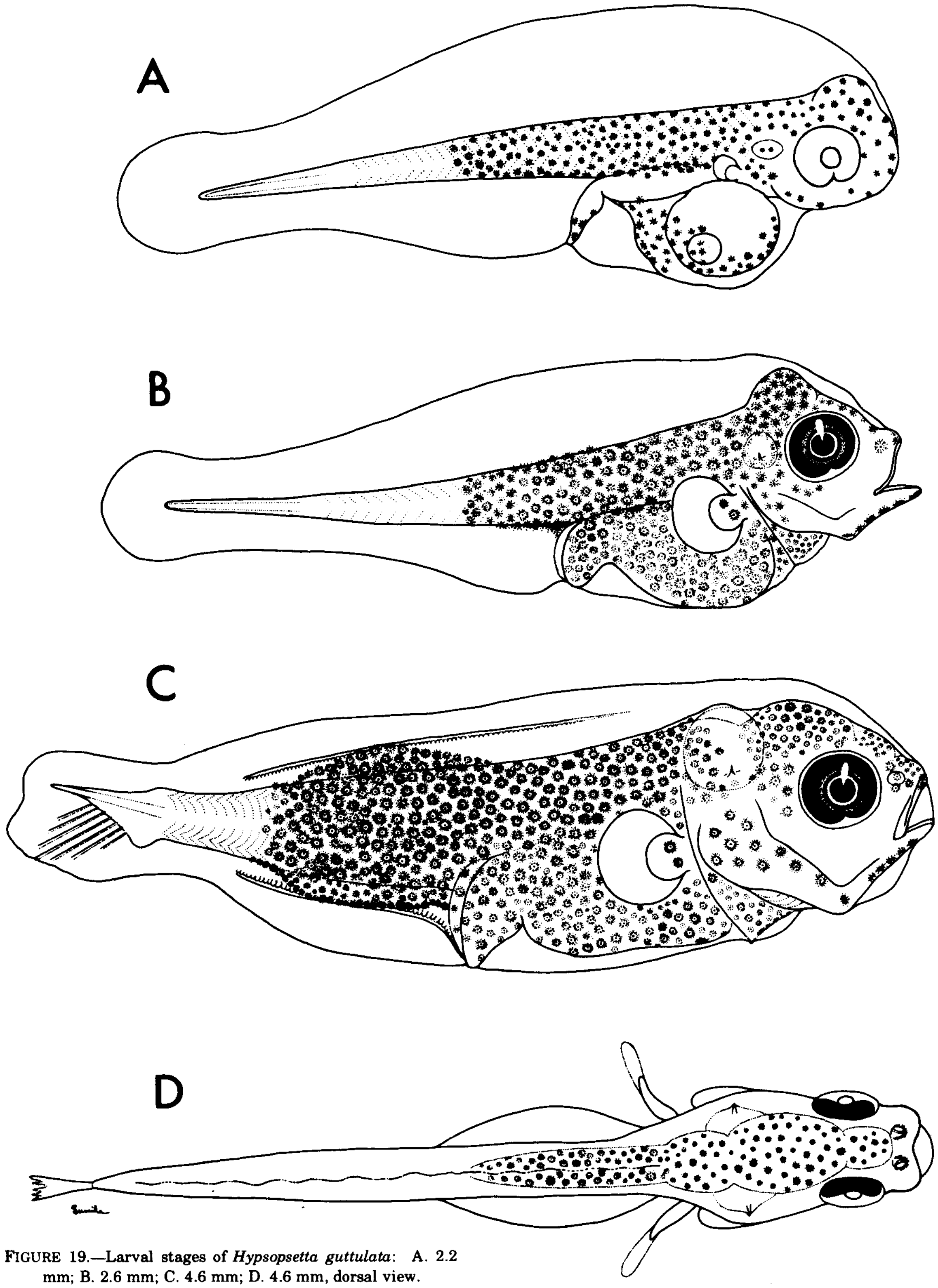


FIGURE 19.—Larval stages of *Hypsopsetta guttulata*: A. 2.2 mm; B. 2.6 mm; C. 4.6 mm; D. 4.6 mm, dorsal view.

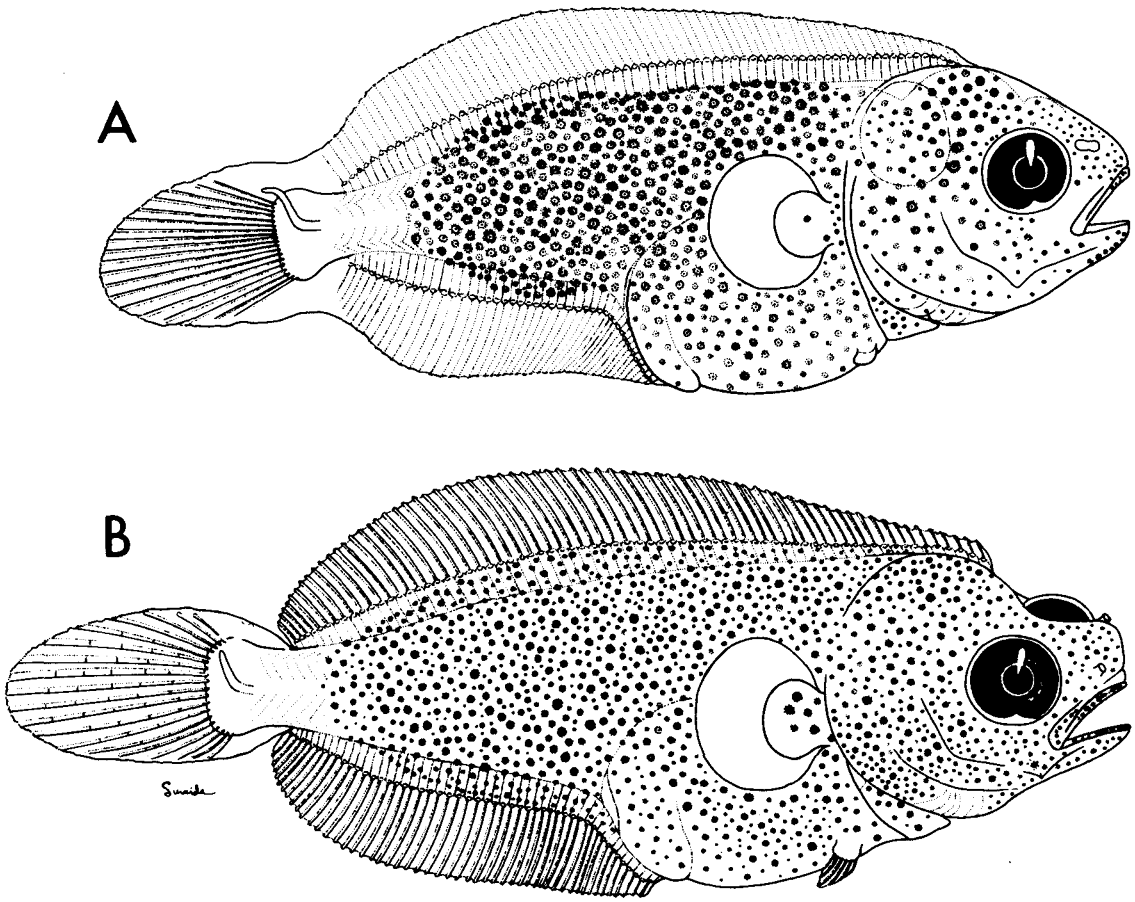


FIGURE 20.—Larval stages of *Hypsopsetta guttulata*: A. 5.9 mm; B. 6.6 mm.

caudal and are complete, or nearly so, on all postflexion specimens (4.4-8.8 mm SL). Pelvic fins are late in forming compared with their developmental pattern in *Pleuronichthys* larvae. Pelvic buds can be observed only after notochord flexion has been completed, and rays are first evident on the 6.6-mm SL specimen.

Distribution.—Hypsopsetta guttulata ranges from Cape Mendocino, Calif., to Magdalena Bay, Baja California, with an isolated population in the upper Gulf of California (Norman 1934; Fitch 1963). Egg and larval material examined by us was collected in bays along the coast, or at CalCOFI stations located over the continental shelf, a pattern of distribution similar to the habitat of *P. ritteri* (Figure 22).

Hippoglossina stomata Eigenmann and Eigenmann (bigmouth sole) Figure 23

Literature.—There is no published account of eggs and larvae of this species. However, Leonard (1971) described a larval series of *H. oblonga* from the western North Atlantic. Earlier, Agassiz and Whitman (1885) and Miller and Marak (1962) described the eggs and early-stage larvae of *H. oblonga*. Miller and Marak reported the egg size range as 0.91-1.12 mm (average 1.04 mm) with an oil globule diameter of ca. 0.17 mm. The larval size at hatching was 2.7-3.2 mm.

Distinguishing characters.—Preflexion larvae of *H. stomata* may be confused with early larvae of *P.*

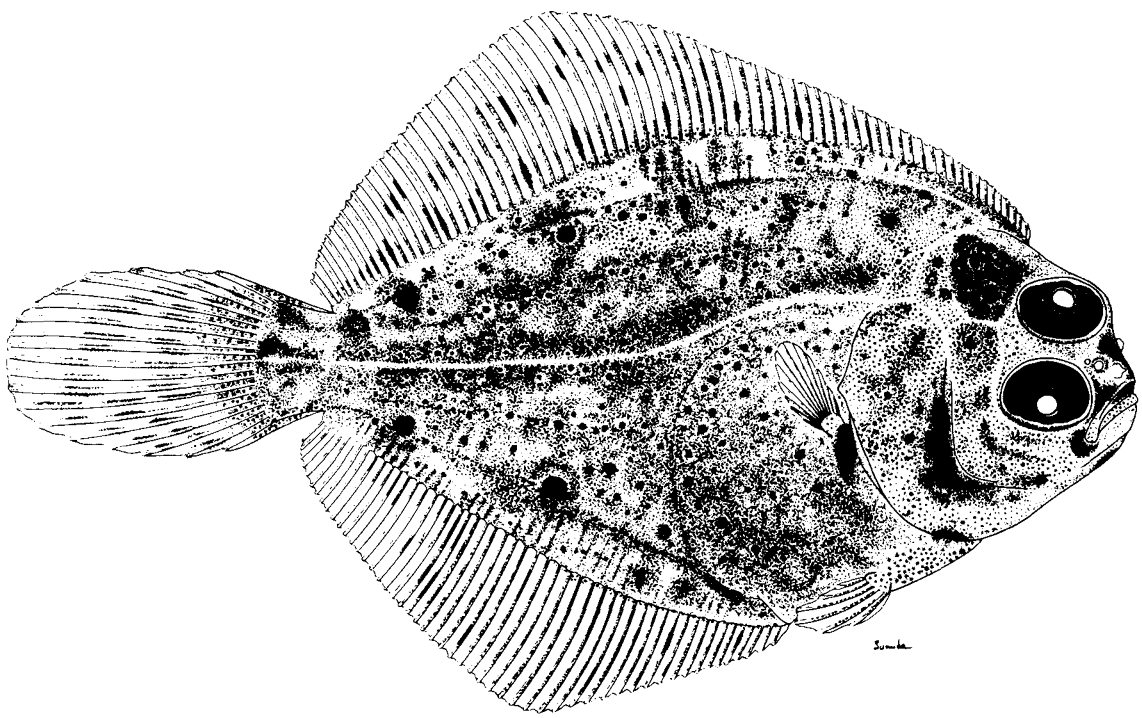


FIGURE 21.—Early juvenile of *Hypsopsetta guttulata*, 13.2 mm.

coenosus and *P. verticalis* due to similarities in size and pigmentation of the larvae, and the presence of pigment on the finfold dorsally and ventrally, posterior to the anus. Characters of *H. stomata* larvae which distinguish them from preflexion *P. coenosus* larvae include the presence of a pigment bar through the eye, heavy pigment on both sides of the pectoral fin base and a sprinkling of pigment on the pectoral blade, a more slender, elongate body, and a significantly smaller patch of dorsal finfold pigment. The same characters help to distinguish *H. stomata* from *P. verticalis*, except for the finfold pigmentation. *Pleuronichthys verticalis* has small, triangular-shaped pigment patches whereas *H. stomata* has a small rounded pigment cluster on the dorsal finfold and a broad patch on the ventral finfold. Larvae of *P. verticalis* are also smaller than *H. stomata* at similar developmental stages.

Larvae in the flexion stage and larger are readily separable from *Pleuronichthys* by the preopercular spines and development of several elongated dorsal rays in the anteriormost part of the dorsal fin. These do not develop on larval *Pleuronichthys* or *Hypsopsetta*.

Pigmentation.—Yolk-sac larvae (ca. 3.7 mm) are heavily pigmented on the trunk and tail except for the posteriormost part of the tail which is pigmented with several small spots dorsally and ventrally (Figure 23A). The upper head and abdominal region have scattered pigment, with a more concentrated bar of pigment on each side of the eye. Both sides of the pectoral fin base are conspicuously pigmented. Finfold pigment consists of a small, rounded patch at the edge of the dorsal finfold, and a broad patch on the ventral finfold, both situated posterior to the anus near the midpoint between the anus and tip of the tail (Figure 23A).

Preflexion larvae, 4.1-7.0 mm NL, undergo little change in pigmentation except to augment pigment in areas of the pectoral fin, abdominal region, and top of the head (Figure 23B).

On larvae forming the dorsal and anal fins, the dorsal finfold pigment spreads to include the area between the fin rudiments and body margin, and the ventral finfold pigment spreads both anteriorly and posteriorly (Figure 23C). Pigment on the pectoral fin base intensifies and also extends out onto the fin blade.

TABLE 16.—Morphometrics, in millimeters, of larvae and juveniles of *Hypsopsetta guttulata*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Body length	Left eye[1]	Noto-chord[2]	Snout to anus	Head length	Snout length	Eye width	Eye height	Body depth at P base[3]	Body depth at anus[3]	Caudal peduncle depth	Caudal peduncle length	Snout to origin pelvic fin
San Diego Bay	2.2 NL	Sym.	Str.	1.1	0.38	0.08	0.17	0.13	0.18	0.28	—	—	—
King Harbor, Calif.	2.3	Sym.	Str.	1.1	0.46	0.12	0.20	0.17	0.18	0.34	—	—	—
7501-120.25	2.8	Sym.	Str.	1.4	0.68	0.12	0.26	0.22	0.62	0.52	—	—	—
7501-120.29	3.3	Sym.	Str.	1.7	0.82	0.20	0.30	0.24	0.82	0.72	—	—	—
San Diego Bay	3.6	Sym.	Str.	1.8	0.84	0.16	0.32	0.28	0.78	0.66	—	—	—
San Diego Bay	4.0	Sym.	Str.	2.0	0.88	0.20	0.36	0.30	0.88	0.84	—	—	—
7412-127.32.6	4.4	Sym.	Str.	2.2	0.90	0.20	0.37	0.32	1.0	0.92	—	—	—
7412-127.32.6	4.6	Sym.	E fl.	2.3	1.2	0.24	0.38	0.32	1.1	1.0	—	—	—
7501-120.22.4	4.9	Sym.	E fl.	2.4	1.3	0.22	0.40	0.36	1.2	1.1	—	—	—
7501-120.29	5.1	Sym.	E fl.	2.5	1.2	0.22	0.40	0.36	1.1	1.1	—	—	—
King Harbor	5.2	Sym.	L fl.	2.4	1.4	0.28	0.44	0.42	1.2	1.2	—	—	—
L.A. Harbor, Calif.	4.4 SL	Migr.	Flexed	2.2	1.6	0.30	0.48	0.42	1.8*	1.9*	0.40	0.40	1.4
La Jolla, Calif.	4.8	Migr.	Flexed	2.2	1.5	0.30	0.48	0.40	1.6*	1.7*	0.40	0.36	1.4
San Diego Bay	5.4	Migr.	Flexed	2.3	1.8	0.34	0.52	0.40	1.8*	1.9*	0.42	0.42	1.6
7501-120.22.7	5.9	Sym.	Flexed	3.1	1.8	0.32	0.50	0.46	2.0*	2.2*	0.44	0.48	1.9
7501-120.24	6.6	Migr.	Flexed	3.2	2.1	0.40	0.62	0.52	2.3*	2.4*	0.50	0.60	2.0
Reared	7.3	Over	Flexed	2.9	2.5	0.40	0.90	0.70	3.3*	3.5*	0.76	0.64	2.1
Reared	7.9	Over	Flexed	2.9	2.7	0.44	0.92	0.68	3.6*	3.8*	0.86	0.70	2.1
Reared	8.8	Over	Flexed	3.6	3.0	0.48	1.0	0.76	4.1*	4.2*	0.96	0.68	2.6
Reared	11.2	Over	Juv.	4.2	3.7	0.50	1.4	1.1	5.7*	6.0*	1.4	1.0	3.3
Richardson Bay, Calif.	12.9	Over	Juv.	4.5	4.3	0.52	1.2	0.92	7.0*	7.0*	1.5	1.0	3.6
	13.2	Over	Juv.	4.8	4.3	0.75	1.3	1.1	6.7*	7.1*	1.4	1.0	3.6
	14.0	Over	Juv.	5.0	4.7	0.75	1.4	1.2	7.5*	7.7*	1.6	1.2	3.8
	14.5	Over	Juv.	5.2	4.8	0.72	1.4	1.0	7.7*	7.9*	1.8	0.88	4.1
	18.4	Over	Juv.	6.4	5.8	0.80	1.7	1.4	10.0*	10.5*	2.1	1.4	5.1

[1]Sym. - symmetrical; Migr. - migrating.
[2]Str. - straight; E fl. - early flexion; L fl. - late flexion; Juv. - juvenile.
[3]Asterisk indicates inclusion of dorsal fin pterygiophores in body depth measurement.

TABLE 17.—Meristics of larvae and juveniles of *Hypsopsetta guttulata*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Size (mm)	Stage[1]	Fin rays: Dorsal	Anal	Caudal	Pelvic	Pectoral right/left	Vertebrae: Precaudal	Caudal	Total	Source of count
7501-120.25	2.8 NL	Prefl.	0	0	0	0	LP[2]				
7501-120.29	3.3	Prefl.	0	0	0	0	LP[2]				
San Diego Bay	3.6	Prefl.	0	0	0	0	LP[2]				
San Diego Bay	4.0	Prefl.	Forming	Forming	Forming	0	LP[2]				
7412-127.32.6	4.4	Prefl.	Forming	Forming	6	0	LP[2]				
7412-127.32.6	4.5	E fl.	Forming	Forming	8	0	LP[2]				
7501-120.22.4	4.9	E fl.	Forming	Forming	6	0	LP[2]				
7501-120.29	5.1	E fl.	Forming	Forming	4	0	LP[2]				
King Harbor, Calif.	5.2	L fl.	ca. 50	ca. 35	15	0	LP[2]				
L.A. Harbor, Calif.	4.4 SL	Postfl.	67	47	19	Bud	LP[2]				
Off La Jolla, Calif.	4.8	Postfl.	66	49	19	Bud	LP[2]				
San Diego Bay	5.4	Postfl.	73	45	19	Bud	LP[2]				
7501-120.22.7	5.9	Postfl.	73	46	19	Bud	LP[2]				
7501-120.24	6.6	Postfl.	69	50	19	6/6	LP[2]				
Reared	7.3	Postfl.	68	47	19	6/6	11/11	11	23	34	X-ray
Reared	7.9	Postfl.	67	51	20	6/6	12/12	12	23	35	X-ray
Reared	8.8	Postfl.	72	50	19	6/6	13/13	12	23	35	X-ray
Reared	11.2	Juv.	73	48	19	4/6	12/12	12	22	34	X-ray
Richardson Bay, Calif.	12.9	Juv.	66	48	19	6/6	12/11	12	23	35	X-ray
	13.2	Juv.	74	53	19	6/6	11/11	12	23	35	X-ray
	14.0	Juv.	78	55	19	6/6	11/11	12	23	35	X-ray
	14.5	Juv.	71	51	19	6/6	12/12	12	23	35	X-ray
	18.4	Juv.	68	51	19	6/6	11/12	12	23	35	X-ray

[1]Prefl. - preflexion; E fl. - early flexion; L fl. - late flexion; Postfl. - postflexion; Juv. - juvenile.
[2]LP refers to functional larval pectoral fins which have no ossified rays.

Postflexion and early transforming specimens are less heavily pigmented than earlier stage larvae, with a noticeable diminution of pigment on the dorsal area of the head and body (Figure 23D).

Morphology.—Larvae of *H. stomata* are closest to *P. coenosus* in size at hatching, notochord flexion, and transformation (Table 18). A specimen 3.7 mm NL has a moderate amount of yolk remaining.

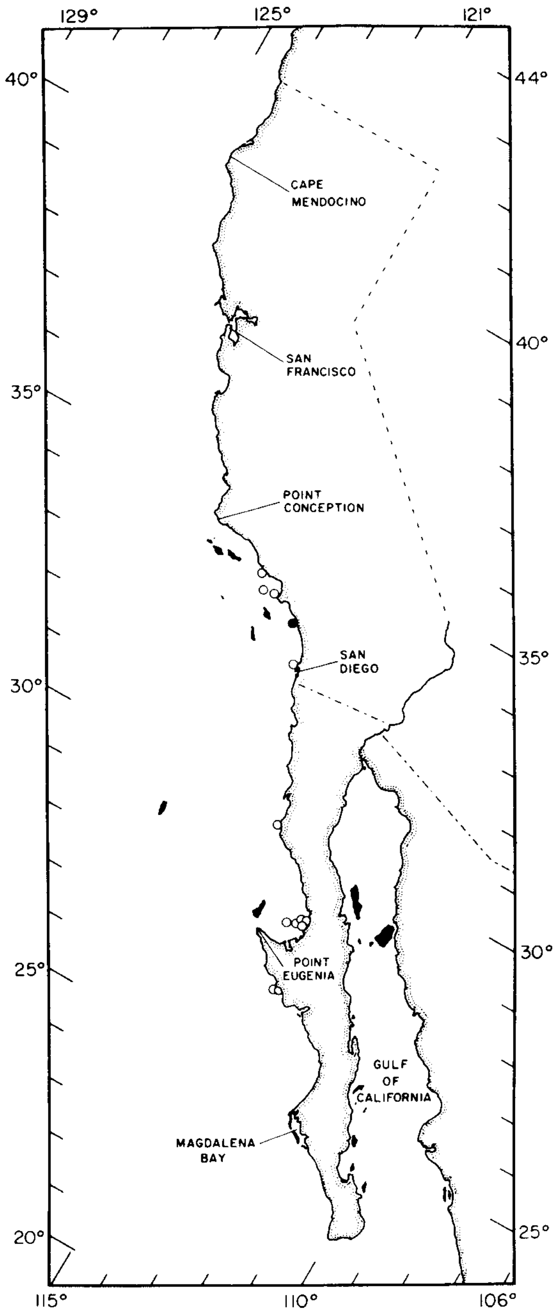


FIGURE 22.—Distribution of eggs and larvae of *Hypsopsetta guttulata* examined in this study. (Open circles represent larvae, closed circles eggs and larvae.)

The right eye is beginning to migrate in a specimen 9.1 mm SL and transformation is almost complete at 11.7 mm SL.

In early preflexion larvae of *Hippoglossina*, the gut is shaped like that in *Pleuronichthys* larvae; however, coiling begins at about 4.5 mm NL and the gut assumes a more compact shape than in *Pleuronichthys*. This is reflected in the relatively shorter snout-anus length. Mean relative snout-anus length remains at about 40% of the body length throughout the larval period, in contrast to *Pleuronichthys* larvae in which there is a gradual decrease in relative gut length during larval development (Table 5). In juveniles, however, there is a decrease in snout-anus length to about 33% of body length, a value comparable with that in *Pleuronichthys* juveniles.

The head is similar in size and shape to that in *Pleuronichthys*. Relative head length increases gradually during larval development. The same is true for relative snout length and is thus opposite to the condition in *Pleuronichthys*; however, it decreases somewhat in juveniles. Relative eye width undergoes a moderate diminution during larval development as in *Pleuronichthys*, but increases moderately in juveniles.

Small preopercular spines develop on larvae from ca. 5.5 mm NL, become most conspicuous on flexion stage larvae, and undergo resorption during transformation from 9.5 mm SL. This spination is distinctive of *H. stomata* when compared with *Pleuronichthys* and *Hypsopsetta*.

Larvae of *Hippoglossina* have a slender appearance compared with some of the deeper bodied species of *Pleuronichthys*. Body depth at the anus is comparatively small in preflexion larvae and remains so in flexion and postflexion larvae and early juveniles (Table 5).

As in *Hypsopsetta*, the caudal peduncle is longer and more slender than in *Pleuronichthys*, except for *P. ocellatus* postflexion larvae.

Fin formation.—Larvae of *Hippoglossina stomata* are comparable with those of *P. coenosus* with regard to size at which the caudal fin develops. Caudal fin formation occurs between 6.2 and 8.8 mm NL (Table 19). Although about six caudal rays are formed on a 7.0-mm NL specimen with a straight notochord, all other specimens with caudal rays have the notochord flexing. The smallest, fully flexed specimen is 7.1 mm SL. Postflexion specimens <9.0 mm SL lack the full complement of 18½ caudal rays. The ural bones supporting the caudal rays are made up of two superior and two inferior hypurals; there is no epural. The lack of an epural bone is a specific

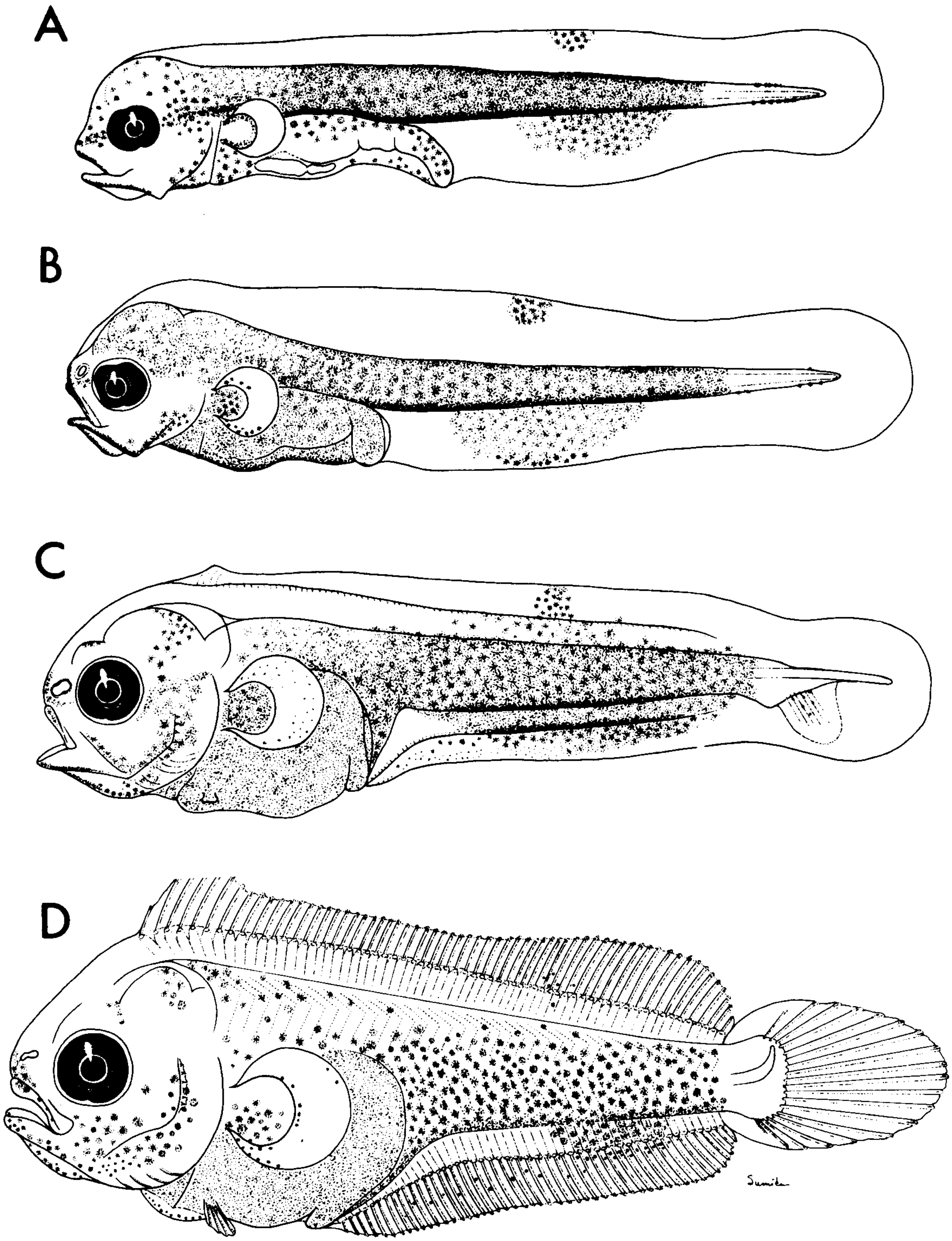


FIGURE 23.—Larval stages of *Hippoglossina stomata*: A. 3.8 mm; B. 4.8 mm; C. 8.3 mm; D. 8.6 mm.

TABLE 18.—Morphometrics, in millimeters, of larvae of *Hippoglossina stomata*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Body length	Left eye[1]	Noto-chord[2]	Snout to anus	Head length	Snout length	Eye width	Eye height	Body depth at P base[3]	Body depth at anus[3]	Caudal peduncle depth	Caudal peduncle length	Snout to origin pelvic fin
7201-117.35	3.7 NL	Sym.	Str.	1.4	0.64	0.10	0.28	0.21	0.50	0.40	—	—	—
7412-103.29	4.1	Sym.	Str.	1.8	0.72	0.07	0.24	0.24	0.48	0.36	—	—	—
7412-88.5.31	4.8	Sym.	Str.	2.0	1.0	0.24	0.36	0.28	0.96	0.68	—	—	—
5801-117.35	5.2	Sym.	Str.	2.2	1.2	0.24	0.48	0.36	1.2	0.82	—	—	—
6310-93.28	6.2	Sym.	Str.	2.2	1.3	0.26	0.42	0.36	1.2	0.92	—	—	—
6605-123.37	6.4	Sym.	Str.	2.2	1.3	0.24	0.44	0.36	1.4*	1.0	—	—	—
5910-117.30	6.2	Sym.	Str.	2.8	1.6	0.30	0.54	0.42	2.1*	1.3	—	—	—
6706-110.50	7.0	Sym.	Str.	2.8	1.8	0.32	0.50	0.42	2.1*	1.8*	—	—	—
5708-118.5.35	6.6	Sym.	E fl.	2.7	1.7	0.40	0.54	0.54	2.1*	1.7*	—	—	1.5
5706-127.34	7.5	Sym.	E fl.	3.0	2.0	0.36	0.66	0.70	2.2*	1.8*	—	—	1.8
6912-83.60	8.3	Sym.	E fl.	3.2	1.8	0.42	0.60	0.66	2.4*	2.0*	—	—	2.0
5807-130.30	7.6	Sym.	Midfl.	2.9	1.9	0.38	0.64	0.58	2.2*	2.0*	—	—	1.8
5709-110.30	7.9	Sym.	Midfl.	2.9	1.9	0.42	0.60	0.52	2.2*	2.0*	—	—	1.7
6706-123.37	8.8	Sym.	Midfl.	3.4	2.3	0.44	0.68	0.60	2.8*	2.4*	—	—	2.4
5706-123.37	7.6	Sym.	L fl.	3.1	2.1	0.46	0.66	0.64	2.5*	2.3*	—	—	1.8
6706-123.36	8.5	Sym.	L fl.	3.4	2.3	0.44	0.70	0.66	2.8*	2.6*	—	—	2.3
6608-120.30	7.1 SL	Sym.	Flexed	3.1	2.2	0.46	0.76	0.78	2.6*	2.4*	0.66	0.62	2.1
5708-115.35	8.0	Sym.	Flexed	3.3	2.4	0.64	0.72	0.68	2.9*	2.7*	0.62	0.70	2.0
6706-123.37	9.0	Sym.	Flexed	3.9	2.7	0.52	0.84	0.84	3.4*	3.0*	0.70	0.82	2.7
6410-83.43	9.4	Sym.	Flexed	3.7	2.7	0.56	0.84	0.84	3.6*	3.8*	0.80	0.84	2.3
5701-120.35	9.1	Migr.	Flexed	3.8	3.1	0.72	1.0	0.96	3.7*	4.1*	0.92	0.68	2.7
5709-110.33	9.9	Migr.	Flexed	4.0	3.2	0.80	0.90	0.86	4.1*	4.3*	0.90	0.76	2.6
6706-123.36	10.5	Migr.	Flexed	4.1	3.5	0.80	1.1	0.94	3.8*	3.9*	0.98	0.88	3.0
5507-130.30	11.7	Migr.	Flexed	4.2	3.7	0.96	1.0	0.88	4.4*	4.5*	1.2	0.90	3.5
Asuncion Bay,	35.8	Over	Juv.	12.4	12.2	2.3	4.3	—	13.4*	13.0*	3.2	2.9	10.5
B.C.	38.2	Over	Juv.	12.2	13.5	2.7	4.2	—	14.2*	13.7*	3.8	3.4	11.4

[1]Sym. - symmetrical; Migr. - migrating.
[2]Str. - straight; E fl. - early flexion; Midfl. - midflexion; L fl. - late flexion; Juv. - juvenile.
[3]Asterisk indicates inclusion of dorsal fin pterygiophores in body depth measurement.

TABLE 19.—Meristics of larvae and juveniles of *Hippoglossina stomata*. (Specimens between dashed lines are undergoing notochord flexion.)

Station	Size (mm)	Stage[1]	Fin rays: Dorsal	Anal	Caudal	Pelvic	Pectoral right/left	Vertebrae: Precaudal	Caudal	Total	Source of count
7201-117.35	3.7 NL	Prefl.	0	0	0	0	LP[2]				
7412-103.29	4.1	Prefl.	0	0	0	0	LP[2]				
7412-88.5.31	4.8	Prefl.	0	0	0	0	LP[2]				
5801-117.35	5.2	Prefl.	0	0	0	0	LP[2]				
6310-93.28	6.2	Prefl.	0	0	0	0	LP[2]				
6605-123.37	6.4	Prefl.	Anterior swelling	0	0	0	LP[2]				
5910-117.30	6.2	Prefl.	Forming	0	Forming	0	LP[2]				
6706-110.50	7.0	Prefl.	Forming	Forming	ca. 6	0	LP[2]				
5708-118.5.35	6.6	E fl.	Forming	Forming	ca. 6	Bud	LP[2]				
5706-127.34	7.5	E fl.	Forming	Forming	ca. 10	Bud	LP[2]				
6912-83.60	8.3	E fl.	Ant. 4	Forming	ca. 10	Bud	LP[2]				
5807-130.30	7.6	Midfl.	ca. 15	ca. 15	12	Bud	LP[2]				
5709-110.30	7.9	Midfl.	ca. 55	ca. 45	12	Bud	LP[2]				
6706-123.37	8.8	Midfl.	ca. 62	ca. 50	16	Bud	LP[2]				
5706-123.36	7.6	L fl.	ca. 63	ca. 45	14	Bud	LP[2]				
6706-123.36	8.5	L fl.	ca. 68	ca. 50	14	Bud	LP[2]				
6608-120.30	7.1 SL	Postfl.	ca. 66	ca. 51	16	ca. 5/5	LP[2]				
5708-115.35	8.0	Postfl.	63	50	ca. 18	6/6	LP[2]				
6706-123.37	9.0	Postfl.	68	53	18½	5/5	LP[2]				
6410-83.43	9.4	Postfl.	68	54	ca. 18	6/6	LP[2]				
5701-120.35	9.1	Postfl.	67	53	18½	6/6	LP[2]				
5709-110.33	9.9	Postfl.	65	50	18½	6/6	LP[2]				
6706-123.36	10.5	Postfl.	66	53	18½	6/6	LP[2]				
5507-130.30	11.7	Postfl.	64	50	18½	6/6	LP[2]				
Asuncion Bay,	35.8	Juv.	67	52	18½	6/6	10/10	11	27	38	X-ray
B.C.	38.2	Juv.	65	50	17½	6/6	10/10	11	27	38	X-ray

[1]Prefl. - preflexion; E fl. - early flexion; Midfl. - midflexion; L fl. - late flexion; Postfl. - postflexion; Juv. - juvenile.
[2]LP refers to functional larval pectoral fins which have no ossified rays.

character in *H. stomata* because other species of *Hippoglossina* possess this bone.

The dorsal fin of *H. stomata* develops quite differently than in *Pleuronichthys*. An anterior group of about five dorsal rays is the first to form in *H. stomata*; these become more elongated than the other rays. The anlage of these is evident on a 6.4-mm NL preflexion specimen and four rays are formed on a 9.3-mm NL early flexion larva. A similar pattern of early forming dorsal fin rays is found in the closely related genera *Paralichthys* (Okiyama 1967; Smith and Fahay 1970; Ahlstrom and Moser 1975) and *Pseudorhombus* (Devi 1969). Although the anterior dorsal rays form early, the pelvic fins do not develop elongated rays, such as in the bothid genera *Syacium* (Aboussouan 1968) and *Cyclopsetta* (Gutherz 1970). The dorsal fin rays differentiate posteriad but most rays form simultaneously and the full complement is developed on a late flexion specimen. The base of the anal fin is evident during early caudal formation, rays are forming on midflexion specimens, and the total number is formed on a late flexion specimen. Pelvic fin buds are evident on early flexion specimens, but rays can be distinguished only on postflexion larvae.

Distribution.—This species ranges from Monterey Bay, Calif., to the Gulf of California, including Guadalupe Island (Miller and Lea 1972). Larvae occurred over a wide band of inshore and offshore stations (Figure 24). The southern limit of *H. stomata* overlaps the northern range of *H. tetrophthalmus* which has different fin counts (Ginsburg 1952). To date, larvae of *H. tetrophthalmus* are not known.

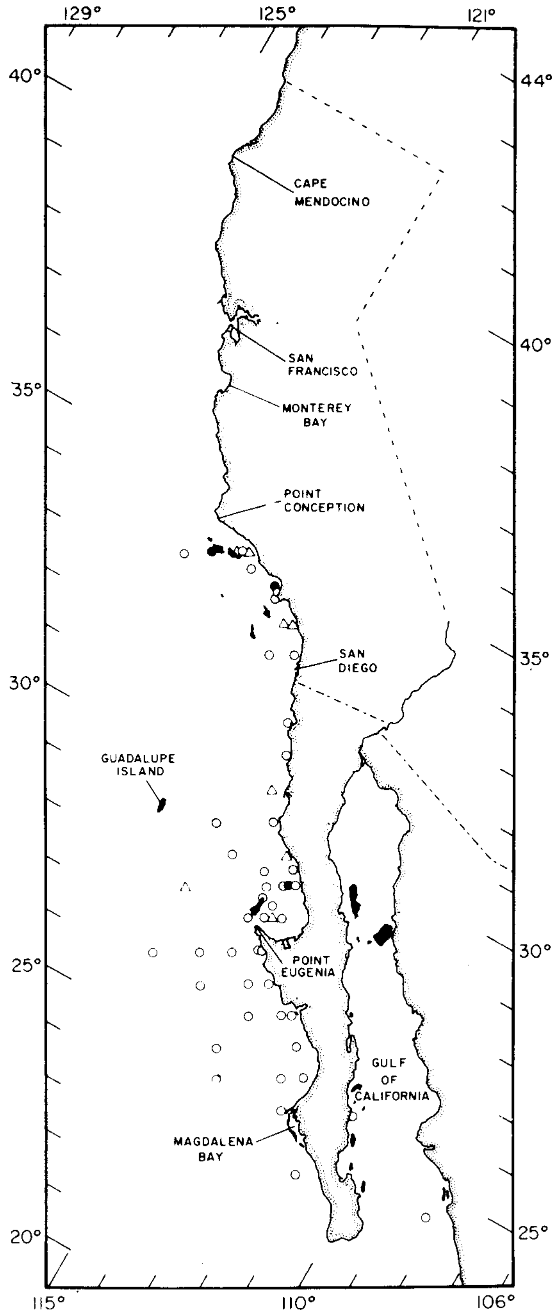


FIGURE 24.—Distribution of eggs and larvae of *Hippoglossina stomata* examined in this study. (Triangles represent eggs, open circles larvae, and closed circles eggs and larvae.)

SUMMARY

We used a combination of larval morphology, meristics, and pigmentation to distinguish seven known eastern North Pacific species of flatfishes with heavily pigmented larvae. Table 20 summarizes many pertinent characters for identifying eggs and larvae of these species. Information is given for three characters of eggs: size, ornamentation of the chorion, and presence or absence of an oil globule.

In most instances, the size of a newly hatched larva is directly related to the size of the egg from which it hatched, and such is the case with *Pleuronichthys*. *Pleuronichthys decurrens*, with the largest egg, has the largest larva, with a successive decrease in larval size of the other species corresponding to their smaller sized eggs. This also applies to the yolk-sac larvae of *Hypsopsetta guttulata* and *Hippoglossina stomata*. *Pleuron-*

ichthys decurrens, with the largest yolk-sac larva, is correspondingly large at caudal fin formation (notochord flexion) and at transformation, whereas *Hypsopsetta guttulata*, with the smallest egg, is correspondingly smallest at all stages of larval development with the exception of some overlap with larvae of *P. ritteri*.

A larval character that is particularly useful in separating preflexion larvae of *H. guttulata* from those of *P. ritteri* is the presence of a pterotic spine on each side of the head of *H. guttulata*. The only species of *Pleuronichthys* with a pterotic spine is *P. decurrens*.

For relating a larval series to its juveniles and adults, and thus substantiating identification of the series, meristic counts, particularly of the precaudal and caudal groups of vertebrae, are indispensible. One can seldom rely on one meristic character alone, but must use a combination of all available counts.

The distribution of pigment, which changes with growth, provides good characters for discriminating among larvae of the several species. It is particularly useful with preflexion larvae, and for this reason we emphasize pigment for this stage in Table 20.

ACKNOWLEDGMENTS

We would like to thank the following individuals for loan of specimens: Gerald McGowen (Occidental College), Joseph Copp and Richard Rosenblatt (Scripps Institution of Oceanography), Maxwell Eldridge (National Marine Fisheries Service, Tiburon), Wayne White (California State University, Fullerton), Robert Behrstock (Humboldt State University), and Sally Richardson (Oregon State University). We are grateful to Dennis Gruber (Scripps Institution of Oceanography) and John Butler (National Marine Fisheries Service, La Jolla) for providing reared specimens. Appreciation is also extended to Susan D'Vincent, Elaine Sandknop, and Betsy Stevens (National Marine Fisheries Service, La Jolla) for their assistance in gathering material from our collections. Henry Orr (National Marine Fisheries Service, La Jolla) deserves thanks for some of the illustrations. Our special thanks go to George Boehlert and Ellen Flentye (Scripps Institution of Oceanography) for providing the scanning electronmicrographs, and to John Fitch (California Department of Fish and Game), Edward Houde (University of Miami), David Kramer (National Marine Fisheries Service, La Jolla), and Sally Richardson for their critical review of the manuscript.

LITERATURE CITED

ABOUSSOUAN, A.
1968. Oeufs et larves de Téléostéens de l'Ouest africain. VII. Larves de *Syacium guineensis* (Blkr.) [Bothidae]. Bull. Inst. Fondam. Afr. Noire, Ser. A Sci. Nat. 30:1188-1197.

AGASSIZ, A., AND C. O. WHITMAN.
1885. Studies from the Newport Marine Laboratory. XVI. The development of osseous fishes. I. The pelagic stages of young fishes. Mem. Mus. Comp. Zool. Harv. Coll. 14, 56 p.

AHLSTROM, E. H., AND H. G. MOSER.
1975. Distributional atlas of fish larvae in the California Current region: Flatfishes, 1955 through 1960. Calif. Coop. Oceanic Fish. Invest. Atlas 23, text vii-xix, 207 distribution charts.

AHLSTROM, E. H., J. L. BUTLER, AND B. Y. SUMIDA.
1976. Pelagic stromateoid fishes (Pisces, Perciformes) of the eastern Pacific: Kinds, distributions, and early life histories and observations on five of these from the northwest Atlantic. Bull. Mar. Sci. 26:285-401.

AMAOKA, K.
1970. Studies on the larvae and juveniles of the sinistral flounders - I. *Taeniopsetta ocellata* (Günther). Jpn. J. Ichthyol. 17:95-104.
1971. Studies on the larvae and juveniles of the sinistral flounders—II. *Chascanopsetta lugubris*. Jpn. J. Ichthyol. 18:25-32.
1972. Studies on the larvae and juveniles of the sinistral flounders—III. *Laeops kitaharae*. Jpn. J. Ichthyol. 19:154-165.
1973. Studies on the larvae and juveniles of the sinistral flounders—IV. *Arnoglossus japonicus*. Jpn. J. Ichthyol. 20:145-156.

BAILEY, R. M., J. E. FITCH, E. S. HERALD, E. A. LACHNER, C. C. LINDSEY, C. R. ROBINS, AND W. B. SCOTT.
1970. A list of common and scientific names of fishes from the United States and Canada. 3d ed. Am. Fish. Soc., Spec. Publ. 6, 150 p.

BELL, R. R.
1971. California marine fish landings for 1970. Calif. Dep. Fish Game, Fish Bull. 154:33-34.

BRUUN, A. F.
1937. *Chascanopsetta* in the Atlantic; a bathypelagic occurrence of a flat-fish, with remarks on distribution and development of certain other forms. Vidensk. Medd. Dan. Naturhist. Foren. Kbh. 101:125-135.

BUDD, P. L.
1940. Development of the eggs and early larvae of six California fishes. Calif. Div. Fish Game, Fish Bull. 56, 50 p.

CLOTHIER, C. R.
1950. A key to some southern California fishes based on vertebral characters. Calif. Div. Fish Game, Fish Bull. 79, 83 p.

DEVI, C. B. L.
1969. Occurrence of larvae of *Pseudorhombus elevatus* Ogilby (Heterosomata—Pisces) along the south-west coast of India. Proc. Indian Acad. Sci. 70(Sect. B):178-186.

TABLE 20.—Summary of egg and larval characters useful in identifying flatfishes with heavily pigmented larvae.

Characters	*Pleuronichthys decurrens*	*P. coenosus*	*P. verticalis*	*P. ocellatus*	*P. ritteri*	*Hypsopsetta guttulata*	*Hippoglossina stomata*
Eggs:							
Diameter	1.84-2.08	1.20-1.56	1.00-1.16	No data	0.94-1.08	0.78-0.89	1.22-1.38
Chorion	Polygonal sculpturing	Polygonal	Polygonal		Polygonal	Smooth	Smooth
Oil globule	0	0	0		1 (0.10 mm)	1 (0.13 mm)	1 (0.23 mm)
Larval morphology:							
Size of available yolk-sac larvae (mm NL)	4.9 (5.54-Budd 1940)	3.9 (3.88-Budd 1940)	2.4 (3.16-Budd 1940)	No data	2.1	2.2-2.3 (1.7-2.1-Eldridge 1975)	3.7
Size range of preflexion larvae	4.9-9.8	3.7-8.5	2.4-5.8	No data	2.1-5.1	2.2-4.4	3.7-7.0
Size range at caudal fin formation (mm NL)	7.8-11.0	6.2-8.5	5.0-7.2	No data <6.6	4.3-5.6	4.0-5.2	6.2-8.8
Size range during transformation (mm SL)	10.5-<29.4	8.2-<17.0	7.3-<12.2	No data	6.0-<12.7	4.4-<11.2	9.1->11.7
Pterotic spines	1 on each side	0	0	0	0	1 on each side	0
Elongated anterior dorsal rays	0	0	0	0	0	0	ca. 5
Meristics:							
Precaudal vertebrae	14-15 (14)	12-13 (13)	13	12-13 (12)	12-13 (12)	11-12 (12)	11
Caudal vertebrae	24-26 (25)	24-26 (24-25)	22-25 (23)	22-24 (22-23)	22-24 (23)	22-24 (23)	26-28 (27)
Caudal rays	18-20 (19)	19-21 (19)	19	18-19 (19)	19-20 (19)	19-20 (19)	17½-18½ (18½)
Pigmentation:							
Finfold of early larvae	Entirely pigmented except for extreme posterior portion of tail	Opposing clusters approx. midway on tail region	Triangular cluster behind anus ventrally; dorsal cluster slightly forward of ventral cluster; persist through notochordal flexion	No data	Few scattered melanophores on distal margins near anus; these do not persist after long preservation. Often with expansion of melanophores along both margins of body posterior to anus	Opposing pigment extending from body posterior of the anus	Small rounded patch dorsally and broad patch ventrally from middle part of tail
Top of head to shoulder region in early larvae	Present	Present	Absent	No data	Absent	Present	Present but sparse
Unpigmented posterior tail region	Extreme tip of notochord only in very early larvae	Tip of notochord followed by narrow posterior band of caudal peduncle in later stages	Last 3 to 5 myomeres through early notochordal flexion, followed by unpigmented caudal peduncle (shorter than in *P. ritteri*)	Caudal peduncle in late larvae	Last 7 or 8 myomeres through notochordal flexion; entire caudal peduncle unpigmented where dorsal & anal fins terminate in transforming sizes	Last 9 to 10 myomeres prior to notochord flexion shortening to 5 or 6 myomeres after flexion	Tip of tail
Pectoral fin base or fin membrane prior to caudal fin formation	Few melanophores scattered on fin base	None	None	No data	Small melanophores along proximal margin of fin membrane	Two to three melanophores on fin base, particularly at symphysis	Dense pigment on fin base, sparse on fin membrane

EHRENBAUM, E.
1905. Nordisches Plankton. Zoologischer Teil. Erster Band: Eier und larven von Fischen. 1905 p. 1-216 Labridae through Pleuronectidae, 1909 p. 217-414 Gadidae to Amphioxidae. Reprinted 1964 A. Asher and Co., Amsterdam.

ELDRIDGE, M. B.
1975. Early larvae of the diamond turbot, *Hypsopsetta guttulata*. Calif. Fish Game 61:26-34.

FIERSTINE, H. L., K. F. KLINE, AND G. R. GARMAN.
1973. Fishes collected in Morro Bay, California between January, 1968 and December, 1970. Calif. Fish Game 59:73-88.

FITCH, J. E.
1963. A review of the fishes of the genus *Pleuronichthys*. Los Ang. Cty. Mus. Contrib. Sci. 76, 33 p.

FREY, H. W. (editor).
1971. California's living marine resources and their utilization. Calif. Dep. Fish Game, 148 p.

GATES, D. E., AND H. W. FREY.
1974. Designated common names of certain marine organisms of California. Calif. Dep. Fish Game, Fish Bull. 161:55-90.

GINSBURG, I.
1952. Flounders of the genus *Paralichthys* and related genera in American waters. U.S. Fish Wildl. Serv., Fish. Bull. 52:267-351.

GUTHERZ, E. J.
1970. Characteristics of some larval bothid flatfish, and development and distribution of larval spotfin flounder, *Cyclopsetta fimbriata* (Bothidae). U.S. Fish Wildl. Serv., Fish. Bull. 68:261-283.

HOLLISTER, G.
1934. Clearing and dyeing fish for bone study. Zoologica (N.Y.) 12:89-101.

HOLT, E. W. L.
1893. Survey of fishing grounds, west coast of Ireland. 1890-91: on the eggs and larval and post-larval stages of teleosteans. Sci. Trans. R. Dublin Soc., Ser. 2, 5, 121 p.

HUBBS, C. L.
1928. A checklist of the marine fishes of Oregon and Washington. J. Pan-Pac. Res. Inst. 3(3):9-16.

HUBBS, C. L., AND Y. T. CHU.
1934. Asiatic fishes (*Diploprion* and *Laeops*) having a greatly elongated dorsal ray in very large postlarvae. Occas. Pap. Mus. Zool., Univ. Mich. 299, 7 p.

KRAMER, D., M. J. KALIN, E. G. STEVENS, J. R. THRAILKILL, AND J. R. ZWEIFEL.
1972. Collecting and processing data on fish eggs and larvae in the California Current region. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC. 370, 38 p.

LEONARD, S. B.
1971. Larvae of the fourspot flounder, *Hippoglossina oblonga* (Pisces: Bothidae), from the Chesapeake Bight, western North Atlantic. Copeia 1971:676-681.

MCALLISTER, R.
1975. California marine fish landings for 1973. Calif. Dep. Fish Game, Fish Bull. 163:33.

MILLER, D. J., AND R. N. LEA.
1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish Game, Fish Bull. 157, 235 p., 1976 addendum, p. 237-249 in reprint edition. Div. Agric. Sci., Univ. Calif., Sale publ. 4065, 249 p.

MILLER, D., AND R. R. MARAK.
1962. Early larval stages of the fourspot flounder, *Paralichthys oblongus*. Copeia 1962:454-455

MITO, S.
1961. Pelagic fish eggs from Japanese waters—I. Clupeina, Chanina, Stomiatina, Myctophida, Anguillida, Belonida and Syngnathida. [In Jpn., Engl. summ.] Sci. Bull. Fac. Agric., Kyushu Univ. 18:285-310.
1962. Pelagic fish eggs from Japanese waters—V. Callionymina and Ophidiina. [In Jpn., Engl. summ.] Sci. Bull. Fac. Agric., Kyushu Univ. 19:377-380.
1963. Pelagic fish eggs from Japanese waters—IX. Echeneida and Pleuronectida. Jpn. J. Ichthyol. 11:81-102.

MOSER, H. G., AND E. H. AHLSTROM.
1970. Development of lanternfishes (family Myctophidae) in the California Current. Part I. Species with narrow-eyed larvae. Bull. Los Ang. Cty. Mus. Nat. Hist. Sci. 7, 145 p.

MOSER, H. G., E. H. AHLSTROM, AND E. M. SANDKNOP.
1977. Guide to the identification of scorpionfish larvae (family Scorpaenidae) in the eastern Pacific with comparative notes on species of *Sebastes* and *Helicolenus* from other oceans. U.S. Dep. Commer., NOAA Tech. Rep. NMFS Circ. 402, 71 p.

NIELSEN, J. G.
1963. Description of two large unmetamorphosed flatfish-larvae (*Heterosomata*). Vidensk. Medd. Dan. Naturhist. Foren. Kbh. 125:401-406.

NORMAN, J. R.
1934. A systematic monograph of the flatfishes (Heterosomata). Vol. I: Psettodidae, Bothidae, Pleuronectidae. Br. Mus. (Nat. Hist.), Lond., 459 p.

OKIYAMA, M.
1967. Studies on the early life history of a flounder, *Paralichthys olivaceus* (Temminck et Schlegel). 1. Descriptions of postlarvae. Bull. Jpn. Sea Reg. Fish. Res. Lab. 17:1-12.

OLIPHANT, M. S.
1973. California marine fish landings for 1971. Calif. Dep. Fish Game, Fish Bull. 159:32-33.

ORTON, G. L.
1953. Development and migration of pigment cells in some teleost fishes. J. Morphol. 93:69-99.

ORTON, G. L., AND C. LIMBAUGH.
1953. Occurrence of an oil globule in eggs of pleuronectid flatfishes. Copeia 1953:114-115.

PINKAS, L.
1974. California marine fish landings for 1972. Calif. Dep. Fish Game, Fish Bull. 161:32-33.

SANZO, L.
1915. Contributo alla conoscenza dello sviluppo negli Scopelini Muller (*Saurus griseus* Lowe, *Chlorophthalmus agassizii* Bp. ed *Aulopus filamentosus* Cuv.). R. Com. Talassogr. Ital. Mem. 49, 21 p.
1931. Uova, larvae e stadi giovanili di Teleostei Sottordine: Stomiatoidei. Fauna Flora Golfo Napoli Monogr. 38:42-92.
1933. Uova, larvae e stadi giovanili di Teleostei Famiglia Macruridae. Fauna Flora Golfo Napoli Monogr. 38:255-265.

SMITH, W. G., AND M. P. FAHAY.
1970. Description of eggs and larvae of the summer floun-

der, *Paralichthys dentatus*. U.S. Fish Wildl. Serv., Res. Rep. 75, 21 p.

STARKS, E. C., AND W. F. THOMPSON.
1910. A review of the flounders belonging to the genus *Pleuronichthys*. Proc. U.S. Natl. Mus. 38:277-287.

TAKITA, T., AND S. FUJITA.
1964. Egg development and prolarval stages of the turbot, *Pleuronichthys cornutus* (Temminck et Schlegel). [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 30:613-618.

TOWNSEND, L. D.
1936. Variations in the meristic characters of flounders from the northeastern Pacific. Rep. Int. Fish. Comm. 11, 24 p.

WHITE, W. F.
1977. Taxonomic composition, abundance, distribution, and seasonality of fish eggs and larvae in Newport Bay, California. M.A. Thesis, California State Univ., Fullerton, 107 p.